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GRANT DUNCAN

Date and place of birth (if available):

Date and place of interview: July 22nd, 2013, Suncor Building, Calgary, AB.

Name of interviewer: Peter McKenzie-Brown

Name of videographer: Ty Reynolds

Full names (spelled out) of all others present: Grant Duncan

Consent form signed: Yes

Transcript reviewed by subject:

Interview Duration: 1 hour, 16 minutes

Initials of Interviewer: PMB

Last name of subject: Duncan

PMB: I'm talking to Grant Duncan who works for Suncor in a consulting capacity, if I'm not mistaken.

DUNCAN: No, advisor. I'm the principal production engineer, just kind of like a chief engineer advisor.

PMB: And we're in the Suncor Building now. Today is the 22nd of July 2013. I'm going to begin, Grant, by asking you to tell me a little bit about your early life; where were you born, where did you go to university, and that kind of thing, and then we'll get onto your career.

DUNCAN: I was born in Manitoba. And the pipelines came through Manitoba in 1954, and my father went to work on the pipelines. And so then for the next ten or 12 years we lived all over Canada; went to three schools in Grade 1, in three different provinces, four schools in Grade 2 in different provinces. The only elementary year that I spent in one school was in Hope, B.C.; I spent Grade 3 there, then back into three schools, and eventually my mother thought we were travelling around too much. So when it got to junior high time we settled in Calgary. She found a job as a teacher. My dad continued to work pipelines. My best friend was my dog because we were moving all the time. And then went to William Aberhart High School in Calgary, went to university to Calgary and then graduated from the University of Calgary in 1970 with a degree in mechanical engineering. And after graduation I went to work for a company called Elast-O-Cor. They made a high-quality urethane rubber product called Adiprene; and we made a lot of parts for industry that had erosion and corrosion.

And so after graduation I got introduced to the oil sands very early on because Great Canadian Oil Sands produces this very abrasive sand, and we provided a lot of equipment to them. We provided scrapers for their froth tanks, we provided linings for their magnetic flow meters, linings for their pipes that took the sand out to the tailings ponds, scrapers for the big rollers that operated the conveyor belts, and coverings for the little rollers that supported the conveyor belts. So between 1970 and 1974 I went to Fort McMurray about 40 times, always to see GCOS.

PMB: And of course GCOS was the forerunner to, or at least part of the forerunner to Suncor. It's one of the components of Suncor.

DUNCAN: That's right, it was Sun Oil Company and it became Suncor.

It was pretty interesting times. Before Suncor, Fort McMurray only had about 1800 people, and when I started going to Fort McMurray in 1970 there was about 6000 people. When I stopped going in '74 there were about 10,000 people. There were only about three hotels, I think, in the whole city; there was Peter Pond, the Oil Sands, and the Riviera, and if you went into the bar in the Riviera you kept your back to the wall because it was a really rough place. And so I left Elast-O-Cor in 1974.

One of the things I'd also been doing at Elast-O-Cor is designing drilling tools and equipment; shock subs, stabilizers, equipment like that, and that eventually lead to a job at a company called Drilco, and that was in Edmonton. And so I started with Drilco and started designing drilling tools, mostly for hard rock in the Foothills, but I was also seconded to -- well not seconded. I was working in Sudbury, Ontario one week per month. We had a Drilco office there, and I was designing drilling equipment for hard rock, for nickel mining. So one of the tools that we were designing for was called a raise bore, and that's where you drill an 11-inch diameter hole from one gallery down to a lower gallery, horizontal galleries, and then you remove the 11-inch bit, and put on a 6 or 8-foot diameter bit and suck it back up to the upper gallery. All the rock cuttings fall away. And these large diameter holes, these 6 and 8-foot diameter holes are used for either an ore drop, or ventilation in these underground mines. And one of the things I started working on was trying to drill inclined raise bores, and even horizontal. So I was working on building a machine that could drill a horizontal well 8 foot in diameter.

PMB: What year was this?

DUNCAN: That would be 1976/'77.

And of course the machine to drill an 8-foot diameter hole through hard rock has to be a pretty strong machine. At the same time I was seconded to Petro-Canada - it was originally Atlantic Richfield Canada, ARCAN - and then that became Petro-Canada, and I was seconded to them one day per week. And so I was coming down to Calgary and working on projects, and one of the projects I was working on was drilling horizontal wells in the oil sands. This was in '77. And then I got transferred to Houston, by Drilco, and a funny thing happened. When I told the guy who was to become my boss at Petro-Canada that I'd been transferred to Houston, and he said well, do you like Houston? And I said well, I've only been there a couple times. I don't really know the place. And he

said well, you have lots of friends in Calgary; every time you come to Calgary you go and see your friends. And I said yeah, I have friends. And he said how do you like working on the projects? And I said well, I like the projects. And he said it sounds like you're asking me for a job. And it took me about 20 seconds to realize what he was saying, and I said, can I have a job? And he said yes. And this Peter Quinn who became my boss at Petro-Canada, and he went on to have a very fabulous career. He ended up being the vice president of (French) out of France.

DUNCAN: Let's call it IFP, and we'll call it the French Petroleum Research Institute, that's easier.

But it was really funny because six months after I started HR phoned me up and they said we don't have a copy of your resume. And I said I don't have a resume. And HR said how did you get a job at Petro-Can without a resume? I said well, I had this book of pictures of all the things that I designed. So six months after I started at Petro-Can I had to write a resume.

PMB: Well, I have a copy of today's resume and it's pretty impressive. You would probably still get a job at Petro-Canada if they still existed.

So sorry, continue that story because that's quite an interesting one. You were drilling really these huge mining drill equipment, and I know that this stuff was much later used, for example, in the underground test facility. But what I found quite interesting looking at the materials you sent me, was that you seemed to do something -- the underground test facility is renowned. It was a great, great project and it was absolutely transformational, and yet you seem to have done something a little bit similar quite a number of years before that.

DUNCAN: That's true. Yeah, the underground test facility did get a lot of press, but seven years before that we had a very successful horizontal test, with steam, at what we called the Mine Assisted In Situ Project.

PMB: Okay, Mine Assisted In Situ Project, and that's called MAISP.

DUNCAN: Right, we called it MAISP. Now SAGD really originated with Roger Butler in Canada, but I think that steam assisted gravity drainage actually originated in Russia. In 1937 the Russians built a mine and built horizontal galleries, and then drilled horizontal wells out of those galleries starting in 1937, and the oil just drained into the galleries, and they would pump it up to surface.

