MANITOBA CLEAN ENVIRONMENT COMMISSION

HEARING

VIVIAN SILICA SAND EXTRACTION PROJECT

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Transcript of Proceedings
Held at Mennonite Heritage Village
Steinbach, Manitoba
TUESDAY, MARCH 7, 2023
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TUESDAY, MARCH 7, 2023

UPON COMMENCING AT 09:30 A.M.

THE CHAIRMAN: Well, notwithstanding the time, this is the Chair speaking. The hush in the room says it's time to begin. So, let's begin with a little time management. I always like to be transparent when I'm seen talking to Sander Duncanson. So, I was asking whether the proponent would like to go first or last in questions, and they've indicated they would like to go last. And they estimate they need about an hour and a half. So, let me work my way down the list and see what others are expecting and then I'll tell you what I've potentially allotted. Dennis, how much time do you anticipate you'll need? I can let you know that the proponents are -- sorry, Dr. Hartmut has indicated he'll have about an hour and a half presentation. So, that takes us down to 4 1/2 hours. The proponent has an hour and a half. We're down to three hours. Can start dividing. Let me ask you a different question. Dennis, do you have questions?

MR. LENEVUE: (inaudible).

THE CHAIRMAN: Yes. No, will you

have questions? Not now, but will you?

MR. LENEVUE: Yes.

THE CHAIRMAN: Okay. So, you have 30 minutes. Springfield (ph), RM (ph) Springfield, are you -- will you be asking any questions?

RM SPRINGFIELD: (No verbal response).

THE CHAIRMAN: Okay. Thank you. Our Line in the Sand?

OUR LINE IN THE SAND: No questions for Our Line in the Sand.

THE CHAIRMAN: MSSAC?

MSSAC: Yes, we do have questions.

THE CHAIRMAN: Okay. And Manitoba Eco-Network?

MANITOBA ECO-NETWORK: We do have (inaudible).

THE CHAIRMAN: That's probably going to work. Okay. So, I think we have a rough timeframe here. Yes, sir?

UNIDENTIFIED MALE: (inaudible).

THE CHAIRMAN: Okay. I -- I think that will work given those that have chosen to pass. So, let's -- let's -- let's start with -- I'll tell you what, we'll start everyone with a half hour. We'll let the proponent go and if there's anything that you feel hasn't been extracted, I'm happy to cycle back if we have time, and the public gives us time because they also need the opportunity to ask questions. Mr. Secretary, can we swear in please, or affirm whichever he's chosen?

MR. CROCKER: Secretary. Can you state your name and spell it for the record, please?

DR. HOLLAENDER: Hartmut Hollaender, H-O-L-L-A-E-N-D-E-R.

MR. CROCKER: Hartmut, do you solemnly affirm that the evidence to be given by you shall be the truth, the whole truth, and nothing but the truth?

DR. HOLLAENDER: Yes, I do.

MR. CROCKER: Secretary. Thank you.

THE CHAIRMAN: Chair. Please, proceed.

DR. HOLLAENDER: Good morning, everyone. I'd like to present our findings from the evaluation of the reports today. Before I do that, I'd like to introduce both of us who evaluated the work. So, I'm a registered engineer here in Manitoba with more -- about 20 years of experience across Canada and internationally, mainly internationally. Worked three years for the regulatory body in Germany, Northern Germany, for the State Authority for Mining Energy, Geology, where did constantly state-of-the-art science and technology reviews for nuclear waste repositories, where I was an authorized expert. And I also looked at state-of-the-art -- and not to confuse us here, let's call it from now on, industry standard, where I checked numerical models for environmental proposals similar to this process. I change then 2013 to Canada. Became -- went to

U of M, was at the Department of Civil Engineering, did the Groundwater Engineering group there. Started as a research assistant, became an associate professor. In the end, I was full professor. In 2020, I became Director of PorousTec Limited, which we did this review with. And 22, I went back to Germany, where I'm CEO of the largest hydrogeology consulting group in Northern Germany. My colleague, Dr. Alan Woodbury, is a professional engineer in Manitoba and British Columbia. He's -- was the professor in groundwater engineering before I came. He's now a lifelong -- lifetime professor emeritus for that position. He has more than 40 years experience in Canada and also internationally. Has done considerable work here in Manitoba, especially on the formation, which we're looking at. And he provided consultation to more than 16 governments and organizations across North America, including also nuclear waste problems.

THE CHAIRMAN: Chair. Hartmut, can I get you to pull the microphone just a little closer to you, please? That's great.

DR. HOLLAENDER: Does this work better? Okay, great. So, to walk you through, I have four blocks today. We wanted to start with the hydrological investigations. We talk about then the site conceptual model, then they bought the numerical groundwater modelling, which was undertaken, and finally the geochemistry. So, what are the overarching concerns in such an endeavour? So, in the end, we talk here about sustainable -- sustainable amount of water, which can be developed or used from an aquifer. And certainly, we know that also there are some user to the mixing of water. So, we want to avoid dewatering from aquifers. We want to avoid mining of groundwater. We don't want to see excessive drawdowns because this might interfere with other wells. We want to check the groundwater quality. So, trying not to -- and use water with poor quality into water supply wells. Subsidence we have discussed yesterday, will not be discussed today. And certainly, preventing cross contamination between aquifers and that is something certainly what we want talk today. And something which was also discussed yesterday, was already the ceiling of earth and the aquifer from surface contamination. There is nothing in this presentation, but there might still arise questions, as yesterday (inaudible) moved some of the questions probably to this session. Looking at the area of interest, we have an area here, which goes from the Sandilands area, (inaudible), this darker blue area, towards the Red River. We have about 80 kilometres. The area of interest in the end is in the centre, and we have about 40 kilometers wide. So, that's a total area about 3200 square metre. So, the key features in the systems are the recharge area up down here. Then we have here, the -- the start of the sandstone formation. Then here, the -- the start of the shale formation, and the carbonate formation, and then finally, certainly the Red River. So -- when we want to study such a problem, which kind of data do we need? So, the first ones are landscape features, boundaries or river creeks, lakes, and either we need to define the recharge areas. This is mainly here, the Sandilands and the Birdshill. Certainly, there's also some research in this -- the other area. Then geology data were taken from the GWDrill database, and some additional boreholes were created. For questions to there, which formations need to be considered? We will talk about that through, and also the layer thickness was done. So, this is all part of the conceptual model then. (inaudible) properties of the formations are required. Key parameters, which we will focus on today, are the hydraulic conductivity and the storativity. And then we will need some regional groundwater table maps with specific dates. So, generally we look for steady state conditions for a certain period. Let's say, maybe the last ten years or the periods when pumping was at a certain state. Let me say, as an example, minimal. And certainly, if pumping is in critical because there are other users. So, we need the wells' location and pumping rates. Key questions today will be on the hydraulic properties of the formation. So, let's start with the content. So, the first slide on hydrogeological investigations where the key question became is the investigation program adequate for such a -- such an investigation. So, we have a -- an area of about 3200 square kilometres for sure, basin scale. That means you do a regional model. That means we don't get any really detailed information on the site. And then there was this assumption, this large assumptions, or questions always, is such a formation, let me say, is the sandstone formation homogeneous or not. Homogeneous means that the properties of these formations are constant in space. We have two -- two different formations. So, one are the aquifers. So, the sandstone and the -- the -- the carbonate aquifers. And here we are interested in the hydraulic properties into horizontal direction. And we have the aquitard, which would be the same formation where we are interested in the hydraulic properties in the vertical direction. Based on experience and literature reviews, and there are plenty of literature out, also published in the name of Dr. Woodbury, these aquifers are not homogeneous. The testing which was done was one aquifer test, which is kind of the industry standard to derive regional data. So, if you assume which kind of data you can arrive, you can get more or less data from one on 2 kilometres around the borehole. And that would give you more or less this idea. There were also done 5 slug tests. There are only local data impact areas about 2 metres around the borehole. Depends a bit how good the formation is, and these are generally not suitable for regional investigations. So, one aquifer test, what does this mean? In our eyes, that means that this -- that the assumption is that the aquifer of the project area homogeneous. If the proponent would not come up with this solution, they would have done more -- with more -- have done more of these investigations. When you investigate the impact area, the drawdown area of this area of the pump test, then you come up to about 3 square -- square kilometre of impacted area. And I just mentioned in the beginning that the study area is about 3200 kilometres. So, we see that only a very small fraction of the aquifer, which was modelled was investigated directly by this pump test. So, in our eyes, it cannot be expected -- also, based on these results, that the area is completely homogeneous, and that is one of the key questions in terms of -- also of these evaluations. So, we have shown, especially using this extensive study by Kennedy and Woodbury, 2002, that there's -- that there's a very heterogeneous aquifer with different properties throughout the whole study area. So, the next question is, was the pump test adequately performed and evaluated? So, we have a pump test, which was a step -- step test followed by a constant rate test. You can see -- see nicely this one, this red line here, which you see here, that is the pumping rate. And you see here, the changes, Step 1 was about 412 U.S. gallons per minute, then it went down to 402 gallons per minute. Then you see it went up to 425 gallons per minute, and then afterward it became constant at 372 gallons per minute. The (inaudible) test, which you see here, this length is three days. So, every of these blocks, which you see is a 12 hour period. So, that what you see here is, that this time, which where the pumping test was variable, is about 9 to 10 hours. So, the length of three days, is this adequate? Generally, what you have to do in a pump test, an aquifer test, to -- to fully get the data, you should wait until all the observation belts show a steady state drawdown. That was not carried out. So, the ones which are very near to the well, they show a constant drawdown, but the one which were further away had still drawdown at the end of the three days. After that, this system was observed for another four days. That means you start shut off the pumps. That's what you see here at this point. And when you shut off the pumps, the water goes back into this. The pressure release, and then you will see that the water table rises again, and that's called recovery. So, all after this was carried out, the data were looked at, and was assumed. And we had the discussion already on this, so that all the methods which were used, they used a couple of methods, were all for confined conditions. What does this mean, confined conditions? That means that the shale formation above the sandstone aquifer, which was pumped, had -- should have no drawdown. As soon as you have a drawdown, this would be not a fully confined unit. So, you assume that this formation is impermeable. No? If you look at the data in Figures 3-2 or 3-3, they show a drawdown of the carbonate aquifer. As an example, observation were 95-8 VW2, drawdown of 1.5 metre. That is for sure larger than a very small drawdown. And in our understanding, the shale aquitard appears to be leaky. The question now is to arrive, why was this data, which was available, not used to understand and to get an estimate on the hydraulic properties on the Winnipeg Shale? The data was available, they were not evaluated in this meaning. And the meaning of this being leaky, is this shale only partial available or is it maybe damaged by -- by -- by boreholes, which were crossing through both aquifers? And how was this introduced afterwards into the numerical model, and we will talk about that later. The Hydrological Assessment Final Report, I used now, the abbreviation HAFR on Page 32, said this information suggests that the Winnipeg Shale is an effective barrier to interact between two aquifers at this location. And that is something which we don't follow at this point. So, looking at the outcomes, let's see these -- and I see there's a mistake inside. There's not a really big shale. There's so many big sandstone. I apologize for this mistake. So, I put together the data for the Winnipeg sandstone formation here. The pump test showed that the K value hydraulic conductivity was about 1.1×10^{-4} metres per second. The numerical model reduces value by more than half in order of magnitude. So, 3.2×10^{-5} metres per second. It was altered again in the transient condition model when they modelled the pumping test. The data were not really clear, so I did not put them here up. And if you compare this with the mean value by Kennedy and Woodbury, as I said, this is a zone approach. So, there's a standard deviation of (inaudible) log units. Then it comes to 5.7×10^{-5} metres per second. And certainly, this kind of values, although there seem to be very small, the differences they have for large difference on this large scale, because please remember that the aquifers was used to be homogeneous and over a stretch of 80 kilometres. So, which question our eyes have not been answered? There were no observation of the vertical hydraulic properties of the shale as I showed before. That their data were available but was not evaluated. And more critical, what will happen to the aquifers, the aquitard and their material properties after the mining activities? So -- so, when you create a cavity, then this cavity certainly, there's some sludged area, which have different properties. There will be a cavity which has infinity and a very large and unlimited hydraulic conductivity. So, how to implement this kind of information in a regional model? And certainly, will water of poor quality be drawn into zones with a currently good quality? That is something we discussed that already a couple of times in regards to the -- to the failure of the -- the caprock. I want to move now to the conceptual model. And the -- the question which we well -- which I would like to start is to introduce to this topic, which informations are critical in a conceptual model? So, what we need to do generally when we -- we do study something like this, we use boreholes, we create -- create then layer 3D system. Now, that's what also was done. I will show that later on and I will walk you through all the steps. The definition of the model area, the description of the boundaries, that is in the end. We need the information on regional flow systems to connect this to the -- to the model area, the choice of the numerical code, and then the initial choice of layer parameterization based on the data, which are available literature review, pump test, and the stratigraphy. And certainly then also all the other things too for layer properties. So, this one here is a picture from -- from the draft at that time. You see here, down here, formation in red, which is the Precambrian shield. Then the yellow would be the sandstone. There's a very small fine line. You see this in this cross section, which would be the shale because that's not very thick. Then we have here, the carbonate formation at the grey, are all the quaternary sediments. Everything what you see here, it is required to have the key formations, the carbonate aquifers, the Winnipeg Shales, the Winnipeg Sandstone, all of them included. Useful are certainly also the quaternary sediments if you want to discuss any exchange at the -- at the surface with -- with rivers. Something which is additional or better to say have no impact on the result is a modelling of the Precambrian bedrock and it was also not discussed yet, although it is included in the model. So, now we start with coming up or bringing in such a model now to life and that is in the end you try to connect this to -- to the -- to the regional (inaudible). And what we need -- we need to create this kind of map. And the industry standard is that we create this for a specific date. That would be the perfect version. The alternative is that you do this for a short period. No? So, what was done in this report is that all data which were available were filled out, and they were looking for a mean value. So, it could be that data from 1980 were plotted together with data from 2020, and that is more one generation in between. So, the risk which works with this that if any of these wells, observation wells, is working in a different way over those 40 years, then you would mix up everything in one -- one map, and you would come up to a -- yeah, a difficult conclusion. So, that is something which is definitely not advised. Now, let's look at whether that would -- they -- what was done is good. So, we have here, let me say, at this Winnipeg next to the Red River, we have the heads. It's a bit difficult to see the contour lines, but if I did this kind of right, then this would be the key gradients at that time. So, you see here, based on that, it goes always to the Red River. If you look at the data for Betcher, you see the data here also, you can put lines over this -- this direction, this to -- you can transfer this into the model. And what we will see that the directional flow based on this analysis, and from Betcher's analysis don't match. One of the key things is, what we see here in the other picture from Betcher is that here to the Red River that is part of the model area, we have here total dissolved solids concentration of 1, 2, 10 and 50 milligrams per litre. So, we are here in a range where we have somewhere between 10 and 50, and just maybe let's call it up to 30 grams per litre. This means that the density changes the measured head that was most likely not added into the result in this calculation because else this turn or this direction would have changed into the direction was -- was -- was indicated by Betcher. Wells are always of key interest to the water supply. And we already showed that this -- that the Winnipeg Shale is leaky. And so one of the reasons why it could be leaky is that they are about 500 wells with just screened over both aquifers in this region published in the PhD thesis by Kennedy. It is not clear, if any, and if there are any, which wells in the modelling domain was screened in the initial model over the both aquifers. That is not presented. And it is also not clear, which -- when the use of provincial database of wells -- observation wells. And we know that in the province unfortunately, this is not in the best condition. So, there are some actual data inside. There are uncertainties in the data, especially about -- also about the position because they started off, but they didn't use the UTM coordinates, but in the end does the quarter section. So, there are a lot of unknowns inside and how they -- they were worked on in this regard. The numerical model was done with FEFLOW, which is an adequate model to solve such problems. And so, that was good. And we really like model, certainly because -- yeah. This is an industry standard model, and this is worldwide used. The report mentioned then regarding the flow of salt that even the smaller volume of water would drastically affect locally quality over time. So they talk about salinity in this case. And salinity can only be modelled correctly if you do the density driven flow, especially with the concentration up to 30 grams per litre, which is near to the Red River in the sandstone formation. However, the model was carried out as a single phase simulation and thus, cannot reflect the brackish water in this study area. For the transient simulation, the question which was open, which data points were available at time t = 0, what are -- what is more or less exactly the initial condition? That is something which seems to be maybe a bit academic, but often, that is the point where you hang in your model and when everything starts, and such would be an important information. So, now we have the key point, which is the -- the groundwater model itself. So, now with all this data, which we have the investigated data onto conceptual model, this model would be created. And so, to introduce this to everyone, what is such a model -- groundwater model? So, a model is nothing else then a simplified schematic -- schematic representation of the part of, this case, the hydrogeological system. Some -- some sound here? Thanks. And so, this system, which we defined there, get some selective properties, which are the hydraulic. Can you make ---

THE CHAIRMAN: Chair. Cal (ph), are you able to kill the feedback?