In 1972 they started to experiment with steam, and they built some horizontal steam wells, and it was a little too hot in the gallery so eventually they drilled vertical wells to the top of their formation at Yarega, and had vertical steam injectors and horizontal producers. It's about 1100 kilometres north and east of Moscow. So I think the Russians were at the beginning of the SAGD world.

In 1976 a bunch of Canadians went over to see the oil mine at Yarega.

PMB: Were you among that group?

DUNCAN: No, I wasn't, no. The only person I can remember was maybe Skov Murray who worked for Esso at the time.

PMB: Another friend of mine, Leroy Field, was also one of the people who went there.

DUNCAN: Well that's good, yeah.

So these guys came back pretty excited, and in 1977 they formed this consortium and called them Mine Assisted In Situ Project. And the objective was to build a mine, just like the underground test facility, with two vertical shafts and a gallery, and then drill horizontal wells. The plan was to drill all the horizontal wells all at the same elevation because we didn't understand what SAGD was at the time. So they came back pretty excited. And there were five companies involved; there was Petro-Canada as the operator, Esso Resources, Gulf Canada, Husky, and Canada City Services. So the five companies involved.

And before we went and built the mine we thought we'd better do a test, so that's where we went to do the Mine Assisted In Situ Project, and the Mine Assisted In Situ Project happened just north of the GCOS, or Suncor mine, at a place called the Syncrude Lower Camp. And we dug a great big pit in the ground, and it was in the Devonian carbonates that underlie the McMurray oil sands. We dug this large pit into which we could put our drilling rig, and spudded the wells at about 10 metres below the oil sand limestone interface, and then we drilled three horizontal wells. They were 310 metres long and eight metres apart. We drilled these wells up into the lower McMurray, and along the base of the oil sands limestone interface. The first 200 metres was cased, and cemented in place, and then the last 100 metres had a slotted liner. And then we put a circulation string into the well bores.

PMB: What is a slotted liner; can you explain that?

DUNCAN: Yeah, a slotted liner is like a pipe with a whole bunch of real fine cuts in the pipe. We were using 18,000 slots, so the slots were about two and a half inches long by not much more than say three or four sheets of paper thick. And they're meant to hold the sand back so that we can produce the bitumen in a steam into the pipe, into the liner, but keep the sand in the formation.

So we had three wells, horizontal wells. The wells were eight metres apart, so the distance from the north well to the south well was 16 metres. And we were trying to do what we call thermal oil mining. We were trying to do a steam drive between horizontal wells. So when I drilled the wells I had a little trouble keeping the -- the first well went fine; drilled it, was able to survey it, spudded it at 98 degrees, got it down to horizontal, but then after that I'd put this 310-metre long steel antenna in the ground and my magnetic survey tools wouldn't work anymore because of this interference. So the second and third wells were a little more difficult to drill.

And it ended up that the north well on the project was four metres lower than the south well on the project, and the middle well was about two metres difference.

So we started steaming the north well, the low well, and trying to produce the upper well. We did that for about eight months, and then finally we switched it. After eight months we started steaming the upper well and producing the lower well, and the oil rate increased significantly. After 16 months we shut down the steam injection.

PMB: Now the reason it increased significantly was that you had, in effect, created a steam chamber.

DUNCAN: That's right, yeah. It just made a lot more sense to put steam in the upper well than the lower well. But we didn't realize that at first. We were doing the reverse because we thought we had to --

PMB: Well logically you would think that it should be the other way because heat rises and yet it doesn't work that way.

DUNCAN: Yeah, it doesn't work that way, no.

At the end of the day we shut down the project. We had six observation holes in the pattern, as well, but we drilled eight core holes after the fact, and we realized that we had created a steam chamber that was the height of the lower McMurray, which was 21 metres high by 25 metres wide. In my mind we had created an early stage or incipient SAGD chamber. We had a steam chamber with a horizontal well injector, and a horizontal producer where the injector was higher than the producer.

Then the consortium said well, the oil price wasn't as good as we thought it could be. And Esso was really interested in cyclic steam for Cold Lake more so than horizontal wells, even though they had drilled this horizontal well at the May Pilot, which was brilliant, and so we shut down the project. At the end of the day we donated all of our stuff to AOSTRA, all of our drilling information, and our production information, we donated that to AOSTRA who went and built the underground test facility seven years later.

And Esso was a little bit ahead of us. They were drilling horizontal wells in Cold Lake, and Roger Butler had drilled this -- they drilled this horizontal well that was Roger Butler's idea, and it was supposed to be a single well SAGD project. And there are actually three names on the patent. There's Roger Butler, a guy named Chuck Bombardieri, and Bruce Slevinski, and Bruce is a good friend of mine so I just want to make sure he gets recognition for being part of the patent.

And they tried to circulate steam in this horizontal well for a long time, and they didn't make a lot of oil at first until they fractured the well, and then the oil rate at the Cold Lake pilot increased significantly. And eventually they drilled two vertical steam injection wells to above the horizontal well, and that's where their SAGD project came from.

PMB: Now I interviewed Barry Stewart - I don't know whether you know him - last week.

DUNCAN: I know Barry, yes. He used to be a vice president at Petro-Can.

PMB: Yeah. Well, he was Roger Butler's boss at that time.

DUNCAN: Great.

PMB: And I said well, what kind of guy was he like? He said well, he was sort of a mad scientist type. He was always wondering around, he was just caught up in his ideas. He told me about this SAGD thing, and I told him he was crazy, it would never work.

DUNCAN: Right.

PMB: But to his credit, he was a great, great visionary and thinker.

DUNCAN: At the same time as we were doing the Mine Assisted In-Situ Project we were also doing an Electric Heat Project. And so I was working on two projects simultaneously, and I was spending a lot of time in the field, drilling the wells, but also PCEJ.

It started out in the late '50s early '60s there was a consortium called ACI which stood for Atlantic Richfield Canada, City Services, and Imperial Oil, and that was called the ACI Project. And then they had pooled a bunch of their land together, and they were looking for technologies to exploit the oil sands. Then Atlantic Richfield became Petro-Can, Cities stayed as Cities, Imperial became Esso, and Japan Canadian Oil Sands bought into the consortium; they farmed in. So it became the PCEJ Project for Petro-Canada, Cities, Esso and JACOS. And as part of the farm-in JACOS gave us a whole bunch of money to do R&D, so we were looking at all kinds of crazy ideas, and one of the ones we looked at was called the Preheat Pilot. And the objective was to preheat the oil sands with electricity and then follow that with steam.

PMB: Okay now, this is very important. What were the dates for this? Roughly when did you begin this project?

DUNCAN: Well I was hired in '78. We started drilling MAISP in 1979. At the same time I was working on the MAISP I was working on the PCEJ project. In fact, my notebooks from the time had more information on PCEJ electric heat than they did on MAISP. So dates; I can look that up here. I think it was about 1980. So I'd finished drilling MAISP in '79, so I was straight into the PCEJ project in 1980, and the PCEJ wells were really quite difficult. They were quite challenging because you had to conduct a lot of power to the formation, you had to cool the wells so they didn't overheat. We had to be able to pump the wells after we'd heated them up. We had to inject brine into the formation to make sure that the formation was more conductive, and they're actually a quintuple completion because I had used hollow sucker rods that I could put naphtha or diluents down the hollow sucker rods to help the bottom hole pumps. So that was 1980/'81.

PMB: Okay you're speaking very, very technically here, and I'm going to ask you to go back and give it to me a little bit more simply. But first of all, what was your job title, or your job function here?

DUNCAN: I was a senior production engineer, I guess. Maybe not even senior. Yeah I think I was maybe a senior production engineer at the time.

PMB: And were you in charge of this project?

DUNCAN: No, I wasn't in charge of it, no. I had a manager and I reported to a manager. But I did the well design, the design for the electric heat wells and the thermal wells.

PMB: Now, you just explained to me what you did, and I consider myself fairly technically inclined, but it went pretty fast. Would you try it again a little bit more slowly.

DUNCAN: Sure, I'd be happy to do that.

We had to design wells that could both apply power to the formations, follow that with steam injection, and follow that with production. So the wells had to do those three things; put electrical power to the oil sands to heat it up, and apply steam afterwards. The wells had to both conduct electricity and be thermally efficient, and at the end they had to be able to pump.

My original design I had wanted to use an insulator, a ceramic insulator to isolate the bottom of the well from the rest of the well so I could transmit power efficiently to the formation. Unfortunately ceramic has a very difficult coefficient of thermal expansion than steel. And we were working with two companies, Corning and Coors. They used to make beer in ceramic bottles instead of glass bottles, and Coors has a very large alumina ceramic company in Boulder, Colorado or Golden, Colorado.

And so we were looking at building ceramic insulators with these two companies, but the steel kept crushing the ceramic. So as I say, we destroyed a million dollars' worth of ceramic in 1979/1980. A million dollars in '79 was still a lot of money.

PMB: Yeah, those were the days.

DUNCAN: Eventually designed the wells with a fibreglass casing to the top of the McMurray formation, and then I used a steel casing with a ceramic coating on it to the lower McMurray, and then through the McMurray we used a gravel pack. We under-reamed the wells to 32 inches in diameter. So we had a 32-inch completion at the bottom of the well. And the reason for the large completion was so we could transmit more power, because the amount of power I could put into the formation was proportional to the square of the radius of the well. So I could put a lot of power in.

PMB: Okay. Now explain to me where this electricity came from and how you actually injected it into the well. So that's the most interesting part of this.

DUNCAN: I used the nine and five-eighths (244 millimeter) casing as the conduit. So the entire well was live, and then it had a fibreglass jacket on the outside of it, an intermediate casing.

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PMB: So you drilled a well and then you inserted it into this conduit which took down electricity.

DUNCAN: Right.

PMB: Now, how did the electricity heat the well? Was it just through contact with the water? Because you've got to have a plus and a minus.

DUNCAN: That's right, you do. We injected some saltwater into the wells to make sure that they were more conductive. And we had designed the wells for four megawatts of power, which is a lot of power, but in truth we never reached that kind of power, and the reason was that we were actually boiling the formation, the connate water that's in the formation was actually turning to steam, and steam is not a very good conductor for electricity. So we never did get to four megawatts of power.

PMB: Now where was the power coming from, just off the grid?

DUNCAN: Just the grid, yes. I think we had 4000 volts and a thousand amps, so it came to four megawatts. We actually were quite successful. We brought the formation temperature from about 12 degrees Celsius up to 65 degrees Celsius, midpoint between the electrodes, but as I said, close to the electrodes sometimes we actually boiled the formation, which is about 160C at that pressure, and then at the end of the day we started to do steam --

The idea was to create paths in the formation so that the steam would preferentially follow the paths rather than divert straight from an injector to a producer. The other objective was to not fracture the formations. Most of the formations had been fractured up to that point. If you looked at some of the original pilots, Pony Creek, or Gregoire Lake, or maybe -- now what were some of the other ones, now, I'm trying to remember. There was Pony Creek, I remember.

PMB: Now when you say they were fractured; it's my understanding that with oil sands, for optimum production you almost never fracture it.

DUNCAN: Well, that wasn't the thought at the day. If you are in very shallow depths, and if you try to fracture the wells you do not get a vertical fracture. You're basically lifting the overburden, so you get a horizontal fracture, more of a pancake fracture. And so many of the operators of the day were actually purposely fracturing the wells to try and get the steam to go away from the well in a pancake fashion. It's only when you get deeper than about 400 metres that you start to get vertical fracs where you would actually bust out of the formation.

Steepbank, that's another one that they did.

PMB: Steepbank, which is now a Suncor project isn't it?

DUNCAN: Probably. We have a lot of oil sands. When they merged the two companies, Petro-Canada and Suncor together, all together we ended up with a big footprint up there.

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But we did not want to fracture the formation in the PCEJ electric heat projects. We wanted to create preferential paths, and then have steam go down those paths and efficiently sweep out the bitumen. Unfortunately the steam pushed the bitumen out of the pattern. And so when we went to put the wells on production we were producing mostly hot water. We produced bitumen, but most of the bitumen had been pushed out of the pattern.

There were two design things that happened at PCEJ that we did not expect, and the first was that there was injectivity in the oil sands. At cold temperatures we were able to lose fluid into the formation. Stony Mountain was about 415 metres from the top of the mountain to the formation, and when I was under-reaming the wells for the gravel packs I was losing fluid at two barrels a minute. And I still remember phoning up and saying I'm losing all this fluid to the formation, guys, and one of our research guys was pounding the table said there is no injectivity in the oil sands. And I said well, tell me where it's going. I'm losing, two barrels a minute.

So the first thing I learned from the project, other than the technical aspects, but from this project and from other projects that we went on to in the future, like Hanging Stone, or the steam wells at Stony Mountain, I learned that there was mobility in the lean bitumen zones, and so you would actually get cold water injection, or drilling fluid, or whatever you happened to be working with.