DR. HOLLAENDER: Does this work better?

CAL: Testing.

DR. HOLLAENDER: It's always nicer to look into the audience than just to the Chair. Sorry, Chair. Yeah. So, let me -- let me continue. So, we talked about, what is the groundwater model? And it is a simplified schematic representation, which is part of the hydrogeological system. And so, we add in this to -- to make this work, select the properties, and the processes, which are going on in the groundwater body. And what do we do with this? It's primarily used to do predictions, hydrogeologic predictions, and to understand certain hydrogeological processes, which are going on. We can also use it for other uses. So, we can use to interpret and to synthesize any observed data. We can calculate data for non-observed points. So, let me say, when you want to look at data or want to build observation wells, and we know that wells are expensive, and we can optimize the locations for them, we can observe, and that's what is always measured to the hydraulic cap, but we can never measure the flux, that is very complicated only inside the borehole. And the model has the ability to look at how much water flows about certain cross sections. We can extrapolate, predict future states, also think about climate change in this case. And when we have different versions of solutions, engineering solutions, this helps us also to pick the best solution because we can see and forecast the -- the -- yeah, the outcome of any method, engineering method, which would apply. The objective of this report was to evaluate the potential impact for the -- for this -- by this project. And in terms of groundwater quantity, that means how much water is available inside the aquifer, the groundwater quality, and the -- the users of the surface and groundwater in this area, which is missing in here, is a clear definition of what are the evaluation criteria. So, we can certainly discuss this and we can analyze this, but it's always required that there's some evaluation criteria so that everyone knows in the end what we are indicating it, and the subside and potential pathways opening up through the limestone to the -- to the aquifer. So, when such a model is built, and you have seen this schematic of this model over the earlier and this presentation, then you start build the grid on that. (inaudible) is here. And then you put the parameters in which you come up with in the conceptual model. And then you come to the key problem, the calibration. Calibration makes this numerical model, this schematic -- sorry. Thanks. Makes this schematic in a way that you can represent the flow, the pattern, the flow pattern, and the data inside that what measures for what happens in the nature. So, what we do in calibration then, we adjust the parameters by -- by varying them in certain reasonable bounds. And this was done in this case, in two cases. One is the steady state where the groundwater measured was based on this mixed data, return dates, which I presented before. And then afterwards, the second calibration was a transient calibration, where the groundwater data were optimised based on this aquifer test. So, the total length of the seven days, which were presented before. Generally, this is followed then in this calibration process by validation. So, in this validation you would use data from another period, different time period, to test with the calibrated data again, to check whether your model is adequate. Also representing this version, this was not carried out. Finally, it comes to sensitivity analysis where you identify uncertainties in your parameters, and these uncertainties you try to cover by variation of your model parameters. The key problem in this calibration process is in our eyes, there is of an oversimplified model. So, there's a keyword for this, it's called equifinality. Think about a very simple system where we have a certain area, recharge area, let me say, 200 millimetre per year recharge, we have two aquifers, and (inaudible) we might fit a good calibration with two different hydraulic conductivities, in this case, 8×10^{-5} metres per second, or the second one is 2×10^{-4}. And this could look like this, that we have this observed data, we plot them here, the observed data against the simulated data, and they should follow this one to one. So, what we would see is now that if the system is underrepresented by parameters, we can have a large number of solutions. And one of the examples would be, we just take half of the recharge values, and we can just refit these two hydraulic conductivities, and we would get this exactly same fit. No? This happens only because in the end, our system is underrepresented and oversimplified. So, what can we do to solve this? The only solution for this is adding more data into the system, so that we can fix one of these aquifers, or one of these parameters which we see here, 1-2-3 in this case. Very simple system, as I said. And then we can get rid of this problem with equifinality. What does this mean for this project? Especially considering that the aquifers, both aquifers, are homogeneous and have one systems. So, we assume that this or we -- we assume that this system are non- homogeneous. That means in this case, are not represented. So, let's now move to the data from the report. You see here again, the observed groundwater evaluation. Here is the simulated. And here, you see the dots representing different formations and these are always the dots from this -- from the model. So, the perfect fit would be this one to one line, which you see here in black. And what we will see is here, we can put here in our lines through. This one here is just the one to one line to make this a bit more visible on the screen. I put a trend line through this system here. And then what we see -- we see systematic overestimation, which starts at 275 metres below. And you see this block, this delta value, this bias here, increases. This is also given by, in the presentation last week presented by Aecom, they came up here just a screenshot from their presentation, is that the mean error, which is just -- you just add up and subtract differences between the data point and the line. There should be exactly zero in a good -- very good model. There are 3 bmetres. And 3 metres means that we have a consistent overestimation of that what was -- was modelled compared to that was observed. So, what does this mean in the follow up model? Calibration is not to industry standard because it has a bias inside. When a model is not calibrated, it cannot represent the natural behaviour. So, it cannot represent the groundwater flow correctly. And that means also, that this model cannot use as a predictive tool at this point. Moving on to the transient part, you see the drawdown -- see of the aquifers. So, the observed data. Sorry, this is a bit small, but I took it directly from the -- from the report. You see here, this line, it says, full lines are the -- the ones which were observed. We see here, the -- the dashed lines, which are the model. And you see that there's always a certain difference. And this difference means that they drawdown in carbonate aquifers often -- are often lower than observed. So, in the simulated version, is especially based new to the behaviour of the Winnipeg

Shale and has impact on the hydraulic conductivity of that. And the initial drawdown, that is the one which you see here, you see here, that goes very differently to that what was observed. It does not follow the observed data. So, there's also some issue with storativity. No? So, both values highlight in the end that we have at least two additional problems here. That the Winnipeg Shale needs a recalibration, and also that the storativity inside the models need to recalibration. So, if you put this a bit longer together, we had hydraulic conductivity, storativity, and recharge rate. They were modified during the calibration process, and they were also done in the second time in the transient model. That is something which is generally not a state-of-the-art. That's what we are not doing. So, generally we calibrate the hydraulic conductivity, and the recharge rate in the -- in -- in the steady state model keeps in constant, and go then inside this -- go on and then in the transient calibration with storativity values. If we are required to change this parameter, that means that we have one of these issues, which I presented before that, we often generally would have this equifinality problem. Then we would -- should go back into the steady state model with the updated K values and see whether that makes a better fit. So, it is not adequate just to change in a transient calibration of the recalibrated K and recharge values. The statistics for the actual fit was not given. So, we have seen a fit with some short statistical methods. In this case, I just presented the mean error for the steady states. There were no statistics on the transient version, and we see sub-optimal fits. So, distance is greater, 300 metres away from the pumping well. They generally show higher observed drawdown than simulated, and the reverse is true for distances under 300 metres. The calibrated values were not compared and discussed to literature values. And there was a constant anisotropy value, which was assumed 10:1, which is the kind of the standard in the beginning, but it was not evaluated in the model whether maybe another anisotropic method or a ratio would -- would fit better. And I don't talk about -- too much about results here, because when someone is not happy with the calibration then it doesn't make sense. As I said, it cannot represent a natural system and then it doesn't make too much sense to discuss about what could happen. So, I will say shortly on the scenario. So, the scenarios which were used were kind of changing certain parameters. We will come to that in the next slide on sensitivity, but key problems like that was also discussed last week and yesterday. The failure of the Winnipeg Shale was not considered in the report. And I put that in the new version that was considered. However, that came in just yesterday or last week, and that's something which I could not familiar with you. The sensitivity analysis is used to look at parameter uncertainty. We know that in this big range of data which we have -- we have different data quality, we have data from field tests, we have literature values, and we have drilling reports, which have different ages. You can assume that not all of this data are -- have the same quality. So, certainly we assume that the data which we today is days with more modern technique, have a lower uncertainty. Something which you do yourself, the pump test, which is supervised by a professional engineer, professional geoscientist, have a higher quality than maybe data which were picked up in the 1960s. So, that is something which we -- which we should evaluate and we should put this into perspective when we do a sensitivity analysis. The sensitivity analysis itself was rather limited. Now, we have here, a screenshot from last week's, where we see that recharge was changed, the carbonate rolling connectivity, the shale of hydraulic conductivity of the sensors, connectivity. That means in the end we have changed four different parameters. That is definitely a limited version and they were either always by a certain amount. You see this here a plus minus 20 percent, dividing and multiplying by 10 percent. The result from this was that the drawdown in the carbon and the Winnipeg sandstones are considered to be moderately sensitive. This is, again, quoting from -- from the report to changes in (inaudible) Winnipeg Sandstone. This command reinforces our idea, the conclusion that the hydraulic parameters, which were used in the numerical model, needs to be re-examined because something which is moderately sensitive has a sensitivity, and only very good calibration would be able to match this, and then would be able to use -- to be used as a predictive tool. What was not considered in any of the sensitivity analysis, the boundary conditions besides retract certainly, that's what I just showed. Were -- they were excluded. They were not used. The last part, which we want to talk today, I want to talk today, is the geochemistry. We have certain reviews related to acid-mine drainage. So, acid-mine drainage did not include the flow, the pH, and the redox condition. So, flow is something which you would be very difficult to do in this case. At this moment, what the data they used different waters, which are mixed and stirred. If you want to add flow, then you have to have a reactive transport model, and a reactive transport model was not carried out. We have different pH and redox conditions. We talked about the suboxic conditions already last week, within the aquifer. And they could lead to, if they changed these conditions to leaching of trace metals into the aquifer. We also had last week, the example of Bru 121-1 in the depths of 36.57 to 37 metres, which is a Winnipeg Shale, where we saw a lot of trace metals. And this could have -- they have the potential of reaching to -- to the water and then reducing the water quality. So, this leaching of surface water into the groundwater was also not considered and was not compared to guidelines. And the potential pathways for such surface waters would be the sinkholes, which we also shortly mentioned last week of the upper carbonate. You will find them near Beausejour and potentially, if they are brownfields, which I didn't look too much into whether they are brownfields and what could be the impact of -- of brownfields on water quality. So, one more thing which we heard last week, and this is again a screenshot from last week from one of the presentations, the estimated tonnage of carbonate and shale waste drop over five years is about 3,500 tonnes. This is an assumption, which is important to how many samples have to be taken. And I just assumed that we have one percent waste rock. That's most likely a bit too small, but it's -- it's used for easy calculations. So, the expected annual production of 1.36 million cubic metre of material, would result in a waste of about 1,360 cubic metres, or if you just use an average density of 1.5, about 2100 tonnes. So, when we use five years, then we would multiply this value by 5. So, 10,500 tonnes plus the cuttings of the drilling. And the rough estimate for five years would be about 1,000 boreholes. So, in my eyes, this -- when our eyes, the total amount of base drop would be definitely larger than the 3,600 tonnes, so that the higher amount of samples would be done. The samples which were done, they are not really many. We had mines with nine samples. And they were taken from -- three from the carbonate rock, three from the shale, and three from the sandstone. And we have discussed that last week already. And I also questioned at that time that no single duplicate was taken. So, in the end, you have data from one point, you set it at certain, and you cannot define with one sample more or less the uncertainty range. So, you cannot say whether the -- the system or the chemical behaviour is completely homogeneous or heterogeneous. The sample, we have an unqualified wrap sample taken from the Winnipeg Sandstone. Remember that the sand was taken from a dump. So, the sand which was lying there. So, this -- the sand was experienced the exchange with ambient air. That means the redox states inside the system changes drastically from the suboxic to an aerobic system. So, the samples which were taken from the sandstone do not mimic the geochemical behaviour inside the formation itself. And partially, the documentation was also not adequate. So, one of the questions as an example, what was happened during the storing of the sample BRU 96-1, between connection and delivering to ALS? Now, it's not clear how this data were -- how the samples were delivered, how fast that was, and which temperature that was. It's not, at least not inside the report mentioned. The geochemical sampling before, during, and after the pump test, does not mimic the reinfiltration of the mining operation. That is one of our key systems of points for the -- for the mining operations, or is this what was done during the pump test and the pumping? Does this somehow relate to that what is expected when the mining operation starts? Now, our eyes, this does not mimic this operations because certainly, the duration was too short. This pump test -- this pump test was only seven days, and it's most likely that this -- this -- this systems (inaudible) will be staying longer. The key driver for acid-mining drainage such as the sort of oxygen short version is DO, pH, and need to be stronger, considered in terms of the geological changes. Let's make a short or broad calculation here. Let's assume that the groundwater is 6˚C, which is kind of that what we would have here in southern Manitoba. And we would look at the equilibrium concentration of dissolved oxygen that would come to 12.45 milligrams per litre. So, by this short time, when the sand separates from the water, there will be contact to ambient air. Certainly, we will not reach equilibrium concentration, but let's say, we would use 40 percent of the saturation. That still means that the water which we reinject or which will be reinjected into the aquifer will have a dissolved oxygen content about five milligrams per litre. The slurry could be pumped coming out. I talked to a couple of drillers before I came to Canada, and said the systems with airlifting, you would get slurry to two -- two times fluid to one times solid. The proposal says it's one to one, but I used my 2:1 in this case. So, when we have 21,000 tonnes of Silica sand for each cluster, that means about -- we would need about 38,000 cubic metres of water to get that through. And if you would calculate this with the average -- the DO, which I calculated for 5 grams, we would come about 70 kilograms, which we're introducing into this cluster of pure oxygen. So, the statement was that the sandstone is suboxic and certainly the introduction of so much oxygen would change the redox state. Certainly, a lot of this oxygen would be also being pumped out again, but that is something which was not included into this evaluation. So, to finalize geochemistry and also this talk, what kind of open questions are left in our eyes? The trace metals, which are contaminants of concerns for drinking water quality were not considered. The model selected only low risk scenarios. So, the numerical model did not seek to address two major issues. So, in the end, they reduced water quality in general to risk to human, aquatic, and agricultural life. The risks were not identified by worst case scenarios. As an example, the samples or the concentration in Bru 121-1, depths from 36.57 metres to 37 metres, I could not or we could not look at fully at this geochemical systems because the data were not presented fully. So, the redox conditions, which are critical for this equilibrium calculations, the Pe value in fixed data, they were missing. When they are missing, generally the default is used. And the default would be 4. That means this is not a suboxic condition. That is an error condition. And the potential changes in groundwater chemistry due to the expected changes of pH and redox conditions were not included because this data were not evaluated. I thank everyone for your attention and I would be happy to be there for questions.

THE CHAIRMAN: Chair. Thank you. We did that in about half the time we had allocated. So, as a result of that, I'll add 15 minutes into each of the participants. So, Mr. LeNevue, you are up first. You have 45 minutes, which will take us to the break.