The second thing I learned is the reservoir pressure has nothing to do with the depth.

PMB: The reservoir pressure has nothing to do with the depth.

DUNCAN: That's right.

PMB: That's counterintuitive.

DUNCAN: Yeah. And at Stony Mountain we were expecting about 4000 kPa reservoir pressure, and we only had 2200.

PMB: kPa, kilopascals.

DUNCAN: And this came as a surprise to everybody as well because they had built the project on Stony Mountain hoping that they could get to the higher pressures, but the reservoir pressure was only 2200. And I came to believe, over the next number of projects that I was working on that the reservoir pressure had nothing to do with the depth, it had to do with the distance that you were from the Athabasca River. The further away you were from the Athabasca River, the higher your pressure would be, and the closer you were to the Athabasca River, the lower your reservoir pressure would be. And I'll try and explain why that happens.

The oil sands actually outcrop at the Athabasca River, so the reservoir pressure adjacent to the Athabasca River would be zero -- well, one atmosphere of pressure. But then as you get further and further away from the river the pressures go up, and it's because there is a little bit of injectivity, fluid movement through the Athabasca, through the (indiscernible) formation, but the Devonian

carbonates that underlie the Athabasca have some permeability as well. Ability to flow fluids - permeability. And so they control the reservoir pressure.

So those are two important things I learned from Stony Mountain and from Hanging Stone. So then we went on from there. Any more questions on PCEJ?

PMB: Let me ask you, the electrical part of it essentially was a flop; is that correct?

DUNCAN: No, we were successful. We put a lot of power into the ground. The only problem that we had was that the power that we put into the ground pushed the bitumen out of the pattern. If we'd had a ring of wells around the pattern we would have picked up a lot of oil.

PMB: It's not likely to be a successful approach to oil sands development. Is it likely to be used again?

DUNCAN: We are experimenting with a project right now.

PMB: Suncor is?

DUNCAN: We are, yes. I can't talk much about it. But we are continuing to investigating electric heat.

PMB: So this still is an open possibility.

DUNCAN: It's still a possibility.

PMB: I'll be damned.

DUNCAN: Yeah.

PMB: And let's see, what else do I need to know about that? I think let's move on from the PCEJ. And JACOS is still involved with that, yes?

DUNCAN: JACOS has its own project, that's right, in the Hanging Stone area.

After PCEJ we went on to build a number of what I call cyclic steam pilots, and we had projects at Hanging Stone. We acquired a company called Pacific Petroleums, and they had some projects going, so we ended up running steam projects at Primrose, and Kirby, Muriel Lake, Cactus Lake, and Kinsella D, the D Field at Kinsella. So we had a number of cyclic steam projects going on, sometimes in patterns, sometimes single well huff and puff, and then we started getting into combustion. And at the Kinsella D Field we had an in situ combustion project going on, that's also known as a fireflood.

PMB: So this is fireflood.

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DUNCAN: fireflood, that's right. And we had a fireflood going at Kinsella D, four wells. One time we got breakthrough from one well to another well of the flame front, and the thermal couples quit at about I think 700 Celsius, and then we ended up with all this pressure on the well from the flame front going past this well. So that was a dangerous situation.

PMB: Now why did you use the cyclic steam, because really the only major producer that uses it is Esso, of course, and it's because of the characteristics of the Cold Lake formation, I believe.

DUNCAN: Right. It's the only game we knew, I think. And we had seen Esso had had success, Gulf had had some success at Wolf Lake. We had had some success at Kirby, and we continued to investigate it. I think the steam projects went on right up until probably close to the oil crash in 1986.

So I was involved in all these different EOR projects. So we'd looked at electric heat, we looked at gas floods, we looked at combustion, chemical floods. And then in 1983 I went into the Drilling Department. I'd had a drilling background from designing drilling tools, and so I went into the Drilling Department as the engineering supervisor for land drilling, and that was an exciting job. I worked with some great people, and we worked all the way from the Arctic to the Foothills, and over to the shallow gas areas. And I was quite proud of some of the stuff that we did.

But I still remember my boss, Ken MacDonald; I was helping him write his performance review one year, and I was writing down the facts that we had drilled 385 wells, and our industry times are about 14 percent better than industry average, so our well drilling times were really quite good, and Ken says to me, he says, two things I'd like you to add to that. He says no lost tools, no lost hole, meaning we never drilled any well that we weren't able to continue forward. We didn't have to leave any ghost holes in the ground. So we did well. We did 385 wells; we beat industry average by quite a bit, no lost tools, no lost hole, no missed targets, so we were doing really well.

And then right at the end of 1985 they said we need a production engineering advisor, and we want you to do that, and so I went back into production right at the end of 1985. And I was very fortunate that I did because 1986 came along, the Petroleum Incentive Program ended, and the oil price went to less than 10 bucks. It was also called the PIP Program, and it was a program that was used by the federal government to encourage exploration.

PMB: It was part of the National Energy Program.

DUNCAN: That's right. And, in fact, the PIP Program was responsible for a lot of the discoveries off the East Coast of Canada and in the Arctic because there was an incentive to go up there and drill these fields. And I think they paid about 75 percent of the cost in the PIP Program.

At any rate, the Petroleum Incentive Program ended, the oil price went to less than 10 bucks, and I was out of the Drilling Department which was fortunate because Petro-Canada went through two major rounds of layoffs in 1986, and we went from over 11,000 people to less than 4000 people. So it was a big reduction in the size of the company. So I dodged that one.

And then we had two labs, two research labs, R&D labs in Calgary. We had the one up by the university in the building that is now the Mechanical Engineering Building for the University of Calgary, and we had another lab out in East Calgary which was the Oil Sands Lab. Both those labs were shut down, and I think almost 200 people were let go. I think of all the employees 200 were let go and five were kept. So that was a big change. That happened in 1986, and it had a real profound effect on me because I was about the only one left. And in 1985 Petro-Canada had bought 27 percent of the shares of this French Petroleum Research Institute, IFP, and we'd entered into a whole bunch of agreements to do R&D with IFP, and I was the only one left. So I ended up taking care of the technical aspects of the collaboration with IFP.

From '86 to about '93 I think I went to France about 15 times, and I learned how to speak French, so you can teach an old dog new tricks. There were a lot more of them than there was me, so I had to learn French, and at the same time we were --

PMB: Were you there on one-week trips or were you there for extended stays?

DUNCAN: Usually just one-week trips, yes. That's a good question.

And then at the same time we also had a share in an oilfield off the East Coast of Spain called Casablanca, Whitehouse, Casablanca. So I would fly over to Spain and I'd go to visit our Casablanca operations.

PMB: Is that called Whitehouse, Casablanca?

DUNCAN: Yes.

PMB: Oh Whitehouse, Casablanca.

DUNCAN: But Casablanca means Whitehouse.

PMB: I didn't make that connection. So it's Casablanca.

DUNCAN: Yeah, just like the movie.

So I'd go over to Spain, then go up to Paris, and then back to Canada, so do this triangle. I did that for a number of years. So that's where I got introduced to offshore as well, because of the Casablanca Offshore Project. So that took us about 1980, 1993 now. And about 1993 I had a strange revelation. I thought I'm not advancing fast enough. I kind of hit a plateau, and Petro-Canada was continuing to have layoffs, downsizings, so the opportunities for advancement within the company were different, and I said to myself I'm going to do something different. And I said I'm going to be the very best production engineer that I can be, but how am I going to get there? So I made a deal with World Oil in 1994.

PMB: World Oil being the foremost magazine or journal (indiscernible).

DUNCAN: Yes, the journal, yes. And I made a deal to write ten articles over a 20-month period on enhanced oil recovery, and so it was every two months I had to put out an article. So by the end of the two years I had read almost a thousand articles, and I tried to involve a bunch of our other people in the company like Abe Collade (phonetic), and Phil Stemmler (phonetic), and people to be coauthors on this project, and at the end of the day World Oil combined the ten articles into a handbook on enhanced recovery engineering, and it's written from a production engineer's perspective, and it covers the thermal projects like steam, the chemical projects, like polymer floods, gas floods, combustion and electric heat, and at the end of the day we put it altogether as a handbook.

PMB: And there it is.

DUNCAN: There it is. And that worked out well for me.

PMB: You don't happen to have a copy of that?

DUNCAN: You can have this one.

PMB: May I? Thank you.

DUNCAN: You certainly can.

PMB: I would like to have that. We'll add it to your file. You're going to have the fattest file in the Glenbow.

DUNCAN: Right.

PMB: Okay. Sorry, continue.

DUNCAN: So that worked out quite well because I boosted myself off that plateau. By having read all those articles I'd learned a whole bunch. And I was continuing to work a lot of different projects, and some international like Casablanca. And then came the offshore. About 1996 I started to get involved in Hibernia, and then in 1998 I'd became very heavily involved in Terra Nova, which was the second major offshore oil property off the East Coast of Canada. So from 1998 until 2009 I spent a lot of time working on Terra Nova. And the Terra Nova wells are subsea wells rather than platform wells meaning that you drill the wells with a semi-submersible drilling rig, a rig that floats on the water, and we drilled I think it was 24 or 26 wells at Terra Nova. There were three gas injectors, about ten water injectors, and about 15 producers. I don't know if the numbers add up. And these were big wells.

Hibernia has big wells, but the Terra Nova wells were really big for subsea wells. A fellow from Statoil, who is one of our partners, his name is Bard Beldring, and he's a Norwegian friend of mine, and together we designed the Terra Nova wells, and they are really high-rate wells. We limited them to 44,000 barrels per day per well for production.

PMB: You limited them to that level?

DUNCAN: Yes, they would produce more than that, but we limited them to 44,000 barrels per day per well.

PMB: Was that for conservation purposes, safety?

DUNCAN: No, for erosion. We were worried erosion on the subsea Christmas trees, and so we did not want to erode out the Christmas trees, so we put that limit on them.

And then the water injectors are pretty big too. I had designed them for 60,000 barrels per day per well, and then the reservoir engineers came along and said we kind of forgot about the formation volume factor, and this is a barrel of oil in a stock tank has a certain volume, but in the reservoir it has about 120, 130 cubic metres of gas compressed into each barrel of oil. So in the reservoir a barrel of oil occupies 1.4 times as much volume as it does when you get it to surface. That's because of all the gas that's in the oil.

The reservoir engineer said we kind of forgot about the formation volume factor. Can we have 100,000 barrels per day per well? I'm like, oh boy. So we did the calculations and said yeah, you can do it. So the Terra Nova water injectors inject 100,000 barrels per day per well, and the producers are 44,000. And we don't even filter the water. We take out the fish, the ones the Spanish haven't caught, and everything else goes down hole. All the plankton and everything else goes down hole, is injected into the reservoir.

PMB: Now the gas that comes out with that, that is basically piped to shore, isn't it?

DUNCAN: No, it's re-injected. It's re-injected for pressure maintenance. No, there's no gas coming to shore yet from the Grand Banks.

PMB: Okay, that will happen someday.

DUNCAN: Hopefully it'll happen sometime, yeah. Not with gas at three bucks an MCF though. It's going to have to be a lot more than that, and it'll probably have to be LNG, liquefied natural gas.

So that was my offshore world. And then the other thing I was doing in those days, starting about 2003, well even before that I was working in Algeria on an Algerian project on the late 1990s and then in 2003 I started to go to England a lot. And we had an office in London, and Aberdeen, and I was working on two projects, one in Libya and one in Syria, and we were doing all the engineering out of London, England. And then I'd go into the field too. So I was into Libya about seven times, and I was into Syria twice. Of course, I have no desire to go to either of those places right now with the wars going on.

PMB: This was basically conventional oil.

DUNCAN: This was conventional, yeah. But that's not what this project's about. This project's about oil sands.

PMB: That's right. Okay, so now I want to come back and ask, is there anything else you'd like to say about your career before we go back and zero in on the oil sands?

DUNCAN: No, I think this would be a good time to talk about the oil sands.

PMB: So let me take a look at your general comments. The mine assisted in situ project, now I have a PowerPoint presentation that you've prepared, and that'll be part of your file. Is there anything else that you want to tell me about that? It's a very complex project from what I can see here, and you've done a pretty good job of explaining it. Is there anything that you would like to add?

DUNCAN: Right. Not on MAISP itself, but in 1999 and 2000 we started to reinvestigate SAGD. So the underground test facility is right adjacent to our Mackay River Project, and they had drilled some vertical wells into the Dover Project, and we were partnering it as well. So we said let's see if we can develop Mackay, Mackay River, see if we can develop that using horizontal wells drilled from surface. So in 1999/2000 I wrote a very large book on how to do this, on how to do SAGD for Mackay. Well, actually I was looking at some of the areas further south at the time, but this became the guidebook for how to do Mackay, and we'd figured out what the build and turns could be for the drilling; you start off at 45 degrees and if you can drill to the west, you'd sail out to the north or whatever, and then turn the well as you're also making it flatter. And so you'd be going from 45 degrees to 90 degrees, and you'd be turning from, say, 15 degrees out of the north and towards the north.