(LONG PAUSE)

THE CHAIRMAN: Chair. Thank you very much. The two of you, please proceed. I'll encourage you to remember to state your name before giving your answer, or you will hear the dreaded clap.

MR. LENEVUE: Good morning. My name is Dennis LeNevue. And I have a few questions, both on the hydrogeology and particularly, on the geochemistry. There was a discussion the last few days about the cavities after the pumping state, when the shale aquitard has collapsed, and the carbonate and the sandstone can be in communication. And we heard evidence that very quickly any pressure gradients would equilirise, and you'd only get flow by diffusion. And I think you mentioned, Dr. Hollaender, that that's not quite right. You have a regional gradient that is pushing water, albeit slowly, to the carbonate and the sandstone that would -- and maybe even nearby pumping wells. It could change the pressure gradient in this -- in these cavities. And so, I'm wondering -- and -- and we have to remember that the carbonate and the sandstone have different water qualities. Sandstone is soft water from what I hear, not much iron, and the carbonate is harder. So, if you mix the waters, particularly those people completed in the sandstone and they got hard water, you're changing their water quality. So, it -- would it be necessary -- possible or even necessary, to do a, instead of a big regional model, a more local model that included your cavity and the recharge, and maybe apply boundary conditions from your larger model, so that you could model inside the cavity and put a very high hydraulic conductivity for both those regions there in the cavity, for the carbonate and the sandstone, to see, if in fact, the model would tell you what kind of a mixing you would get. It would -- you think that that's a -- a necessary or viable exercise?

DR. HOLLAENDER: As I mentioned on one of my last slides, this would require a reactive transport model. And a reactive transport model is a very complicated system. And would make it -- technically it's possible, whether it is adequate to carry out in such an environmental proposal is questionable. In other words, I have not seen that in my life before.

MR. LENEVUE: I thank you for your answer. I I'm not quite sure I understood it. Do you -- do you -- do you -- do you think a -- a local model ---

THE CHAIRMAN: Chair. Gentleman, please remember to state your name.

DR. HOLLAENDER: Yeah. So, your question was, Hollaender, speaking, whether a model -- a local model is necessary? Local model would certainly add to understanding, but the local model which answers the question that you just answered, would be not adequate for such a system. It is very, very complicated, and takes a lot of information, which are not available.

MR. LENEVUE: Thank you for your answer. I guess I have a related question, but from your answer, it's probably not a great question. But what -- what I have trouble understanding is, in the regional scale model, they're measuring or modelling as well, recharge or reintroduction of water, as -- as we withdraw. And from what I understand, there was no actual reinjection of water. It was just reducing ground -- drawdown with respect to the net flow comparison of the reinduction to what the withdrawal was. So, I'm perplexed about how you could model reinjection if the reinjection actually was implemented in the model?

DR. HOLLAENDER: I showed that the model, Hollaender, speaking, is a basin scale model. Such local flows pattern are very complicated to put in. We heard last week from Aecom, that the mesh is refined to 5 metres next to the well. This would give some indication next to the wells in this regard, but in the end, a fully analysis of the local flow pattern is still with the regional model, not possible.

MR. LENEVUE: Thank you for your answer. So, I -- I guess my question really was, could you, on a local model, actually put a reinjection point in and a withdrawal point to see -- especially for the fact that there might be -- the side scan sonar showed there's a cavity in the carbonate, to see on the local scale, if you would actually get transfer of water from the reinjection into the carbonate, especially this oxic water that you're putting back? So, I guess, it's again, I assume you would need a local scale model to do that, but I hear that's complicated.

DR. HOLLAENDER: This kind of local

model, Hollaender, speaking, is much easier, because it only looks at the water fluxes, not at the geochemistry changes, and would be possible.

MR. LENEVUE: Thank you for your answer. It's Dennis LeNevue. I'd like to move to geochemistry. And you made some observations there about the number of samples and I showed this slide a little earlier. I think there's not an appreciation of the complexity in the sandstone of the different minerals there, including concretions and interbedded shale, and oolite, which are all known to be contained pyrite. And I hear in response to my IRR, it can be up to five percent of these materials in the aquifer. And those materials, the concretions you see on that slide there, and interbedded shale or shale from the collapsed aquitard, which is drawn up with the sand, were not analyzed geochemically at all. So, is that not a deficiency? Should not -- should -- should have these known pyritic species in the sandstone, should they not have been geochemically analyzed?

DR. HOLLAENDER: Hollaender speaking. The analysis done by Aecom and ALS from the lab don't show any pirit.

MR. LENEVUE: Okay. Thank you for your answer. It's Dennis LeNevue. You also mentioned about the small number of samples, and particularly for the sandstone. And given the fact that aquitard can collapse into it, and -- and these other pyritic species are in it, and in other areas, we know that the sandstone itself can have sulfide. And they only did three samples when there's 1.36 million tonnes per year coming out. And -- and two of those samples were outside the project area. And I understood you had to base it on the disturbed area, not which would be inside the project area. And -- and then there was -- that leaves one sand sample was taken from a stockpile that was exposed to air for a year and a half, a year before it was covered. So, would in your report, they said that's not acceptable. So, I hear no sand samples in the region that was disturbed. I would have thought you would need 80, 100, especially throughout the whole project area. Can you comment on that lack of sand samples?

DR. HOLLAENDER: It was presented last week by Aecom, that they applied cement system, which is adequate. It is important to consider how much tonnes of rock is taken, based on that you take your samples. I showed today that the amount, the estimate on the waste rock, expected waste rock should be higher. Therefore, I also see the requirement for more samples. I have not calculated the amount of samples, which is required.

MR. LENEVUE: Thank you for your answer. It sounds like you do agree there should be more samples taken. So, is that a -- a recommendation, or -- or -- or can we look forward to, or should we -- should this be a requirement? I guess, it's my question for more sand sampling throughout the project area rather than what we've seen so far?

DR. HOLLAENDER: Hollaender speaking. I'm not a decision maker. I do a technical review and the decision is done by someone else.

MR. LENEVUE: Thank you for your answer. And I'd like to -- thank you for your calculation of the dissolved oxygen that is coming in with the water and showing that that's not insignificant. As well, there is -- when you airlift and you spray water, you get what is called entrained air, which is actually gaseous air that may well be -- and the gaseous air based on its density of -- at the surface of about 1.2 grams per litre compared to 10 milligrams or so for the same volume, is 100 times as much air in a bubble compared to dissolved. Isn't there an opportunity from this entrained air to introduce even much more air into the aquifer than just dissolved air?

DR. HOLLAENDER: Hartmut Hollaender speaking. We did not look at any system which is based on entrained air. Entrained air was not mentioned in the hydrogeological assessment. Therefore, we didn't look at this aspect.

MR. LENEVUE: Thank you for your answer. It's Dennis LeNevue. Yes, it was not mentioned in my -- in the assessment. I think that's my point. It's -- I think it should have been. And so, that's a deficiency. And -- and that should be corrected. So, I have -- but I have another question about the air. We know we're injecting air by airlift. And the air is supposed to return up the production pipe, but I see no reason or it -- why it couldn't also leak out the bottom. You can't see down there, and you know, a little bit of excess pressure and you could get some of the air coming out the pipe. And when you're sending air in, it says in the patent, as 300 to 600 cubic feet per minute. A tiny leakage out of your air tube in your airlift could amount to a lot more oxic conditions in your aquifer. And I understand they're not measuring this in the produced water. They never have. So, can you make any statement or any judgment about the potential to introduce even more air from the airlift process?

DR. HOLLAENDER: Hollaender speaking. The working version of the well is (inaudible) patent. This will be evaluated by the according authority. It was not part of the hydrogeological assessment report.

MR. LENEVUE: Okay. It's Dennis LeNevue. Thank you for your answer. I have no more questions.

THE CHAIRMAN: Chair. Thank you very much. MSSAC, I believe you are next in the queue.

MR. MANN: Thank you, Chair. This is Jason Mann, working with MSSAC. I have a handful of questions for Dr. Hollaender, based on the hydrogeology review and model review. So, on Page 9 of -- of your proposal or presentation, pardon me. And -- and it comes out in other narrative here in your presentation, variability is key and it's important. I -- I tied back some of the dialogue that was had in prior days where I think it was Mr. Mills (ph) on the panel, described the sedimentary rocks and depositional environments, where these rocks are laid down, is fairly uniform and well understood. And that might be true, and in fact it's often true, but beyond that dialogue is the discussion about the other few 100 million years that occurred or transpired since that deposition. You know, in the Western Canadian Sedimentary basin as a whole, there's been tectonism that's resulted in jointing of these rocks. Exposure geologically, to erosion and carst activities to, at least the mid-Devonian at a minimum. Thereafter, in more recent times, glaciation, other erosion processes, glacial tectonics, isostatic rebound. So, my question is this, would you expect that this history of geology in Manitoba to be at least some of the root causes that are resolved in, for example, the permeability distribution that Paula Kennedy derived in her work in the province?

DR. HOLLAENDER: Hollaender speaking. We know that certainly, the geniusis of formation can be described, and certainly also, geniuses of the carbonate and also of the sensor aquifer were studied. But let's -- let's go back maybe to a bit simpler system where most people can grasp something on. When we would go to -- to the direction of (inaudible) where we see an unconfined aquifer, which could be kind of that what was there millions of -- 100 of million years ago, then we will see when we go through the landscape and we make small boreholes, that sand is not everywhere the same. Although this -- this Assiniboine Delta Aquifer was created more or less through the last glaciations. So, we have in every system, although, if you understand the system, a certain amount of heterogeneity. This can be more, this can be less, but there is always a certain amount.

MR. MANN: Thank you for your answer. Jason Mann speaking. On Page 13, you describe some of the questions that in your review or in your interpretation haven't been answered. And -- and I'll just run them through. There's three bullets. "No observations of the vertical, hydraulic properties," pardon me, "of the Winnipeg Shale in the mining area. What will happen to the aquitards, the aquifers, the material properties after the mining activities? Will water of poorer quality be drawn into zones that are currently good quality?" These are your three bullets on Page 13, which in your review and in your perspective, have not been answered at all. Can I ask you, why it would be important to have these questions answered before, perhaps issuing a licence for this project?

DR. HOLLAENDER: Hollaender speaking. If you look at the -- the shaded formation, this departs two aquifers at this moment. The general understanding is that when we work on aquifers, manage aquifers, we don't -- we shouldn't mix waters. You can see this on my first slide, which I introduced about what we are looking at this. Certainly, there is the information already that some of this -- there just seems to be these 500 wells, which have interconnections. So, this one has an impact on the current groundwater quality and certainly the changes by the optimal -- optimal mining operations will add on to these changes. That has to be seen in context and has not discussed. We look to topic two, what will happen to the aquifers, aquitards, and the properties? We have discussed widely in this hearing, the failure of the shale and also part of the limestone aquifers. That should have been maybe already included in such a report. It will have impacts on the aquifers. If we look at the sandstone aquifer, we will have voids inside. We will have disturbed areas, which was defined as sludged areas. They will have not the same properties in the -- in place sandstone. We look at the limestone. The limestone has three different areas. The top fractured system, the competence system, the lower fractured systems. In the groundwater model, they were considered to be one, which is okay for a regional model. So, that does not give us -- and if we have a collapse of some parts, the connectivity to the system will be different, that was not included. And the last part, I think we have talked also, Mr. LeNevue, just asked a couple of questions. Yes, there will be changes of water. This can lead to poor water quality. We have -- I've showed in my presentation that trace metals were not considered widely. And so, that certainly will -- could have some impact.

MR. MANN: Jason Mann. Thank you for -- for your answer. On Page 16, there's a discussion of the conceptual model and the regional groundwater table maps. Um. Your second bullet identifying or highlighting that all available data was used. So, in terms of establishing the model and -- and -- and some of the calibrations, so in other words, water levels or data from 1980 may be plotted with data from 2020. There was discussion in the panel in the last days that all available data was used in -- in a -- in a similar manner. I.E. -- and I believe you stated in your discussion here this morning, really, the -- that process is getting at mean values, averages. Dr. Miln Harvey, I believe, stated in his view, this approach, included all available data and was representative of all the aquifer conditions overtime, high water levels, low water levels. But my question to you is, is this -- is this actually just an averaging exercise?

DR. HOLLAENDER: Hollaender speaking. I cannot comment fully on Dr. Miln and his group work, which he had carried out, but it was described that they took the mean value.

MR. MANN: Thank you for that answer. Jason Mann speaking. So, mean values, there -- there is variability in water levels in -- in aquifer systems and in recharge rates in time. And I believe you -- I mean, you identified this issue and had some dialogue around some of your concerns in using averaged data over long periods of time. Can you reiterate your thoughts about that and how this might affect maybe model performance or predictions if -- if these averaged mean, pardon me, water levels are -- are used, in terms of the modelling -- modelling process?

DR. HOLLAENDER: Generally, what you would expect, is that the spreading around. So, 1:1 line would be larger because you would compare data from different times. You know, the same simulation. What would be not expected is that what is seen that there's a constant bias in increasing -- increasing distance between the simulated and the observed data.

MR. MANN: Thank you for your answer. Another -- another comment, and I think it comes out later in -- in the discussion. And I'll circle back to your comment on bias because I think you've talked about that again in -- in one of your later slides, but at -- at this moment, just in terms of the -- the model, and there was some discussion about verification in the panel prior, I -- I believe you identified that as well in your deck this morning, that verification wasn't necessarily part of the process. Can you describe in your view, how this fits in with the modelling process and why it may be important in any model?

DR. HOLLAENDER: As I said, when we build a model, it's a schematic, a simplified schematic of the nature. And although the larger the models are, in this case, the region model, the larger is the simplification. However, every office models have to mimic the behaviour of the nature that's done, or corrected by, or created, or we do this by the calibration process, where we also prove that the model is adequate to simulate the processes going on. If you have the distance or constant bias, which increases in a calibration, then this model would not be able to simulate the processes in the nature correctly.

MR. MANN: Thank you for your answer. I do have a follow up question on that, but I'll go sequentially in terms of the order of the slide deck. On Page 23, you talk about equifinality. This is Jason Mann speaking. Unique versus non-unique solutions, and you provide a little schematic here to describe what -- what you're talking about. Those questions of unique versus non-unique solutions were raised in the IR process. They were discussed in panel. You've identified them here. Your final comment on this on -- on Page 23, is that more data is required. My question is then, you know, what might be a practical approach to refine the model or -- and then ultimately its results in this regard? So, whether this is your opinion or state of practice, either one, like, for example, would building in the heterogeneity in the aquifer system that's been described by others. Building that into the model, does that help with this issue? Or what would be your perspective? You know, or is it more -- more drilling and pump tests, or maybe it's both? I just was interested to hear your perspective on how, or what data, or what more data could be used to help mitigate, let's say, the risk of this oversimplification that you describe on Page 23.

DR. HOLLAENDER: Hollaender speaking. There have been wide work being created by Kennedy, published in (inaudible) Thesis 2002, and also in the work which published by Kennedy and Woodbury. Both systems because it's the same work, uses heterogeneity as the attempt with different zones, approaches. Data were collected, evaluated widely during this PhD. This data have been checked academically. It could be easily used. Additionally, certainly for the local impacted area where the mine is stated, more than one pump test would be very helpful to identify the local heterogeneity.