PMB: I'd like to go back a little bit to the underground test facility where, at least to the layman like me, the really important activity took place around 1987/'88 when there were some of those original experimental wells. But of course then it continued as a test project for another 10 or 15 years before it was finally sold I think to Suncor or Petro-Canada. I can't remember who ended up owning the project.

DUNCAN: I think we ended up owning the land the UTF is on.

We're just in the process of abandoning it right now. I was out there about six weeks ago. I was out to Mackay River. I was doing some training out there and I just drove down the road just to see how they're doing on the UTF, and they're abandoning it. I think we've abandoned one shaft, we're into abandoning the second shaft right now.

PMB: Let's go back a little bit. So it was built with shafts and tunnels?

DUNCAN: Right.

PMB: So great big shafts which it sounds to me as though they almost used the kind of super drills that you were using up in Northern Ontario at one point where they drilled those shafts before they actually began the two-part tunnels.

DUNCAN: You know, I'm not sure how they did it. I know that when we were envisioning it we were going to use a technique where we actually froze the ground, as they do for potash mining in Saskatchewan. If they're drilling through an unconsolidated formation, they put in a bunch of pipes around where the big hole is going to be, and they freeze the ground so it's consolidated, and then they can drill through it. You can also do it with other machinery as well.

PMB: What was your experience with, first of all there was the UTF. There was the initial project which by accounts initiated, or really kind of proved to a lot of people the possibility of SAGD. And then there was another ten or some number of years of further test in which different companies, I think, had to put in about $15 million each or something to fund further research.

DUNCAN: Yeah. I don't know anything about that.

PMB: Were you involved in that at all?

DUNCAN: No, I wasn't. No, I was heavy duty into offshore at that point.

PMB: Oh, okay. But you did go up to the UTF, or not?

DUNCAN: Yes, I've been in the mine, yes.

PMB: What's your general impression of it?

DUNCAN: I've been in other mines. Most of the mines I'd been in were hard rock mines for Sudbury, and so it was built into the carbonate, which is much more stable. They still had to stabilize the walls. It was bigger than I expected it to be. The width of the galleries was bigger than I expected. But I was only down in the mine once, and I really don't know that much about the project.

In 1999/2000 I wrote this book on how to do SAGD for Petro-Canada, and we had a lot of stuff in that book. And then in 2002 we started building Mackay River.

PMB: Okay, it was I think Cenovus and I think it was JACOS which were the first two companies to actually do SAGD. They were kind of the real pioneers in that. And so now around 2000 you're writing a whole manual or you say a book. What kind of document is it?

DUNCAN: Well, it's a Word document; it's a binder about this thick. It's not a bound book, it's basically a binder, and it has all the aspects I could think of as to how you would develop a SAGD project, from the production engineer's point of view. So we looked into the oil properties; the viscosity of the oil, what our steam/oil ratio was likely to be, what size of slotted liners we would

use, the casing design; how was the casing going to withstand the temperatures. So there was a lot of stuff in that book. And like I said, it became the guideline for Mackay.

PMB: Is it still sort of the Bible for that project, or has your experience kind of surpassed it?

DUNCAN: Well of course we've evolved past it because we have now ten years of experience with Mackay, or almost 13, and we have about nine years' worth of experience at Firebag, so we're doing very well. But I still refer back to it. And then the other reason I refer back to it is because of the gas-over-bitumen hearings.

PMB: This is a really important issue, and somebody told me that when she worked for Dome, part of her contribution was to sterilize some of the oil sands by producing the gas. Would you tell me a little bit about that, please? That's very important.

DUNCAN: I think it was in the 1990s, I'm not sure exactly what year, it might have been the 1980s, the Alberta government decided they could split the resource, and the gas that overlies the bitumen could be sold as gas, and then the bitumen could be sold as a separate resource. And I remember our Senior Vice President, Sam Stewart, saying this is nuts, you never split the resource in a reservoir.

Let me come back to Sam Stewart for a second. He was from Atlantic Richfield in the United States, and I think geology is his background; he had been sent up to Canada to buy land in the Redwater play. And by the time he got to Canada the Redwater play had all been sold up, so --

PMB: This would have been in the '50s.

DUNCAN: Late '50s, yeah. And the Redwater leases had all been tied up, so he just went further north and bought a whole bunch of moose pasture which became the bitumen leases, and that's how Atlantic Richfield and eventually Petro-Canada ended up with so much land in the Athabasca Oil Sands was because of Sam Stewart.

PMB: But he must have known that it was oil sands area, or was he literally looking for or thinking about finding conventional oil land?

DUNCAN: I have no idea. All I know is he bought a whole bunch of land, and we ended up with a lot of property.

PMB: And that would have been one of the reasons why Atlantic Richfield was such a key player in Syncrude.

DUNCAN: Right.

PMB: And then of course it pulled out.

DUNCAN: Right. Coming back to the gas over bitumen; Gulf, which became ConocoPhillips, at their Surmount property, said wait a minute, we're trying to do steam assisted gravity drainage in these properties, or cyclic steam in these properties, and the reservoir pressure has been depleted, and the reason it's been depleted is because the gas producers are taking off all the gas, and now we're going to have to rebuild that pressure with steam, which is going to cost more gas than the gas you've removed. And it went to two hearings; one was in 2000, and I think the second was in 2003. And I was certainly a part of the 2003 hearing. I provided help for the first one and I was on the panel for the second one. So even though I was supposedly working on other projects like Terra Nova or East Coast, I was still involved in the oil sands; couldn't get away from it. So the gas-over-bitumen hearings, I did refer to my book often in the hearings.

PMB: And what was the outcome of those hearings?

DUNCAN: The outcome was that the board decision was in favour of the oil sands operators.

PMB: So this is the ERCB?

DUNCAN: Yes, the ERCB. And they ruled in favour of the oil sands producers, and told the gas producers they had to shut-in. And a lot of the logic to that was that the value of the gas was just some very small fraction of the value of the oil. So from a province, from a royalty perspective it just made more sense to shut-in the gas than to destroy the resource. That's probably a stronger word. I mean you get into these hearings people say all kinds of things, but you didn't want to sterilize the resource.