MR. MANN: Thank you for your answer. Page 24, again, this is going back to the calibration discussion. And I believe here as well, although I don't see it written here, but I believe -- this is Jason Mann speaking. In your dialogue this morning on -- on this Page 24, I believe you started to talk about a bit of bias that you described in terms of the calibration. And -- and I think, and I -- and this is why I'm asking the question, I think this dialogue goes back to a question you had asked during the panel in the last days. You had pointed out a plan view calibration map where some of those correlations at distance from the project weren't -- weren't necessarily as tight as -- as some of the -- the calibrations closer to the heart or the project area of the model. Dr. Harvey, I believe, suggested you were cherry picking the results, and identifying these poor calibration areas that are removed, or distanced from the heart of the model, and -- and project area, and thus, would have, perhaps, less impact on the results of the model. Can -- can you revisit this, please, and explain your thoughts or concerns regarding these calibrations and if maybe you've answered the question for me today, is it about -- is -- is that what's related to these -- what I believe you called biases and calibration in these distant areas or other areas that just would ask you to revisit your thoughts or explanations on -- on that?

DR. HOLLAENDER: Hollaender speaking. So, I tried to intercorporate Dr. Harvey's comment on this into this block. If I just like to phrase again, back to this slide, which I opened here. You see that the point where the calibration went away from the 1:1 mark, is at about 275 metres. We can certainly discuss about one or two metres left or right, but that means that the area of interest is included in the biased area.

MR. MANN: Okay. Thank you for your answers. Jason Mann speaking. So, I -- I -- I understand again, I think you did answer the question, I -- I had related to this by -- by demonstrating what you've shown here and -- and what you see in this calibration data, but -- but does that then -- does it then tie back to some of those other calibration areas that were -- were, you know, a -- a broader delta in terms of observed versus modelled? Is that -- are those results part of what creates that -- that different -- your red line there? Is that a different slope? Is that -- that's part of what -- what that result involves? Am I correct in that interpretation?

DR. HOLLAENDER: Hollaender speaking. Yes, this interpretation is correct.

MR. MANN: Okay. Thank you. Jason Mann speaking. That helps me understand your -- your discussions prior and today on this item. On -- on Page 26, on the bullet regarding calibrated values, you -- you identify the anisotropy that was assumed in the model at 10:1 vertical -- that's a vertical versus horizontal, or in other words, vertical permeability is 10 times less than horizontal, is what I'm saying. That's -- that's often used in modelling studies. That's -- that's not surprising to see, but with the known changes in the shale aquitard with its removal effectively, can you comment then on the -- I'll call them windows, that -- that will open up between the aquifers and how you see the progression of the physical hydrogeology of the aquifers with the opening of such windows through the shale? So, where I'm -- I guess I'm -- I'm asking your thoughts on is that, with the removal of the shale, obviously, it changes the interconnection of those two aquifer systems, but in the -- in the model, there's still the anisotropy vertically versus horizontally in terms of permeability. But the removal of the shale certainly is significant. It's of low permeability. It's an aquitard. Can -- again, can you describe what you think the response of the aquifer systems will be with the opening of these windows or interconnections between the aquifers, please?

DR. HOLLAENDER: Hollaender speaking. So, the failure of the shale and the partially also caprock limestone, will results that hydraulic conductivities, which are presented also here, in the -- in the report, will increase drastically. So, it will become a void space, and the void space has an unlimited hydraulic conductivity. Hydraulic conductivity is equal in vertical, in horizontal direction. So, an anisotropy cannot be found in a void space. That means the water exchange between the aquifers has no resistance, is purely related to the gradient. Now, we have to think about how this water flow could be. Unfortunately, the model, regional model, cannot give this answer. As I mentioned before, the carbonate aquifer has three zones. The fracture top version, the component part, and the bottom fractured version. So, we know that the bottom fractured version will fall also into the void. Partially, the competent part will fall into the void. So now, we have to identify the largest hydraulic conductivity. The largest hydraulic conductivity is in the fractured part, which is just above the shale. But it's the lowest resistance. The gradient is small as everywhere the same in that moment. In this case, the water would flow horizontally in the fractured zones from a wide area around into this void to fill up the -- the head difference. So, we will have a reduction in head inside the fractured zone. We have still more or less the same constant head from before inside the limestone. So then afterwards, we will have a slow equilibrium, which we are getting slower to the equilibrium by bringing water from the competent limestone into the fractured zone, which is below.

MR. MANN: Thank you for your description of a complicated problem. Jason Mann speaking. I don't think I have any follow up questions on -- on that. I think I have a couple last questions in there, largely related to geochemistry. So, Pages 29 and -- and 30, perhaps. You do identify a lot of complex things involved here with changes in oxygen states, and redox, and all of those important things. But I'd -- I'd like to go back, if I could, to discussion about some of the mixing simulations or mixing results that were presented in the panel in the last days. I believe it was, Mr. Miln, described the, you know, that these aquifers are good water quality in general. We do know they have different water quality, but they're generally good water quality. And the mixing of these aquifers was similar to taking, you know, a couple of bottled water sources and -- and mixing them together. But I -- I'm -- I'm interested in your view where in presenting those mixing results, fundamentally, the proportions of mixing presented wouldn't necessarily, at least in -- in my own interpretation, align with that analog. That's why I'm asking you this question. So, in an upward mixing scenario, which I believed in our dialogue in panel, doesn't actually exist. It's largely downward gradients. However, an upward mixing scenario was presented where a proportion of 70 percent of sandstone waters to the overlying carbonate were modelled to -- to produce a favorable water quality result as an end member. Conversely, around or as round numbers, 30 percent of carbonate aquifer water could be mixed with sandstone aquifer water before, perhaps, some parameters got close to the drinking water guideline or otherwise, became a challenge. So, that's where again, fundamentally, looking at those proportions of mixing, the fingerprints of these water qualities are different. And I mean, that's just borne out in that -- in that -- in that analysis, I think. So, my -- my question is, you know, can you -- can you comment on this? Is that a logical interpretation? Or could you elaborate, or expand on these mixing -- this mixing dialogue?

DR. HOLLAENDER: Hollaender speaking. In my answer to Mr. LeNevue, I mentioned already that there could be a better analysis, but that is very, very complicated. So, the industry standard would be the version, which was carried out. To take water source from 1:1, to take the other water source and you mix them to certain compartments. What is the issue with this system is that the mixture certainly, is not constant throughout time and space. But this interface, exactly where the shale breaks, you would have 100 percent exchange of water. You would completely change the water, let me say, exactly there was sandstone water before, now there will be carbonated water from the carbon aquifer. And with distance from this point, the concentration will reduce. But it does not only reduce with space, it also does with time because water flows in this aquifer. It takes a long time. The well from the residents who takes this water is not directly at the mine site. So, this question cannot be answered with the analysis. But this is also very, very complicated answer, this question exactly.

MR. MANN: Jason Mann. No, thank you for that answer. Because they hadn't gone down to that level of detail, but in hearing your answer, that is a complicated item. I don't think I have a follow up on -- on that at this moment. I think -- I think I have one -- one last question. Jason Mann speaking. And I -- I think this is largely tied to fit -- what I'll say is physical hydrogeology versus geochemistry, but maybe they're blended together. But at the panel, there was discussion, and I believe in the slide deck or perhaps even in -- in -

- in the root reports, nonetheless, I believe that the panel presented their view, their -- an outcome of their work, that the effects are short-term and reversible. So, this makes sense to me at perhaps, a borehole scale, or at a cluster scale, or as related to a pumping test. You know, if we're talking about physical hydrogeology, you run a pumping test and we heard that the wells recover quickly to about 80 percent static levels, and then over the next weeks come back to 100 percent. So, those physical hydrogeology changes resultant of a pumping test or other activities, I mean, that -- that statement makes sense to me. But the loss of the shale aquitard is not reversible. And we've talked about -- and I think even today in your slide deck and in some of the questions that I've asked and you've answered, the discussion about the re-equilibration of the heads and the aquifers, which will include some exchange of the waters between the aquifer systems. So, can -- can you -- and -- and maybe you sort of answered this already because I asked similar questions, can you describe in your view what this means for these two aquifer systems in the longer term? Sorry, just -- just to finish or just maybe help put context on the question, you know, will -- will these two aquifer systems become one over time? For example, is that -- is that a potential outcome here? In other words, that would be a change that is a progression and isn't reversible. And then as an add on to that, is there a scenario where the heads, you know, the gradients from the carbonate aquifer to the sandstone, you know, still do have that downward scenario. In other words, they don't necessarily equilibrate, and mitigate, or reduce, or slow vertical exchanges of water down to, you know, concentration gradients. And -- and I ask that question, like, seasonally. And recharge rates between these aquifers are different, I think. So, kind of a two parter. In your view, based on what your analysis is of the project and the work done, what -- what will become of the two aquifers in time? Will they become one? And or if they don't, do those gradients still exist for those exchanges of water in the long-term from the upper aquifer system to the lower?

DR. HOLLAENDER: Hollaender speaking. This question has a lot of aspects. So, first of all, we have an area, which is -- will be mined for more than two decades. And I think there is some conclusion about that there will be a failure of some, at least some of the interior of the shale. The more failure of the shale there will be, the more this will become in this area, that is important in this area, one aquifer. It will be not oncoming and an aquifer, one aquifer upstream, or downstream. The impacted area will grow with time, but will also due to this flow on the intermixing or the small mixing just based on dispersion, will also get smaller. So, more will go away from this impacted area. Mr. Miln presented the upwards scenario in geochemistry. And the reason for that is that currently, the head in the sandstone is larger for most parts than in the carbonate. Not everywhere, but for the most parts. You will see that also, on the schematic drawing in the beginning, which I showed that the sandstone aquifer is extending further than the carbonate. That means the recharge where the water comes in has a higher head at that point. When this head is carried through, and this water releases, not as shown in the modelling as the Red River, but it will release below the Lake Winnipeg. And of course, into Lakes Winnipeg slowly. So, now there's this disturbance. The disturbance of failure of the shale, and then the pumping situation. That is what Mr. Miln, Aecom, presented in this additional data, that due to these pumping situations, we will have the gradient, which is going from the carbonate into the sandstone. So, in that case, the -- there will be water flow from directly what I explained just before, will be from the carbonate in the sandstone formation. But with time, when -- let me say, the site has finished, you have Sio's of wells. You have taken out the heads, all -- all that. Then nature will take over again and you will have the higher heads coming from the sandstone again. In this case, the water will be pressed from the sandstone into the carbonate. That just takes a long time. So you have to assume that the water flow inside this -- this aquifer, I've not really calculated. Mr. Miln might be able to talk about that exactly, but that's a few metres per year. So, this groundwater moves naturally a few metres per year. So, very, very slow. So, it's -- it's a very, very long and slow process.

MR. MANN: Thank you for that answer. Jason Mann speaking. That -- that does definitely help set the entire context around some of the dialogue that's been had about these changes. And I appreciate your response in that regard on that question and all that I've asked. I don't believe I have any follow up questions. Thank you for your time and thank you, Chair for -- for the time to ask the question today. Thank you.

THE CHAIRMAN: Chair. Thank you, both, for that exchange. It is 11:04. Looks like a good time to take 10. So, we'll regroup at 11:14.

(OFF RECORD: 11:04 A.M.)
(ON RECORD: 11:14 A.M.)

THE CHAIRMAN: Let's regroup in one minute, please.

(LONG PAUSE)

THE CHAIRMAN: Chair. Okay. The required people are in their seats. So, over to you, Mr. Williams.

MR. WILLIAMS: Williams(ph) speaking. And good morning, members of the panel. And good morning, Dr. Hollaender.

DR. HOLLAENDER: Good morning.

MR. WILLIAMS: Williams speaking. And Dr. Hollaender, I'd like to start by turning you to Aecom, A-E-C-O-M, Figure 6-3, of the Hydrogeological Assessment Final Report, which is found at PDF, Page 12 of Appendix A, Part 3. You have that in front of you, Dr. Hollaender?

DR. HOLLAENDER: Yes, I have.

MR. WILLIAMS: Williams speaking. And Dr. Hollaender, you have reviewed Figure 6-3, for the purposes of preparing your September 22 opinion, and you also have commented upon it in your opinion. Agreed?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. WILLIAMS: Williams speaking. Dr. Hollaender, at a high level, the typical steps of groundwater modelling include model testing, model evaluation, model calibration, and sensitivity testing, benchmarking, history matching, prediction and parameter estimation. Agreed?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. WILLIAMS: And without asking you to elaborate, Williams, speaking, I'll ask you to confirm that one of your concerns with the Aecom modelling exercise is that the calibrated final hydraulic parameters do not match with the actual well test data. Agreed?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. WILLIAMS: Williams speaking. And again, at a high level, calibration is the process in which a math -- a mathematical model simulation is compared to a known data set. Agreed?

DR. HOLLAENDER: Hollaender speaking. No data set might be not exactly the correct word, but the selected data set.

MR. WILLIAMS: Williams speaking. And thank you for that correction. Focusing on Figure 6.3 of the Aecom Hydrogeological Assessment Final Report, it assesses a selected data set being observed. Groundwater elevation and -- and versus minus simulated groundwater elevation. Agreed?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. WILLIAMS: Williams speaking.

And at a high level, it provides us with the comparison between the actual observed groundwater elevations in real wells drilled in the region versus the simulated groundwater elevation provided by the hydrogeological model for the same locations as the real wells, and under current existing conditions. Agreed?

DR. HOLLAENDER: Hollaender speaking. Generally, yes. What you will see on this slide is that wells have an equal distance. The observation points that is based on the relation that in earlier times, the relocation was not exactly noted. It was always placed in the centre of any quarter section. But else, this is correct.

MR. WILLIAMS: Williams speaking. And thank you for that. And I'd like to direct your attention on the right hand of Figure 6-3 to the legend. And specifically, you'll see the dark green dot. In that legend, you see that Dr. Hollaender?

DR. HOLLAENDER: Do you speak about -- Hollaender, speaking, the interval 0 to 1?

MR. WILLIAMS: Williams speaking. I

am referring you to that interval 0.1021. You see that?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. WILLIAMS: And that -- Williams speaking. And that dark green dot, according to the legend, represents circumstances where the actual observed groundwater elevation is 0 to 1 metre higher than the simulated groundwater. Agreed?

DR. HOLLAENDER: In this case, it is opposite. So, the simulated are one -- maximum 1 metre higher than the observed.

MR. WILLIAMS: We'll double -- Williams speaking. Isn't -- doesn't this refer to observed minus simulated groundwater, sir?

DR. HOLLAENDER: Yeah. You're -- you're correct. That's correct. Sorry.

MR. WILLIAMS: So, just to make -- Williams speaking. Just to make sure the -- the record is clear, sir, the dark green dot represents circumstances where the actual observed groundwater elevation is 0 to 1 metre higher than the simulated ground?

DR. HOLLAENDER: Yes, correct. Hollaender.

MR. WILLIAMS: Williams speaking. And we would consider that a good match between the observed groundwater and the simulated groundwater. Agreed?

DR. HOLLAENDER: Hollaender speaking. For regional model is a good match.

MR. WILLIAMS: Similarly, Dr. Hollaender, the light green dot represents circumstances where the actual observed groundwater elevation is 0 to -- to 1 metre lower than the simulated groundwater. Agreed?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. WILLIAMS: Williams speaking. And at a regional level, sir, again, we would consider that a good match between the observed groundwater and the simulated groundwater. Correct?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. WILLIAMS: Williams speaking. And -- and still focusing on the legend, we see the gold dots second from the bottom, I'll suggest you, Dr. Hollaender, represents circumstances where the observed groundwater elevation is 5 to 10 metres higher than the simulated groundwater. Agreed?

DR. HOLLAENDER: Yeah. It would be light red for my eyes, but it could be also defined as gold, agreed.

MR. WILLIAMS: And turning to the bottom dot, the red dot, the dark red dot, that represents -- Williams, speaking -- represents circumstances where the actual observed groundwater elevation is at least 10 metres higher than the simulated groundwater. Agreed?

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. WILLIAMS: And when the -- at a regional level, when the actual observed groundwater elevation is at least 10 metres higher than the simulated groundwater elevation, that is definitely not a good match. Agreed?

DR. HOLLAENDER: Hollaender speaking. This is a local measurement. And a local measurement, as I showed in my presentation, can have an uncertainty. So, in most cases, I would agree, but in some cases we could also discuss that this data are not fully quality checked and might be incorrect. So, let me say, if there's one or two of this versions at a certain point and it's a single event, then this would tend more to the quality of the data. When we see a group of data, which have the same issue then it is more or less or generally a calibration issue.

MR. WILLIAMS: Williams speaking. And just to make sure I have your answer, sir, you're suggesting that if you see a -- a dot in isolation, that might be a data issue, but when you can see a -- a cluster of dots, where there is a difference of at least 10 metres, that is probably a calibration issue?

DR. HOLLAENDER: Hollaender speaking. In general? Yes.

MR. WILLIAMS: Just before we leave the legend and Williams speaking. At the top of the legend, I'll suggest you, the pink dot represents circumstances where the actual observed groundwater elevation is 10 metres lower than the simulated groundwater from the Aecom model. Agreed?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. WILLIAMS: Dr. Hollaender, it's Williams, speaking again. And for the purposes simply of orientation, you would agree that the dark black line encompassing the dots on Figure 6-3, represents the domain of the Aecom model. Agreed?

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. WILLIAMS: Williams speaking. And so again, to orient us to the east of the domain, we see Hazel Creek. Agreed.

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. WILLIAMS: And to -- Williams speaking. To the west of the domain, just outside the domain, we see the City of Winnipeg. Agreed?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. WILLIAMS: Williams speaking. And in the -- within the DoME model domain, encapsulated in purple, we see the spatial area that represents the 24-year life of the Sio Silica mining development. Agreed?

DR. HOLLAENDER: That is the not detailed description of the project area. Hollaender speaking. But the -- yeah, it's the large scale of it. That's correct.

MR. WILLIAMS: Williams speaking. Dr. Hollaender, if we move to the northwest from that area, purple area, through Anola and towards the Red River Floodway, you see a clump of pink dots. Agreed?

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. WILLIAMS: Williams speaking. And I'm not sure if clump is the -- the -- the hydrogeological term, but a cluster of -- of pink dots is what you see there. Agreed?

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. WILLIAMS: Williams speaking. And a bit south of the cluster of pink dots is a cluster of red dots. Agreed?

DR. HOLLAENDER: Hollaender speaking. If you talk about that which is just west of Anola, agreed. West of Anola means between Winnipeg and Anola halfway.

MR. WILLIAMS: And Dr. Hollaender, it's Williams speaking. And immediately to the east of Winnipeg, there was another cluster of red dots. Agreed?

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. WILLIAMS: Williams speaking. Dr. Hollaender, I'm going to pull you back to the east and to the -- the area of the -- the purple area representing the spatial area of the 24-year -- 24-year life of the Sio Silica mining development. And you can accept these numbers subject to check or you can zoom it out and -- and look at it more closely.

DR. HOLLAENDER: Sorry, I have just duplicate the picture that I can see on my screen. I hope that it works.

MR. WILLIAMS: Williams, speaking. And thank you for your -- your hard work and I apologize for the inconvenience. Within the purple lines, I'll suggest to you, Dr. Hollaender, you will see at least 10 gold dots representing circumstances where the actual observed groundwater level is 5 to 10 metres higher than the simulated groundwater. Agreed?

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. WILLIAMS: Williams speaking. Again, within or at the purple lines, I'll suggest to you, you will see five red dots representing circumstances where the actual observed groundwater elevation is at least 10 metres higher than the simulated groundwater. Agreed?

DR. HOLLAENDER: Hollaender speaking. At least four with the one, which is on the edge, might be inside, might be outside.

MR. WILLIAMS: Williams speaking. And -- and thank you for your precision. And again, it would be fair to say that the majority of the dots within the purple area are in the 1 to 5 metre range. Agreed?

DR. HOLLAENDER: Hollaender speaking. Agreed. Hollaender speaking. Maybe. So, we have -- the legend is very complicated to read and it's only the size of the picture. So, I would say there's a majority would be between 1 and 5 metres.

MR. WILLIAMS: Williams speaking. And thank you, Dr. Hollaender. And if you could just go to the big scale just for a last couple questions on Figure 6-3. And Williams speaking. And thanking you for that. Again, if we go to the clump of pink near the Red River Floodway, this clump suggests that the simulated water levels are 10 metres too high. Agreed?

DR. HOLLAENDER: Hollaender speaking. Most of them, agreed.

MR. WILLIAMS: And this would suggest a high misfit between measured and simulated heads in this area. Agreed?

DR. HOLLAENDER: A misfit of 10 metres would be relatively high. Agreed.

MR. WILLIAMS: And similarly, the clump of red dots suggests -- just beneath that suggests the simulated water levels are 10 metres too low. Agreed?

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. WILLIAMS: Williams speaking. Dr. Hollaender, do these large positive and negative residuals raise any concerns in your mind about the assignment of boundary conditions in -- in the Aecom model?

DR. HOLLAENDER: Hollaender speaking. Yes, it raised. Some of them were presented this morning in my presentation. I could go into details there and we would probably figure out a couple of more.

MR. WILLIAMS: Williams speaking. I think it's at Figure 6-3. And those clusters is emblematic of some of the concerns you had with the extent of the domain. Agreed?

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. WILLIAMS: Dr. Hollaender, it's Williams speaking. And I'm going to just ask you to turn to Page 25 of your report. You're in Dr. Woodbury's report from September of 2022. And Dr. Hollaender, it would be your view that a concern for the sustainability in the long term of -- of the sandstone aquifer -- sorry, is -- is that of migration of saline waters into freshwater zones east of Red River and north and south of

Winnipeg? Agreed?

DR. HOLLAENDER: Hollaender speaking. It was reported in Ferguson et al, 2007.

MR. WILLIAMS: Williams speaking. And from your perspective, it is important in assessing the EAP that we have an understanding of the possibility of movement of more saline waters from the west of the Red River, moving into fresh portions of the sandstone and carbonate aquifers. Agreed?

DR. HOLLAENDER: Based on Ferguson et al, Hollaender, speaking, this is currently the case.

MR. WILLIAMS: Williams speaking. And in your conversation with the municipalities a bit earlier this morning, you noted that Kennedy in 202 incorporated these salinity and density effects into her extensive three dimensional model of the aquifers in southern Manitoba. Agreed?

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. WILLIAMS: Williams speaking. But Aecom did not. Agreed?

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. WILLIAMS: Williams speaking. I want to direct your attention to the statement really, and the -- the first two sentences on the -- the top of Page 25. Also, just to you, Dr. Hollaender, that you state on Page 69 in the HAFR, it is stated that, "It will be beyond the scope of the modelling efforts to assess water balance in the context of present and future groundwater use. Thus, effects of saline water intrusion are not considered." You see that statement, sir?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. WILLIAMS: In layperson's language, Dr. Hollaender, can you explain why the fact that it was beyond the scope of the modelling effort to assess water balance in the context of present and future groundwater use led to your conclusion that the effects of saline water intrusion are not considered?

DR. HOLLAENDER: Hollaender speaking. Saline water simulations or with different densities increases the complexity of the numerical equation drastically. Computation times increased (inaudible). Calibration also takes much longer. Therefore, modellers generally look which state and to which states they can use a single phase as done in this report. And it is based on the understanding of the numerical modeller to make these decisions. The international guidelines, when salt water should be included, and density driven flow has to be used or should be used. The version which is generally accepted is one percent salinity. So, that means when we have a density of water of 1,000, one percent would be 10 grams. So, as soon as the TDS would be larger than 10 grams, you should use density driven systems. Williams speaking. Just below that quote, you referenced Kennedy and Woodbury, 2005, and Wang et al, 2008. Agreed, sir? Williams speaking.

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. WILLIAMS: And you are -- based upon your knowledge of the literature, you are familiar with Kennedy and Woodbury 2005, and Wang et al, 2008. Agreed?

DR. HOLLAENDER: Yes. Hollaender.

MR. WILLIAMS: Williams speaking. Do you have any observations about the consistency of the recharge estimates presented in the Aecom model as compared to the recharge estimates presented in other models such as Kennedy 2005 or Wang 2008?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. WILLIAMS: And what are those observations?

DR. HOLLAENDER: Hollaender speaking. The results, which -- which Aecom used were inside the area. However, this area was very wide between different studies, not the one which we discussed here.

MR. WILLIAMS: Do you have any observations about the estimates of domestic water use found in Aecom 2021 as compared to other estimates of domestic water use conducted within the broader region?

DR. HOLLAENDER: Hollaender speaking. Yes, we reported this in this report.

MR. WILLIAMS: Williams speaking. Dr. Hollaender, from a sustainability perspective, can you contemplate circumstances where the cumulative withdrawal within the Red River carbonate and Winnipeg sandstone aquifers reduces the groundwater flow moving west? And as a result the freshwater boundary intrudes further towards the east?

DR. HOLLAENDER: There is -- so, one interesting or one very obvious case, Hollaender, speaking, is the City of Winnipeg where there was slaughterhouses more or less in the centre of the city until the middle of the '80s. They induced a very large drawdown cone, which changed the regional flow pattern towards the centre of Winnipeg. They were shut down, I think in the late '80s, early '90s. Since then the groundwater table is recovering. And this has also shown that there is salinity changes over long times in that area based on the withdrawal, which was (inaudible) by those two slaughterhouses.

MR. WILLIAMS: Dr. Hollaender, I didn't hear the last sentence you said there. You said something about based on the withdrawal.

DR. HOLLAENDER: Yeah. Hollaender speaking. So, there's two slaughterhouses, huge amount of water for the processing. That is normal. Slaughterhouses use a lot of water. And so, they took this out of the carbonate aquifer. The water table in Winnipeg was lowered. People who are getting used to this. So, if you look at houses which were built in the '70s, in the '80s, they were not sealed against water. But stopping of this withdrawal, the water came back. Salinity throughout the time increased slowly, very slowly. It's a slow process. And now, people have the issues of flooded basements due to the missing withdrawal, if you have not planned out in the -- in the '70s.

MR. WILLIAMS: Williams speaking. Dr. Hollaender, would it be fair to say, in terms of the Aecom model, that you have concerns that the model domain may not be large enough to account for large scale physical effects such as saline water intrusion or long-term sustainability?

DR. HOLLAENDER: Hollaender speaking. It depends on the time horizon to project. As I mentioned a couple of times today, the groundwater moves very slow. And it is a question, which kind of period you want to forecast.

MR. WILLIAMS: Williams speaking. Just the last few questions, sir. Focusing on the -- the effects of the removal of Silica sandstone from the Winnipeg sandstone aquifer, you would agree that it will increase the overall storativity of the aquifer within the project site. Agreed?

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. WILLIAMS: Williams speaking. And it would be your expectation that the hydraulic conductivity of the aquifer would also change? Agreed?

DR. HOLLAENDER: Hollaender speaking. That's again, a complicated topic. If you look at the regional scale where we have to fill the voids this material, it will need an adjustment, and increase in K value. If we look at the local model, you would need to model the void, which we show -- we have seen last week on the geotechnical sonar scans.

MR. WILLIAMS: Williams speaking. And thank you for that. And focusing on the local level, there are no estimates of its impact on hydraulic conductivity given in the Aecom report?

DR. HOLLAENDER: Hollaender speaking. The report didn't show any impact. The new results presented last week showed some impact.

MR. WILLIAMS: Williams speaking. In terms of the implications of removing sand from the aquifer and its subsequent effect on hydraulic conductivity locally, does it remain to review that the effect on hydraulic connectivity will be significant?

DR. HOLLAENDER: Hollaender speaking. This was not evaluated.

MR. WILLIAMS: Dr. Hollaender, sorry, I didn't hear that.

DR. HOLLAENDER: Hollaender speaking. This was not evaluated in the report.

MR. WILLIAMS: Dr. Hollaender, it's Williams speaking. In your evidence, you indicate that there was no testing at a pilot project site in which the aquifer was actually mined out. Agreed?

DR. HOLLAENDER: Agreed, because there was no mining system.

MR. WILLIAMS: And you -- Williams, speaking, and you commented about the absence of testing where the aquifer is actually mined out and drawdown is measured at various distances from a producing cluster. Agreed?

DR. HOLLAENDER: Hollaender speaking. If you change it to, will be mined out or might be mined out, then I agree.

MR. WILLIAMS: Williams speaking. From a hydrogeological perspective, what might we learn from testing the mining of a cluster rather than a single mine?

DR. HOLLAENDER: Hollaender speaking. We heard last week that the process is inside a cluster are different. Aecom presented last week, results that there could be a failure of a -- or an impact of 200 metres around such a cluster. That means would include the whole size of the cluster, or in other words, it would mean that the whole cluster could collapse. Only the large pillars between each clusters were defined as stagnant.

MR. WILLIAMS: Williams speaking. Dr. Hollaender, I thank you for your time and for that answer. Thank you.

THE CHAIRMAN: Chair. Mr. Williams, you're done?

MR. WILLIAMS: (No verbal response).

THE CHAIRMAN: Thank you. Is the proponent ready at this time?

MR. DUNCANSON: Mr. Chair, Sander Duncanson. Yes, we're happy to get started. I don't expect we'll be finished by lunchtime, but in your hands as to how you'd like to manage that.

THE CHAIRMAN: Chair. Well, we've still got 40 minutes. So, I suggest we -- we use it. So, please proceed if you're willing.

MR. DUNCANSON: Good morning, Dr. Hollaender.

DR. HOLLAENDER: Good morning.

MR. DUNCANSON: Sander Duncanson, speaking, counsel for Sio Silica. My first question for you, the technical review that you and Dr. Woodbury prepared for the project, that was focused on physical and chemical hydrogeology. Is that right?

DR. HOLLAENDER: Hollaender speaking. Correct.

MR. DUNCANSON: Duncanson speaking. And -- and your technical review in fact, was limited to hydrogeology, correct?

DR. HOLLAENDER: Sorry, can you repeat that question, please?

MR. DUNCANSON: Yes. Duncanson speaking. In fact, your technical review was limited to hydrogeology, correct?

DR. HOLLAENDER: Hollaender speaking. Yes, we looked at the documents A1 to A6 and B.

MR. DUNCANSON: Duncanson speaking. You did not, Dr. Hollaender, assess geotechnical matters, correct?

DR. HOLLAENDER: Hollaender speaking. That is correct.

MR. DUNCANSON: Duncanson speaking. And Dr. Hollaender, you do not have any degrees in geotechnical engineering, correct?

DR. HOLLAENDER: Hollaender speaking. I'm a civil engineer. I'm educated in geotech.

MR. DUNCANSON: Duncanson speaking.

Sorry, Dr. Hollaender, I didn't catch the end of that response. You said you're educated in civil engineering. And then I ---

DR. HOLLAENDER: Hollaender speaking. I'm a civil engineer, civil engineer educated in geotechnical engineering.

MR. DUNCANSON: Duncanson speaking. Thank you. So -- so, I take it that as part of your civil engineering education, you did learn about some geotechnical matters. Have you ever worked as a professional geotechnical engineer, doctor?

DR. HOLLAENDER: Hollaender speaking. I have not worked as a geotechnical engineer.

MR. DUNCANSON: Duncanson speaking. Just a few final questions on geotechnical matters. Dr. Hollaender, given some of the statements that you made last week on geotechnical matters in you're questioning, just so that we're clear, that was not part of the technical review work that you conducted for this project, correct?

DR. HOLLAENDER: Hollaender speaking. It was not done in my work. (inaudible) has discussed geotechnical issues yesterday. They were not present last week.

MR. DUNCANSON: Thank you. Dr. Hollaender, Duncanson speaking. Dr. Hollaender, I reviewed your CV. It's impressive. You are currently a Professor of Civil Engineering at the University of Manitoba. Is that correct?