PMB: Well, your comment about it taking more - and I don't know whether this is true or not, I suspect it is - takes more gas to build steam to pressurize those reservoirs than the gas that you actually got out.

DUNCAN: That's right, yeah.

PMB: A very interesting point. But of course prior to that, I think it was in the '80s, Dome Petroleum had received approval to withdraw gas. They would have done exactly the same thing.

DUNCAN: Petro-Can did, too. We were actually producing gas up in that area until we realized -- well, actually we sold those properties, and it was only later after we'd sold them that we realized what Gulf was doing. So we were producing gas there in the '80s. I'm trying to think of when we sold the properties. Probably around 1990, and then about a decade later there was the gas-over-bitumen hearings.

PMB: There's a technology that's developed really fairly recently, I think, called Cold Heavy Oil Production with Sand, CHOPS. Have you had much experience with that?

DUNCAN: No, I don't like to produce as much sand as they do. And SAGD is so efficient compared to others. If you look at our production from Mackay and Firebag, Mackay is at the low

end and Firebag wells are really at the high end, and a lot of our wells will produce 1800, 2000 cubic metres per day of total fluids, with about a 70 percent water cut from the steam. So we're producing at really, really high rates.

PMB: So the CHOPS production is really small potatoes?

DUNCAN: Really, for us, it would be very small potatoes, yeah.

PMB: I'm trying to zero in on your oil sands experience. Other technologies, and I'm thinking of toe-to-heel --

DUNCAN: Tie? Toe-to-heal air injection.

PMB: Yeah, air injection. So that technology; do you have any experience with it?

DUNCAN: No.

PMB: What about the other forms of steam flood or fireflood?

DUNCAN: Well, we probably have done as many firefloods as most people would have.

PMB: What's your experience with that?

DUNCAN: Been a lot more unsuccessful firefloods than successful if you get fire breakthrough to the wells.

We had another combustion project that we did up in Shekilie, up in northeastern British Columbia. And it was a reef, it was a light oil, and we were actually trying to do firefloods in light oils. The trick to a fireflood is that you have to have a continuous spectrum of carbons. So light hydrocarbons have only two or three carbon atoms in the hydrocarbon, and the bitumens might have 40 or 50 carbons. You have to have a continuous spectrum. So you have your C50s which are your bitumens, you have your C5s which are your gasolines; if you're missing the C20s then the fireflood will stall on you.

There's two fellows up at the University of Calgary, Dr. Moore and Dr. Meahta, who are experts in fireflood, and if you want to talk about firefloods, those are the guys to talk to.

PMB: What are their names?

DUNCAN: Dr. Gordon Moore, and Dr. Raj Meahta.

PMB: Yeah, I think I've tried to reach him. After this interview I'm going to write down some names of people that you might like to recommend.

Other enhanced oil recovery projects; now I remember in the '80s there were EOR projects that you did mention. I remember there used to be a CO2 flood, there were some kinds of solvent floods, there were a number of different things that were used in the past. Were you involved in any of those?

DUNCAN: Yes I was, and a lot of that's covered in the World Oil Handbook. Carbon dioxide is a really interesting fluid. It has an affinity for oil, it turns to a liquid phase at about 1000 psi (pounds per square inch), at 7000 kPa (kilopascals) it becomes almost the density of water, at about 10,000 kPa, has one-tenth the viscosity of water, and it will absorb into the oil and provide energy to push that oil towards the producers. The only problem with CO2 is it's corrosive. If you have carbon dioxide and water together you get carbonic acid, which is corrosive. But CO2, I think, has a lot of potential.

PMB: So the efforts, for example, to take carbon dioxide from industrial facilities and inject it - sequestration? Carbon sequestration?

DUNCAN: Carbon Capture and Sequestration, CCS, yes.

PMB: And yet here's an example where it actually might be used to contribute to the production of oil sand or bitumen.

DUNCAN: Not oil sands no, it's only good for light oil. We generate CO2 in the oil sands from our steam generators, and hopefully someday there will be a pipeline that'll go down towards the south where we can inject CO2 into light oilfields.

PMB: Why won't it work with the oil sands?

DUNCAN: There's not enough mobility to get the CO2 in contact with the oil sands, and the affinity of the CO2 to be absorbed in the oil sands is really tough.

PMB: Now a lot of companies right now, and in the past, have tried injecting different diluents and different hydrocarbons to try to get the bitumen to flow better. What's your experience with that, and what's your perception of the future of those concept projects?

DUNCAN: We are actually experimenting with a project right now; it's called NSOLVE. But we're doing an experiment on that right now, close to the Dover facility, in fact. So we're trying many different things.

PMB: Actually, I've spoken to somebody at your company about that, and I'm trying to remember exactly what he said. It involves injecting what hydrocarbon?

DUNCAN: Probably be a diluents like naphtha; something we could produce at our upgraders, so it would be a naphtha kind of material.

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PMB: So ideally, then, what you would do is upgrade, and then you would take the diluents, the naphtha, and pipe it back or truck it back, and then inject it, and then that would stimulate production?

DUNCAN: That's right, yeah.

PMB: Any idea how successful it's been?

DUNCAN: We don't know yet, no. That's why it's a pilot.

PMB: And I think that's covered almost everything. Is there anything else you want to say? It's, right now it's up to you. You can say what you like.

DUNCAN: A couple things, just to continue with my career. Suncor and Petro-Canada merged in 2009, and I decided to take a little sabbatical. I early retired, and went to work for another company.

PMB: What company was that?

DUNCAN: Oh I'd rather not say right now, but I went to work for another company.

PMB: This sounds like a pretty lousy approach to retirement, if you don't mind my saying so.

DUNCAN: Yeah, I retired at the end of February. I was down in St. John's when I retired, and retired at the end of February and started my new job on March 1st. So I think I was retired for 16 hours. I didn't play very much golf at the end of February.

Anyway, I went to work for this smaller company, and got to work on the Bakken, North Dakota, Montana. And some other resource plays like in the Montneys and whatever, and it was an interesting experience. But Suncor asked me to come back five times in that two-year period, and so I finally said okay, I'll come back, and so I'm back at Suncor after my two-year sabbatical, and having fun.

PMB: Now the concept, and I don't a hundred percent get this, and perhaps you can help me out. The concept of a resource play. What I've heard is that somebody told me fairly recently a lot of the oil sands companies are developing the oil sands like a resource play. The term "resource play" doesn't make a lot of sense to me. Explain that to me.