DR. HOLLAENDER: Hollaender speaking. That's not correct. I'm an adjunct professor at the university. I left 30th June 2022.

MR. DUNCANSON: Duncanson speaking. Thank you for that clarification. When I went through your -- your CV, it appears as though you've -- you've held a variety of academic positions at the University of Manitoba and other universities around the world for almost 25 years. Is that fair?

DR. HOLLAENDER: Hollaender speaking. Yeah. The whole period is about 25 years. The time at university is a bit less, I think, probably 20 years.

MR. DUNCANSON: Duncanson speaking. Thank you. And Dr. Hollaender, you've also done some work outside of academia, including some project work in Germany, and working as a consultant. Is that right?

DR. HOLLAENDER: Hollaender speaking. That's correct.

MR. DUNCANSON: Duncanson speaking. Dr. Hollaender, how much of your time would you say is spent working in academia versus consulting?

DR. HOLLAENDER: (inaudible) Hollaender speaking. Do you consider work for the government regulatory body as consulting?

MR. DUNCANSON: Duncanson speaking. This is always the danger of asking these types of questions. I suppose it depends on the nature of -- of the work you're doing for the government. Let me ask -- let me ask this, how much of -- of your time roughly, would be spent doing consulting for private companies or the government in Manitoba as opposed to work elsewhere, including academic work?

DR. HOLLAENDER: If I would consider everything, I would come between 10 and 15 percent within Manitoba, most likely below 10 percent.

MR. DUNCANSON: Duncanson speaking. Thank you, Dr. Hollaender. And just to be clear that the 10 percent that you quoted there, is that 10 percent of all of the work that you do or 10 percent of the consulting work that you do?

DR. HOLLAENDER: The 10 percent was based on the time in Manitoba, and it was based on the time in the last -- therefore, in the last 10 years.

MR. DUNCANSON: Duncanson speaking. I don't want to belabor the point, but just so that I'm clear, so, sir, of -- of all of the work you've done in Manitoba, roughly 10 percent of that work has been consulting work. Is that right?

DR. HOLLAENDER: Hollaender speaking. I said less than 10 percent.

MR. DUNCANSON: Duncanson speaking.

Thank you. Dr. Hollaender, do you agree that there is a difference in the level of rigor required for academic or research level hydrogeological studies as compared to studies prepared for a project application or environmental assessment?

DR. HOLLAENDER: Hollaender speaking. These are two different things. In research, we look for increasing the knowledge. We are not doing wrong what our original ground what are models for mining purposes. Therefore, agreed.

MR. DUNCANSON: Duncanson speaking. On -- on Slide 2 of your presentation this morning, we don't necessarily need to pull it up, but we certainly can. You -- you referenced the concepts state-of-the-art, and you also reference the concept of industry standard. Would you agree that those are two different things?

DR. HOLLAENDER: Based on communication or based on standard literature, the state-of-art or science and technology is research level. The state-of-art is industry standard. Hollaender speaking.

MR. DUNCANSON: Duncanson speaking.

Sorry, Dr. Hollaender, I didn't quite catch that. So -- so did I -- did I hear you say that there is a distinction between state-of-the-art for academic purposes and state-of-the-art for industry purposes?

DR. HOLLAENDER: Hollaender speaking. I disagree? There is a distinction between whether you work at the edge of research or at industry standard. The terms of state-of-art or science technology for at the edge of research and state-of-the-art industry standard. Some of the industrial works have to be based on the state of edge. You might consider nuclear waste repositories there.

MR. DUNCANSON: Duncanson speaking. Thank you for clarifying that for me. Dr. Hollaender, are you familiar with the EAP guidelines in Manitoba?

DR. HOLLAENDER: Hollaender speaking. Roughly.

MR. DUNCANSON: Duncanson speaking. Have you personally ever built a, pardon me, a hydrogeological model for a project at this stage of its development in Manitoba?

DR. HOLLAENDER: Hollaender speaking. I have created the size of models, but not in Manitoba.

MR. DUNCANSON: Duncanson speaking. Dr. Hollaender, you discussed earlier this morning, some of the previous studies that have been done of the groundwater in -- in this part of Manitoba, would you generally consider the Red River carbonate and Winnipeg sandstone aquifers to be relatively well characterized through past studies?

DR. HOLLAENDER: Hollaender speaking. That is a difficult question. The size of these aquifers are enormous. Therefore, any investigations you would -- you can add to the knowledge the available knowledge. So, the question can only be answered in relation to the expected location and the things which you want to perform with this aquifer. Overall, this cannot be answered directly.

MR. DUNCANSON: Duncanson speaking. Dr. Hollaender, you presented a few years ago, on a model that you developed to assess hydrogeological parameters of the Red River carbonate in East Saint Paul, Manitoba. Is that right?

DR. HOLLAENDER: Hollaender speaking. That is correct.

MR. DUNCANSON: Duncanson speaking. Given that you prepared that model, Dr. Hollaender, would you consider that model to be well done?

DR. HOLLAENDER: Hollaender speaking. The model which we discuss is a coursework model from a PhD student.

MR. DUNCANSON: Duncanson speaking. And so, just to be clear, Dr. Hollaender, do you feel like that was that, that model was a well done model?

DR. HOLLAENDER: In terms of an academic degree, that was a B+.

MR. DUNCANSON: Duncanson speaking. And the geographic area of -- of that model, that was to the west of the proposed Sio project and just east of the Red River. Is that correct?

DR. HOLLAENDER: Hollaender speaking. It was west of the Sio version area and east of Red River. That is correct.

MR. DUNCANSON: Duncanson speaking. And the boundaries of that model are -- are within the boundaries of the model that Aecom developed for the Sio project. Is that right?

DR. HOLLAENDER: Hollaender speaking. As far as I could remember, that is correct.

MR. DUNCANSON: Duncanson speaking. That model was also developed using the FEFLOW software. Is that right?

DR. HOLLAENDER: Hollaender speaking. I cannot recall the code, whether we used FEFLOW or (inaudible) at that time. I would need to review this. It's a couple of years back.

MR. DUNCANSON: Duncanson speaking. Would you accept that subject to check?

DR. HOLLAENDER: Hollaender speaking.

Yes.

MR. DUNCANSON: Duncanson speaking. And I appreciate that this is a few years back. So, I just have a couple more questions and if you need to take those subject to check as well, that's fine. But can you confirm, Dr. Hollaender, that that model did not include density dependent flow?

DR. HOLLAENDER: Hollaender speaking. We only looked at the carbonate aquifer. We didn't include, as far as I know, the sensing aquifer.

MR. DUNCANSON: Duncanson speaking. And -- and just to be clear, while you were focusing on the carbonate aquifer, the model did not include density dependent flow, correct?

DR. HOLLAENDER: Hollaender speaking. The model for the carbonate aquifer did not include density difference flow.

MR. DUNCANSON: Duncanson speaking. Can you confirm, Dr. Hollaender, that the Red River was used as the western boundary for that model?

DR. HOLLAENDER: Hollaender speaking. There are lots of reports by KGS, by Stantec, by other companies, for the carbon aquifer. The Red River is a boundary condition.

MR. DUNCANSON: Duncanson speaking. And you can confirm the that, that was used as the boundary?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. DUNCANSON: Duncanson speaking. Dr. Hollaender, as part of the work that you did for Sio's proposed project, did you go back and look at how Aecom's modelling of the Red River carbonate and the associated boundary conditions compared to the East Saint Paul model that you did a few years ago?

DR. HOLLAENDER: Hollaender speaking. That is a course project by student, which I cannot compare to results from a model, which is inside this review.

MR. DUNCANSON: Duncanson speaking. Sorry, sir, just to make sure that I heard you properly, you did not compare those models for the purposes of your technical review?

DR. HOLLAENDER: Hollaender speaking. As I mentioned, a course project by a student cannot be compared to model results by such an endeavour.

MR. DUNCANSON: Duncanson speaking. Dr. Hollaender, you mentioned, I believe, already this morning, the PhD thesis of Dr. Paula Kennedy in 2002. Is that right?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. DUNCANSON: Duncanson speaking. Would you agree that the focus of Dr. Kennedy's work included numerical groundwater modelling of the area west of Sio's proposed project?

DR. HOLLAENDER: I have not reviewed it at that time in detail. The parts which I looked during the review would include parts of that area.

MR. DUNCANSON: Duncanson speaking. Can you accept, subject to check, that the focus of Dr. Kennedy's work included numerical groundwater modelling of the area west of Sio's project?

DR. HOLLAENDER: Hollaender speaking. Yes. Detailed information can be given by Dr. Woodbury. 1

MR. DUNCANSON: Duncanson speaking. And you may need to take this subject to check as well, Dr. Hollaender, but would you agree that the groundwater model domain in Dr. Kennedy's work was further west and primarily focused on areas of elevated salinity?

DR. HOLLAENDER: Hollaender speaking. As far as I know, that is correct. But what I remember, the majority would be west.

MR. DUNCANSON: Duncanson speaking. Dr. Hollaender, are you aware that Dr. Kennedy concluded that the effects of density on the head values were quite small? Less than 0.12 metres, as the bulk of the head measurements are from relatively fresh zones?

DR. HOLLAENDER: Hollaender speaking. I have not reviewed the PhD thesis in that detail.

MR. DUNCANSON: Duncanson speaking. Recognizing, sir, that you've not reviewed that PhD thesis in detail recently, assuming that what I just read to you is in fact a statement in Dr. Kennedy's thesis, would you agree that, that would indicate that the density effect that she found was relatively small, despite the focus on areas west of the Aecom model domain?

DR. HOLLAENDER: Hollaender speaking. I don't think that I can agree. We did a study south of Winnipeg and Saint Germain, where an older borehole was drilled in the 1920s, was sealed with an old plug. The old plug failed and the whole community has saline water inside the carbonate acquire. The saline water came from the sandstone.

MR. DUNCANSON: Duncanson speaking. And -- and Dr. Hollaender, can you -- can you just confirm whether that location you just described as west or east of the Red River?

DR. HOLLAENDER: Hollaender speaking. This is south of Winnipeg, just directly on the highway -- Pembina Highway towards U.S. border, just south (inaudible).

MR. DUNCANSON: Duncanson speaking. And sorry, sir, just to be clear, was that west or east of the Red River?

DR. HOLLAENDER: The impacted area is south of the Red River there. So, you would consider it most likely west, southwest.

MR. DUNCANSON: Duncanson speaking. Another previous study that was referenced earlier this morning, was the Wang et al, 2008 study. You're familiar with that, doctor?

DR. HOLLAENDER: Hollaender speaking. Partially.

MR. DUNCANSON: Duncanson speaking. Are you aware that in that study, the authors developed and calibrated a numerical groundwater model for Southeast Manitoba?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. DUNCANSON: Duncanson speaking. To your knowledge or based on your knowledge of that study, Dr. Hollaender, in your view, were the authors able to reasonably calibrate the numerical groundwater model and simulate the groundwater flow system?

DR. HOLLAENDER: Hollaender speaking. I cannot comment on that. I have not reviewed this part of the thesis of this paper.

MR. DUNCANSON: Duncanson speaking. Thank you, sir. You -- you may not be able to answer this next question either, but I'll ask it anyways and let me know whether you can or can't. To your knowledge, Dr. Hollaender, did the authors of that study make note of any corrections in their model for density or salinity in their calibration efforts?

DR. HOLLAENDER: I have to apologize that I haven't looked into this study in that detail. If you like, Dr. Woodbury would be able to answer those questions.

MR. DUNCANSON: Duncanson speaking. Perhaps I'll pause there. My understanding was Dr. Woodbury was not available to answer questions of the technical review and my questions are -- are -- are for you, sir.

DR. HOLLAENDER: Sorry, for that, Mr. Duncanson. Hollaender speaking. Dr. Woodbury was not asked to join here. I was solely asked to come alone.

MR. DUNCANSON: Duncanson speaking. Dr. Hollaender, you stated in your presentation this morning that Sio's pumping test for the project assumed that the sandstone aquifer is confined. Is that right?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. DUNCANSON: Duncanson speaking. Would you agree that the key difference in approach between a pumping test for a confined aquifer versus an unconfined aquifer is the duration of the test?

DR. HOLLAENDER: The -- you talk about -- Hollaender, speaking, about two different things at this point. Unconfined and confined aquifers behave differently in that drawdown. And formation where the (inaudible) is above the interface of the aquifer to the next aquitard, in this case, the interface between the sandstone and the shale is considered confined. There are only two types of aquifer's definition. By definition, which are confined and unconfined version. A leaky system as discussed is in between these two systems.

MR. DUNCANSON: Duncanson speaking. Thank you. Dr. Hollaender, are you aware that standard industry practice in Canada is for a confined aquifer to run a 24- hour pumping test, and for unconfined aquifers is to run a 72-hour pumping test?

DR. HOLLAENDER: Hollaender speaking. I thought that had two of them.

MR. DUNCANSON: Duncanson speaking. I take that, sir, that you agree?

DR. HOLLAENDER: Hollaender speaking. Agreed.

MR. DUNCANSON: Duncanson speaking. Dr. Hollaender, are you familiar with the EAP that was prepared by Friesen Drillers in 2019 for the RM of Springfield's municipal groundwater supply?

DR. HOLLAENDER: Hollaender speaking. No.

MR. DUNCANSON: Duncanson speaking. Are you familiar with the EAP prepared for the City of Steinbach in 2015 for the proposed Park Road municipal supply well field?

DR. HOLLAENDER: Hollaender speaking. No.

MR. DUNCANSON: Duncanson speaking. Would you be surprised to know, Dr. Hollaender, that in both cases, for substantially larger volumes of net groundwater withdrawal than what Sio is proposing, they were supported by a single pumping test?

DR. HOLLAENDER: Hollaender speaking. I have not reviewed the work.

MR. DUNCANSON: Duncanson speaking. Fair enough. I will leave my questions on those EAPs there. Dr. Hollaender, you say in a few places in your report that Sio's proposed technology for its project is new and unproven. Do you recall saying that?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. DUNCANSON: Duncanson speaking. To be clear, would you agree that the technology itself, that Sio is proposing to use is widely used and well understood, it's the application of that technology to sand extraction that's novel?

DR. HOLLAENDER: Hollaender speaking. During drilling processes, there is airlifting, is a common process. Airlifting to mine sandstone is not common.

MR. DUNCANSON: Duncanson speaking. And -- and sir, I -- I take that to mean that the -- again, the -- the well technology itself is standard. It's the application of that technology that is in your view, new and unproven?

DR. HOLLAENDER: Hollaender speaking. Partially correct. It has to be considered that the airlifting inside the drilling system works inside the pipe, while this one is not always inside the pipe.

MR. DUNCANSON: Duncanson speaking. I'm sorry, sir, I didn't quite hear that, the last part. You're saying that the -- the air inside the pipe -- that there's air that's outside of the pipe as part of this method that's uncommon?

DR. HOLLAENDER: Yeah. So, it is slightly different. If you would have a picture of that, then we could probably discuss this.

MR. DUNCANSON: Duncanson speaking. Thank you, Dr. Hollaender. I think we'll come back to -- to that after lunch, but I'll just move to a few other questions before we break. Have you reviewed Dr. Ferguson's review of Aecom's model for the Sio project?

DR. HOLLAENDER: Hollaender speaking. I have shortly looked at that, yes, but I have not commented on it.

MR. DUNCANSON: Duncanson speaking. Dr. Hollaender, would you consider Dr. Ferguson to be a reputable expert in this field?

DR. HOLLAENDER: Dr. Ferguson is a reputable expert in his field.

MR. DUNCANSON: Duncanson speaking. And would you agree that he has extensive experience in this area?

DR. HOLLAENDER: Dr. Hollaender speaking. He was working for good time in this area.

MR. DUNCANSON: Duncanson speaking. Just before we break for lunch, Dr. Hollaender, I'm going to ask a few questions about calibration. You discussed one of the metrics for calibration this morning, which was that residual mean error should be minimized and close to zero, and you noted that Sio's mean error is roughly 3 metres in one area. Is that right?

DR. HOLLAENDER: Hollaender speaking.

That is not correct. Three metres over the whole area. It's not a specific area.

MR. DUNCANSON: Duncanson speaking. Yes, thank you for -- for that clarification. Would you agree that Aecom explained that 3 metre value last week when it was here to present? And they explained that that 3 metres was the result of historic data relating to the Red River Floodway construction and drilling practices around the City of Winnipeg?

DR. HOLLAENDER: Hollaender speaking. As I showed today, when you mix different dates from different measurements, that could be one of the outcomes.

MR. DUNCANSON: Duncanson speaking. But Dr. Hollaender, you -- you do acknowledge that, that specific issue with the calibration was something that was discussed specifically last week and Aecom's experts did explain the -- the cause of that 3 metre value?

DR. HOLLAENDER: Hollaender speaking. If you ask me this question directly, it was discussed.

MR. DUNCANSON: Duncanson speaking.

Thank you. And Dr. Hollaender, there were other calibration criteria that were discussed last week that you did not discuss in your presentation. For example, one of the criteria that Aecom discussed last week was normalized root mean squared error or RMS. Sorry, NRMSE. And based on the B.C. groundwater modelling guidelines, they discussed that anything under 10 percent is generally considered good, and anything under five percent is generally considered very good. Do you agree with those thresholds?

DR. HOLLAENDER: Hollaender speaking. Different jurisdictions have different acceptance. There is no groundwater code in Manitoba. So, we can apply as an example, the version from Alberta, or from British Columbia, or from any other province, or from another country. So yes, there are certainly some limits. And the thing is, with calibration is that you cannot cherry pick. All the versions which you use have to be in accordance to the guidelines. You cannot just say I'm using normalized main square error, which might fit, which fits in this case, but you can say, I neglect the issues shown by the mean error.

MR. DUNCANSON: Duncanson speaking.

And I -- and I appreciate that we should not cherry pick, which is why we think it's important to go through all of the criteria. Based on your knowledge and experience, Dr. Hollaender, would you agree that NRMSE values under 10 percent would generally be considered good for modelling calibration and values under five percent would be considered very good?

DR. HOLLAENDER: Hollaender speaking. As I mentioned just before, yes that are good numbers. However, we have to consider all values.

MR. DUNCANSON: Duncanson speaking. Thank you. And based on that metric, you would agree that Aecom's model would be considered very good?

DR. HOLLAENDER: Hollaender speaking. I cannot evaluate model based on one criteria.

MR. DUNCANSON: Duncanson speaking. To be clear though, Dr. Hollaender, based on that criteria, the Aecom model would be considered very good?

DR. HOLLAENDER: Hollaender speaking. Industry standard is not to evaluate one parameter.

MR. DUNCANSON: Duncanson speaking. Okay. We'll move on to the next parameter. Aecom last week discussed a correlation coefficient and if a model has a correlation coefficient of at least 0.95, it would be considered calibrated. Do you agree with that?

DR. HOLLAENDER: Hollaender speaking. That is the weakest criteria, which is there in -- in statistics. It fits more or less for every model.

MR. DUNCANSON: Duncanson speaking. Dr. Hollaender, you do agree that consideration of correlation coefficient is one of the metrics considered for calibration?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. DUNCANSON: Duncanson speaking. And based on that metric, would you agree that Aecom's value of roughly 0.99 would be considered well calibrated?

DR. HOLLAENDER: Hollaender speaking. As I mentioned before, industry standard is not just to evaluate one parameter only.

MR. DUNCANSON: Duncanson speaking. Recognising that, sir, we'll move to another metric, which is the global mass balance. And Aecom discussed that as well last week, and discussed based on various sources that it is generally considered -- a model is generally considered to be well calibrated when it has a global mass balance of less than 0.05 percent error. Do you agree with that?

DR. HOLLAENDER: Hollaender speaking. That is incorrect. The mass balance of the model has nothing to do with calibration.

MR. DUNCANSON: Duncanson speaking. So, just so that I'm clear, Dr. Hollaender, you disagree with consideration of global mass balance in the context of model calibration?

DR. HOLLAENDER: Hollaender speaking. The global mass balance tells you how much water flows into the model and how much flows out of the model. And it describes the mass, which is lost or won inside the model by the numerical calculations. A low value like in this -- this exercise is required to present any data. If you have large values here, you cannot present this data at all. So, it is a requirement to present data for calibration. It's not part of the calibration.

MR. DUNCANSON: Duncanson speaking. So, based on that, Dr. Hollaender, would you consider that the -- the three metrics, three primary metrics for calibration would be residual mean error, NRMSE, and correlation coefficient?

DR. HOLLAENDER: So, the remaining ones, if I remember right, were the mean error, the normalized mean square error, and the error square value. I cannot recall at this point, whether there was a fourth one. You might help me in this case.

MR. DUNCANSON: Duncanson speaking. Sir, would you agree that with the exception of the 3 metre value that you discussed this morning with respect to residual mean error, the other metrics would all suggest that Aecom's model is well calibrated.

DR. HOLLAENDER: Hollaender speaking. We talked now, 10 minutes about cherry picking, and it doesn't change the way that all the parameters have to be inside acceptable levels.

MR. DUNCANSON: Duncanson speaking. I think you and I may have different understandings of the term cherry picking, but we can -- we can leave that -- that alone. Would you agree with the statement, Dr. Hollaender, that no calibration is ever perfect?

DR. HOLLAENDER: Hollaender speaking. I presented this morning that we simplify the nature to put this into a model to predict states. Therefore, any model cannot be perfect and also the calibration cannot be perfect.

MR. DUNCANSON: Duncanson speaking. Dr. Hollaender, are you familiar with the term, model forcing?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. DUNCANSON: Duncanson speaking. Can you explain what that term means?

DR. HOLLAENDER: Generally, we talk about this in terms of parameters and boundary conditions, which we apply to certain models to fit in most cases the observed -- observed -- observed data. As I mentioned also, the questions by Jason Mann, that this is not possible. Not Jason Mann, I'm sorry for that. This morning was not Jason Mann, but it's not possible by all time. It's Mister -- sorry, I forgot your name.

MR. DUNCANSON: Mr. Chair, I'm about to move on to a new line of questions and we're almost at 12:30. Would you like me to break now or continue?

THE CHAIRMAN: Chair. I think this might be a good opportunity for a break. So, let's regroup at 1:30, please. Thank you.

THE CHAIRMAN: The -- well, let's see, the four of us, the two of you, and one, we have, whatever that adds up to, eight. We have the eight of us in our -- eight people are in their important seats. So, let's -- let's proceed, please.

MR. DUNCANSON: Thank you, Mr. Chair. Sander Duncanson, speaking again. Dr. Hollaender, I'm going to start with a few follow up questions to some of the things we talked about before lunch. First, we talked a little bit about the model around East Saint Paul that was presented in 2018. And I believe you said that, that information was not reviewed as part of your work for this project. But you would agree that the information about that model is publicly available?

DR. HOLLAENDER: Hollaender speaking. This information not publicly available.

MR. DUNCANSON: This is Duncanson speaking. So, just to be clear, Dr. Hollaender, you're saying the information about that model is not publicly available?

DR. HOLLAENDER: Hartmut Hollaender. This is (inaudible) literature. It was presented to the RM Springfield to a small amount on the council, and it was part of the discussion of ongoing in investigations. So, this one more for the RM Springfield for the council and the discussion of additional research in that area.

MR. DUNCANSON: Duncanson speaking. You would agree, Dr. Hollaender, that information about that model was also presented at CGS Edmonton?

DR. HOLLAENDER: I have to look into my literature part, whether -- which kind of information were given there. I need the title and I would need to look it up.

MR. DUNCANSON: Duncanson speaking. Would it surprise you to know that Aecom did review the results from that model and both in terms of hydraulic conductivity and specific storage, that model produced very similar results to Aecom's model?

DR. HOLLAENDER: As I said, I cannot comment on that because we have not used this, but if you say so, I certainly somehow trust you in this (inaudible) direction. But -- yeah. I -- I cannot agree or disagree at this point.

MR. DUNCANSON: Duncanson speaking. Definitely don't take my word for it. I think that's something that Aecom can probably speak to in rebuttal next week. One of the things we talked about this morning, Dr. Hollaender, is the concept of industry standard. In your view, do you have a good understanding of what's considered industry standard in the mining industry in Manitoba?

DR. HOLLAENDER: I have good understanding what is the industry standard for brown water models. Whether this are for water works or for my industry, that is something that is not much different. The amount of information in Manitoba is very complicated because in the end, there's no exact document, guideline, how long what the models have to be in Manitoba for specific systems.

MR. DUNCANSON: Duncanson. Just to be clear, Dr. Hollaender, setting aside the distinction between mining projects and other projects, in your view, do you have a -- a good sense of what is considered industry standard in ground modelling for EAPs in Manitoba?

DR. HOLLAENDER: So, EAP should look at the impact of certain endeavour, in this case, the mining. So, we have a regional model here, which shows some impact. Model something like Aecom, some impact. And a couple of these questions were discussed in the final report.

MR. DUNCANSON: Duncanson speaking. So, just so that I'm clear on the answer to my question, recognizing, certainly not disputing Dr. Hollaender, that you're an expert in groundwater modelling, but in terms of what is considered industry standard for EAPs in Manitoba, in your view, do you have a good sense of what industry standard for EAPs is, in Manitoba?

DR. HOLLAENDER: I have reviewed a couple of groundwater models. And so, I have grasp what is the required for groundwater models. And I'm producing every day, groundwater models in our jurisdiction. Germany, it's a bit easier because there's a federal guideline for groundwater models, as an example. And you talked about the normalized means (inaudible). It's because one of the parameters which we also should fit there, the requirement is 5 percent, and the accepted tolerance is 2 percent in Germany, just as an example. Didn't use here in Canada because -- yeah. Other ways, like we see what you used. But there are a lot of jurisdictions were having different parameters. I think we talked about this, this morning too. And -- yeah. Still extends to the point that certainly this can be discussed in (inaudible) because there's no own guideline.

MR. DUNCANSON: Duncanson speaking. And just to close this off, Dr. Hollaender, so I -- I heard you say that you have reviewed a handful of the EAPs, but would it be fair to say that most of the groundwater models that you've been involved with in Manitoba have been either for academic or government purposes?

DR. HOLLAENDER: For Manitoba, that is correct.

MR. DUNCANSON: Duncanson. Thank you. Would you be able to estimate, Dr. Hollaender, how many reports you have personally stamped with your (inaudible) stamp in Manitoba?

DR. HOLLAENDER: I can mention that. It's not much.

MR. DUNCANSON: Duncanson. I think -- I think that's sufficient. One of the things we talked about this morning with the technology that Sio is proposing to use for its extraction. And one of the things, Dr. Hollaender that you mentioned that is different in your view about what Sio is proposing as compared to other water well technology, is that Sio will be injecting error into the aquifer below the production pipe. Did I get that right?

DR. HOLLAENDER: More or less, that is correct.

MR. DUNCANSON: Duncanson. Are you aware, Dr. Hollaender, that as part of its EAP that is being considered by this commission, Sio is not in fact proposing to inject air below the bottom of the production pipe?

DR. HOLLAENDER: I assume that, as I said, this was, first of all, not part of the analytical assessment, but some of the figures which I saw maybe more than misleading.

MR. DUNCANSON: Duncanson. Sorry, Dr. Hollaender, can you just state the end of that response again? I didn't hear you.

DR. HOLLAENDER: Would have been to -- to have the -- the schematic at this moment. But first of all, I mentioned that the mining or the well itself, was not part of the evaluation. We did not comment on that too much. The result is the quote with you gave this morning, that it is partially improvement that it works in that way. But some of the drawings or this schematic drawings which you started with on Monday is definitely a bit misleading because also the cycling on the flow of water, which is induced by the small errors is definitely a bit different than it should be when you induce a flow at that time. So, there's input. So, it is difficult to understand fully what is meant there.

MR. DUNCANSON: Duncanson. Dr. Hollaender, I just want to -- to make sure that I understand this. And -- and apologies, that I don't have the schematic up on the screen. I'm not as technologically advanced as some of my colleagues, it appears. But do I understand that you're saying, so, on the one hand, I think I heard you say that, you know, a review of the technology was not within the scope of -- of your technical review. But then I think I heard you say that the schematics were misleading in -- in how they were presenting the water flow?

DR. HOLLAENDER: So, if I remember

right, you might correct me. Hartmut Hollaender speaking. There is outer pipe and an inner pipe. And the inner pipe is a production pipe. The production pipe goes below the injection pipe, which you have there. And this in the end induces the flow of fluid, which goes to the side, and then it would come down from the bottom to the (inaudible). That is also which would fit with the scanned solar, which you have presented last week. However, the review of the -- of the well itself was not part of our report and of the job.

MR. DUNCANSON: Duncanson speaking. Dr. Hollaender, are you aware that with air rotary and dual rotary drilling, the bit for the drill is below the bottom of the casing?

DR. HOLLAENDER: Yeah. It has to be below the casing because else it could not drill.

MR. DUNCANSON: Duncanson speaking. And that means that air is injected into the formation below the bottom of the casing with that type of drilling?

DR. HOLLAENDER: There are different ways. So, the one which is used most like -- in most in most areas they just use it above that, but I'm sure that there's also technique where there will be (inaudible) press that in. But -- yeah. That is not what I'm aware of at this point.

MR. DUNCANSON: Duncanson speaking. And I think this will be my last question on this. For the drilling techniques where the air is injected below the bottom of the casing, are you aware of any adverse effects on groundwater quality associated with that type of drilling technique?

DR. HOLLAENDER: I cannot comment on that. Hollaender, speaking, because I'm not an expert on -- on drilling. And as I said, we -- we didn't also review the drilling process exactly.

MR. DUNCANSON: Duncanson speaking. Thank you. Dr. Hollaender, I'll finish that line of questions there. I think the -- the last topic that we touched on this morning that I just have a quick follow up questions about relates to calibration. And I'm not going to go through all the things we talked about before lunch again. But when you were discussing that figure, Figure 6-3, in Aecom's work, and I don't know if we can pull that up on the screen, but you were -- you were discussing that with ---

DR. HOLLAENDER: It is up there.

MR. DUNCANSON: Thank you. Duncanson speaking. And if you recall when you were speaking with Mr. Williams, you -- you talked about the cluster of -- of red and pink dots. Do you recall that?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. DUNCANSON: Duncanson. And Dr. Hollaender, would you agree that the majority of the red and pink dots in this figure are located in the vicinity of the Red River Floodway and the City of Winnipeg?

DR. HOLLAENDER: Hollaender speaking. The majority is a wide word. Means only the majority. It doesn't talk about quality and quantity. So, I better not to answer because that would be a very misleading answer.

MR. DUNCANSON: Duncanson speaking. Just in terms of the number of and concentration of the pink dots and the red dots that are shown on this figure, you would agree with me that the -- that most of those dots are located in the upper left portion of the figure, which is in the vicinity of the Red River Floodway in the City of Winnipeg?

DR. HOLLAENDER: Hartmut Hollaender. As I showed this morning in my presentation, this is a constant bias starting at about 275 metres below sea level. The lowest heads along the Red River. So therefore, the area along the Red River are certainly the largest that was shown nicely, I think this morning on that presentation.

MR. DUNCANSON: Duncanson speaking. Thank you for that, Dr. Hollaender. If Aecom had removed those outlier data points, would it be reasonable to expect that that would have improved the calibration results?