DUNCAN: Not as a development of the oil sands.

PMB: What does "resource play" mean?

DUNCAN: Okay, a resource play is a shale. We'll go back a long time. Alberta was underwater for most of its history, and so we had a lot of shales and sediments that were laid down. And then about 80 million years ago most of the sediment that came into the basin came from the Shield, the

Canadian Shield to the northeast. Alberta was underwater and it was closer to the equator, so it was hot and so you had all these carbonates being built up. You had the Devonian carbonates and whatever. And then about 80 million years ago the Rocky Mountains overran the North American Plate; raised up the Rocky Mountains and pushed the entire province of Alberta down to the southwest. So the entire province dips towards the southwest.

(Indiscernible) the sediments came from the Rocky Mountains, and they built up to quite a depth, and a lot of pressure. And so we had all these shales down there, and it was hot, it was under a lot of pressure, you had all this algae and everything that had been into the formation, into the shales, and it became hydrocarbon.

PMB: Now just before you leave that, my understanding is the Pacific Plate ran under the North American Plate?

DUNCAN: No, it ran over top.

PMB: It ran over the top? Oh really.

DUNCAN: It pushed Alberta down and raised the Rocky Mountains. The Rocky Mountains used to be almost 6000 metres high. They were like a high plateau in Tibet, and then they've eroded down. And so all this rock was sitting on top of all this shale and generating hydrocarbon. And because the province was dipping, the hydrocarbon started to migrate up towards the northeast, and there was this big ocean there, and so there was all this oil that spilled into the ocean, and the stuff that didn't spill in evaporated, and the oil sands actually probably originated as oil from the Duvernay Shales, hundreds of kilometres away, but then migrated up, and then the light ends evaporated, then what was left was this heavy bitumen product.

But that hydrocarbon that originated in the Duvernay Shales or the Montneys is still there. There's still a lot of hydrocarbon there. And so a resource play in Alberta would be you would drill a long horizontal well into a Duvernay Shale or a Montney Shale, and then you put hydraulic fracturing techniques in. Hydraulic fracturing is where you break the rock with water pressure, and follow that with a sand, or a bauxite, or a ceramic to hold that fracture open. So typically if you're using Bakken as an example, you would drill a two-mile long well, and you'd put in 24 fracs, large fracs, and then the oil would flow through the fractures and into the wellbore and then be pumped up to surface. If it's gas it would be --

PMB: So basically a resource play is just saying look, there's a big hung of sediment here, or it could be sandstone which is rich in hydrocarbons, so we're going to --

DUNCAN: Total organic carbon (indiscernible).

PMB: -- we're going to frack it, and we're going to pull it out. That's all that means?

DUNCAN: Yeah, except the sand body that we're talking about is really, really tight. Sidewalk cement has more permeability than the shales that we're talking about in the Montney.

PMB: Because what I've heard is that you tend to get gas out of shale, but oil is tight oil, it comes not out of shale but out of sandstones and other kinds of rock, more commonly.

DUNCAN: Right. And the Bakken in North Dakota and Montana is unusual. A lot of shales produce gas, but the Bakken in North Dakota, Montana produces oil, light oil.

PMB: Right. And is it a shale or is it a sandstone mix?

DUNCAN: There's not a lot of difference between shales and sandstones, it's only grain-size. So if it's a sandstone, you call it a sand. If the grain size is large, you call it a sandstone, and if the grain sizes are really, really small, like clay-size material, you call it a shale; it could be the same mineralogy, but the only difference is the grain size.

PMB: What else do you want to say? Anything to add to this? It's been a very important interview.

DUNCAN: Well, I'm happy to be back at Suncor, and I'm working on some really exciting projects. I'm in a technology development sort of world. Suncor has a lot of potential. We have a huge land base, and we are planning to increase our in situ production significantly. The two big projects we have right now are Firebag, with about 150,000 barrels a day production, and Mackay at about 30. When I looked at the board this morning we were making 190,000 barrels per day of bitumen production from SAGD wells, in situ, and we plan to increase that to about 450,000 over the next decade.

So we have one project on the books right now called Meadow Creek, and we're starting to do the engineering for that. So we'll be looking two years of engineering, two years of construction, so four or five years down the road we'll have first production from Meadow. Meadow Creek is down to the south, south of Stony Mountain. Then we have Lewis which is towards Mackay, and then we're looking at a Mackay River expansion.

PMB: What are the most important recent developments in technology? Now, we can talk about SAGD, obviously, that was transformational, but within that, because I know that in order to do SAGD, for example, you had to be able to drill down, drill two horizontal wells, and keep them close together, and so that required the development of new kinds of technology. What are the most important technologies that are being developed today, in your view?

DUNCAN: Drilling continues to improve. We're going to have to address certain things like blowdown. All the projects, as you get to around ten years down the road you start to have to go to blowdown mode, and that's where they produced the last couple years by putting in a non-condensable gas, like a methane or something like that, to capture the heat that's in the rock. Of all the steam that we've put in, 99 percent of it is in the rock, not in the fluids, because the rock has a much higher specific heat, and so we're going to try and capture that energy. So I think the next two

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years we're going to see a lot of development in blowdown, in taking these projects to their final two years of life.

PMB: Capture that energy. This doesn't (indiscernible) with me. I don't understand it. How would you capture that -- what would you do with it? You would just use the existing heat that's in the rock to produce the last couple of years of --

DUNCAN: That's right. So if the rock is at 240 degrees Celsius, so it has all this heat that's captured in the rock, and if we just put gas into this instead of steam - it costs money to generate steam - but if we were to put in a gas of some sort --

PMB: Oh so not natural gas?

DUNCAN: Well, it could be. And maybe it could be CO2. If you could put CO2 in as a gas you have to worry about corrosion as I've mentioned earlier, but if you could put that in, and actually capture the heat and take this hot gas, this hot CO2 or whatever it is, towards the boundaries of the steam chamber you could continue to produce lots of bitumen without generating steam. So I see that as being a very important --

PMB: That would be a huge cost-saving opportunity.

DUNCAN: It's an opportunity, yeah. Maybe get rid of some CO2 as well.

PMB: Right. Okay, anything else?

DUNCAN: I guess what I do now is I'm training and mentoring. I spent a lot of time putting courses together for our young engineers because we have a lot of people who are a lot younger than me at this company that need training, so that's what I'm doing now is training and mentoring.

PMB: Okay. I think that just about wraps it up. Thank you very much.

[END OF RECORDING]