DR. HOLLAENDER: Hartmut Hollaender. I cannot talk about removing outliers because outliers could be a data error. It could be also, a true measurement and false mistakes. So, it is difficult to comment on this at this point with this is information.

MR. DUNCANSON: Duncanson speaking. That's fine. We can let the Aecom experts speak to that. But just to make sure that you have an opportunity as well, to speak on this, Dr. Hollaender, we talked before lunch about how Aecom's experts had explained that those outlier points -- would you agree that those outlier data points were also discussed and explained in that Kennedy and Woodbury work that we've talked about, as well as the Wang et al, 2008 study?

DR. HOLLAENDER: Yes. So, outliers, Hollaender, speaking, have to be certainly discussed. And the discussion is certainly in this report, but this is at a certain distance to the -- yeah, the investigation area where the mine -- proposed mine should be. We get the discussion this morning about the details, how the quality is in the project area. There were some discussion on that. And I think this would be helpful if Aecom potentially would discuss these (inaudible) again.

MR. DUNCANSON: Duncanson speaking. I think we might take you up on that invitation, Dr. Hollaender, as part of our rebuttal next week, but I'll -- I'll -- I'll leave that for now. And just so that people who are less familiar with groundwater modelling than yourself, in this room, are clear, when we're talking about a mean error of about 3 metres, would you agree that seasonal variability in this area is in the range of roughly 2 to 3 metres?

DR. HOLLAENDER: Hollaender speaking. Yeah. That is a hard rocket probably in the range of a few metres. Important to understand that this data was derived from mean values. That means, the seasonal impact was removed by the filtering as far as I understood. And therefore, the seasonal effect would not be a reason for such changes.

MR. DUNCANSON: Duncanson speaking. Thank you, sir. I think that the reason we ask that question is simply just to help convey the magnitude of -- of what we're talking about here in terms of what 3 metres represents. But I think we're ---

DR. HOLLAENDER: Do you like that I comment on that? Is that a question or was it only a comment from you?

MR. DUNCANSON: Please, go ahead.

DR. HOLLAENDER: This is -- so, one of the things which I didn't include in today's presentation, were the results. The results showed last week, but there's drawdown of 25 metres maximum in one aquifer, eight metres in the other aquifer. But that was related to the point that certainly, there was an impacted area, and this impacted area of 200 metres in diameter was exchanged by the sandstone formation. So, we discussed already, that on a local scale, the flow pattern would be most likely different than this regional model. And so, this head differences cannot be judged at this moment. So, we have to judge in the end, the -- the value of what -- what puts this mine -- mine operation do, against that what we have as an average error in terms -- looked at this moment. That the error in this impacted area, this mining area, you see a lot of dots, which are in this orange range, between 5 and 10 metres. And that is something which we should relate to that what we are predicting afterwards. That is the error. This one, I have not included because again, I could not review this work, but there's definitely an interesting point, which you might want to pick up in the discussion in the next 1 1/2 weeks.

MR. DUNCANSON: Duncanson speaking. Thank you, Dr. Hollaender. Are you familiar with the term, representative elementary volume?

DR. HOLLAENDER: Yes, I am aware of REVs.

MR. DUNCANSON: Duncanson speaking. And would you agree that heterogeneity in a formation can be captured within REV in a groundwater model?

DR. HOLLAENDER: REV, means representative element volume, because you have a certain area, a certain volume, Hollaender, speaking, by the way. I'm sorry for that. So, the REV has unique unit -- unit value. Might be 10^{-4} m/s for hydraulic conductivity. But doesn't mean that the next REV is the same property. It can be the same property. Then you could include them together to one REV, or it can also be different. So, we have certainly, a model, has not only one REV, it has many REVs.

MR. DUNCANSON: Duncanson speaking. Just so that I'm clear, Dr. Hollaender on the answer to my sort of general conceptual question, you know, when we're talking about the concept of, you know, homogeneous aquifers and heterogeneous aquifers, you would agree conceptually that heterogeneity can be captured within representative elementary volume in a groundwater flow model, right?

DR. HOLLAENDER: If you have several REVs, then you can do that. Within one REV, it can only be done by -- it cannot be done because the standard has one system.

MR. DUNCANSON: Duncanson speaking. So, just so that I'm clear, Dr. Hollaender, you're suggesting a single representative elementary volume cannot capture heterogeneity within an aquifer?

DR. HOLLAENDER: Not enough, no. Hollaender speaking.

MR. DUNCANSON: Duncanson speaking. On Slide 9 on your presentation, you -- you mentioned the Kennedy and Woodbury study. And you note that, that study shows heterogeneous aquifer properties in the study area. Would you agree that looking at what properties were actually described in that study, the magnitude of the heterogeneity is actually low?

DR. HOLLAENDER: Hollaender speaking. If I remember right, the magnitude of -- is about (inaudible) standard deviations.

MR. DUNCANSON: Duncanson speaking. Sorry, sir, could you just repeat the end of that response just so that I can make sure I heard properly?

DR. HOLLAENDER: Hollaender speaking. As far as I know, the standard deviation is about 1.9 (inaudible) scale.

MR. DUNCANSON: Duncanson speaking. Dr. Hollaender, would you consider that value to be a low value in relative terms for heterogeneity in terms ---

DR. HOLLAENDER: Hollaender speaking. So, when we talk about hydraulic conductivities as presented also by Aecom last week, Dr. Harvey mentioned that all this small lines, which we were seeing, there's dotted lines, were one order of magnitude. So, when we have hydraulic conductivity as an example of 10^{-5} and we have a gradient, a certain gradient, which comes maybe to a flux of -- over certain cross section that, let's say, of a 100 cubic metres per year. As an example, we would increase this by one order of magnitude, to 10^{-4}, then the (inaudible) boundary would be coming from hundred to thousand. So, that's always what you do. And we talk about nearly two orders, two log cycles, then we're talking here about the factor hundred. So, the factor based on that standard deviation, you know that this is 43 percent in both directions. So, we cover 47 percent of the total accumulation. And if you would cover three standard deviations, we would always cover 97 percent of this. So, it's -- it's based on this (inaudible) function. It only covers a certain the amount, but that range is pretty large. We talk here about seven magnitudes.

MR. DUNCANSON: Duncanson speaking. Thank you, Dr. Hollaender. And the -- the Wang et al, 2008 study, which is one that been referenced a few times today by yourself and others, you would agree that, that study found that the average hydraulic in the Winnipeg sandstone aquifer is very uniform?

DR. HOLLAENDER: I would need to get this table again. I cannot recall this directly.

Hollaender speaking.

MR. DUNCANSON: Duncanson speaking. Would you accept that subject to check?

DR. HOLLAENDER: Yes, I accept that subject to check.

MR. DUNCANSON: Duncanson speaking. Sir, we discussed saline water a little bit earlier, and -- and you have elsewhere as well. In terms of -- of sort the -- the definition of -- of what's considered saline versus brackish, versus fresh, versus brine water, would you agree that saline water is generally considered between 10,000 and 35,000 at TDS milligrams per litre?

DR. HOLLAENDER: The definition which you used would be used for most countries as brackish water. So, saline water is salt water. We define as more than 35,000, below 35,000 somewhere between fresh and -- and salt water. Therefore, you would call it brackish water, but saline water itself, it is something -- exact definition for that, I probably would -- would start -- it's definitely in the brackish area. So, it might be in that range. But the key definition is fresh, brackish, salt water, that would be 0 to 10,000, 10 to 35,000, 35,000 to larger milligrams per litre each.

MR. DUNCANSON: Duncanson speaking. And just to follow up on that, Dr. Hollaender, you would agree that freshwater water is generally considered below 2,000?

DR. HOLLAENDER: Yes. So, if you have total fresh water, which is therefore agricultural drinking water purposes, this has to have at least below 2,000. A jurisdiction would even have lower definitions of (inaudible).

MR. DUNCANSON: Duncanson. Thank you. Just shifting to a -- a new area, Dr. Hollaender, you talk in your presentation this morning about trace metals leaching into water. Do you agree that trace metals are mainly contained in sulfides? And without sulfide oxidization -- oxidation at -- those metals would not typically be released?

DR. HOLLAENDER: Yeah. So, trace metals are not really related to sulfides. So, (inaudible) metals are metals which have a very low concentration, and which have a potential impact on human health. Certainly, if you talk or if you join this to answers, and you want to look about the release of -- of the trace metals, then we can certainly talk about acid mine drainage. That is probably the -- the -- the -- the target of your question.

MR. DUNCANSON: Duncanson speaking. In your view, Dr. Hollaender, what would drive pH and redox changes in the aquifer in the absence of oxygen?

DR. HOLLAENDER: So, when we have no oxygen then the redox stage is very simple. It is either unoxic, which means we have still some, like, nitrates, where some oxygen is bound, or we have no oxygen at all, then it is anaerobic. So, when we have no oxygen in use, then there is also no change in the redox states.

MR. DUNCANSON: Duncanson speaking. Thank you, Dr. Hollaender. On this topic, you mentioned in your presentation that Aecom did not consider changing conditions. Do you recall saying that?

DR. HOLLAENDER: At least it was not visible enough in the report. Hollaender speaking.

MR. DUNCANSON: Duncanson speaking. Sir, are you aware that there was an entire section in the hydrogeology and geochemistry report that specifically assessed the potential changes in redox conditions?

DR. HOLLAENDER: Yes. There was a section on that. That's correct. Hollaender speaking.

MR. DUNCANSON: Duncanson speaking. So, sir, when -- when you say that Aecom did not consider something when there's an entire section in the report that's dedicated to assessing that thing, can you explain what you mean by that? What do you mean by, Aecom did not consider something when they have an entire section in their report that describes it.

DR. HOLLAENDER: Hollaender speaking. So, the numerical model which was used (inaudible) model, the geochem model to -- to look at the water quality afterwards, did not look at the solution.

MR. DUNCANSON: Duncanson speaking. And -- and you talked this morning, about the default Pe. When you reviewed that section in the Aecom report that dealt with potential changes in redox conditions, did you understand that the oxygen partial pressure in that assessment was set to atmospheric conditions, not a default Pe?

DR. HOLLAENDER: The redox condition is not atmospheric conditions. Redox is -- is a voltage. And -- and this voltage can be put on a log scale. And that is what would be the value of Pe. So, these two units don't fit. Maybe you have to rephrase your questions so that I can understand it.

MR. DUNCANSON: Duncanson speaking. So, sir, the oxygen partial pressure in the assessment was set to atmospheric conditions. Was that something that you were aware of or did you understand?

DR. HOLLAENDER: Then that would be (inaudible).

MR. DUNCANSON: Dr. Hollaender, your -- your testimony is that would result in a Pe of equal to 4?

DR. HOLLAENDER: So, you -- you see the

partial pressure of the atmosphere. So, you have oxic conditions. Is that correct?

MR. DUNCANSON: The danger of asking someone like me these questions, Dr. Hollaender, I don't think I'll be able to answer that for you. And sorry, this is Duncanson speaking. But my question to you was just to make sure that I'm clear that your understanding is, if the oxygen partial pressure that was in the assessment was set to atmospheric conditions, in your view, that translates into a Pe of 4?

DR. HOLLAENDER: I would need to review that. I could maybe talk this after the -- after the break.

MR. DUNCANSON: Duncanson speaking. That's -- that's acceptable. Dr. Hollaender, did you review the draft waste characterization and management plan that Sio filed prior to the hearing?

DR. HOLLAENDER: Only shortly. Hollaender speaking.

MR. DUNCANSON: Duncanson speaking.

Within that plan, do you understand that Sio is proposing to conduct additional sampling work prior to commencement of operations?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. DUNCANSON: Duncanson speaking. And would you agree, Dr. Hollaender, that containing waste rock and removing it from the project site and disposing -- disposing of it in a licensed facility, that is more protective of ground water than conventional well drilling practices, where drill cuttings are typically just left on the surface?

DR. HOLLAENDER: The material brought to a designated site is according to best management practice.

MR. DUNCANSON: Duncanson speaking. I think that, that officially answers my question. And Dr. Hollaender, we've -- we've talked a little bit about geochemistry, and you talk in your presentation about geo chemistry. Do you have any degrees in geochemistry?

DR. HOLLAENDER: Hollaender speaking. Geochemistry is a small part of the education. I worked on geochemistry for a couple of years during my time when I was a regulator in Germany.

MR. DUNCANSON: Duncanson speaking. So, just to be clear, Dr. Hollaender, you do not have any degrees in geochemistry. Correct?

DR. HOLLAENDER: That would require an own study. I have a degree in civil engineering.

MR. DUNCANSON: Duncanson speaking. And sir, would you consider yourself an expert geochemist?

DR. HOLLAENDER: Hollaender speaking. Expert is always a (inaudible) by definition. I can definitely comment on -- on geochemistry, and have done that in a couple of projects.

MR. DUNCANSON: Duncanson speaking. Have you completed waste characterization programs for mining projects across Canada or anywhere in Canada?

DR. HOLLAENDER: Hollaender speaking.

No.

MR. DUNCANSON: Duncanson speaking. And do you have experience with predictive water quality models using common modelling techniques such as PHREEQC?

DR. HOLLAENDER: Hollaender speaking. Yes.

MR. DUNCANSON: Duncanson speaking. And just to be clear, Dr. Hollaender, on the extent or scope of your experience with those models, have you, yourself, developed models using those programs?

DR. HOLLAENDER: Hollaender speaking. I expect that you mean whether I have analyzed water samples and predicted water quality directly? Is that correct? Was that your question?

MR. DUNCANSON: Duncanson speaking. Let's -- let's go with that question.

DR. HOLLAENDER: I've done that in the terms of nuclear waste storage.

MR. DUNCANSON: Duncanson speaking. And sir, you've done that in the context of nuclear waste storage. Have you done that in the context of any mining project?

DR. HOLLAENDER: The requirements for nuclear storage are much higher. So, it would be not an issue to do that also at -- at mining areas.

MR. DUNCANSON: Duncanson speaking. But just, Dr. Hollaender, so, just so that we're clear, I take it that you think you could do that work for a mining project, but -- but you have not, in fact, done that work for any mining project?

DR. HOLLAENDER: Hollaender speaking. That's correct.

MR. DUNCANSON: Duncanson speaking. On Slide 29 of your presentation this morning -- thank you. There was discussion of an assumption of one percent waste rock. Can you explain what data that value -- what data was used to produce that assumption of one percent waste rock?

DR. HOLLAENDER: That was a minimum amount, which I expected. So, there is more data on it. Just as you see, this is an assumption. The assumption is taken daily when you have no data. I have no access to Sio Silica's data.

MR. DUNCANSON: Duncanson speaking. Thank you. And on the next slide, Slide 30, you discuss the ratio of fluids to solids. And you talked about using a ratio of 2:1 fluid to sand, as opposed to 1:1. And I think I heard you say that, that was based on discussions that you had with colleagues in the drilling industry in Germany?

DR. HOLLAENDER: Hollaender speaking. That's correct. So, it might be 1:1, but we had the discussion on the 1:1. I discussed with them whether airlifting would be able to do that, and they said, no. That 2:1 is something which they could reach. But why I used this? If you use 1:1, then the numbers become (inaudible). That's correct.

MR. DUNCANSON: Duncanson speaking. And just so that the commission is clear, Dr. Hollaender, the colleagues that you discussed this with in Germany, did they have any specific experience with Silica sand in Manitoba?

DR. HOLLAENDER: They have no information about Canada drilling techniques.

MR. DUNCANSON: Duncanson speaking. You talked about this a little bit this morning in your presentation. But in your report, you state that the Winnipeg Shale layer is currently non-existent, cracked, and/or pervious in the areas where Sio conducted its groundwater testing, correct?

DR. HOLLAENDER: That is possible. Hollaender speaking.

MR. DUNCANSON: Duncanson. Just so that we're clear, Dr. Hollaender, that is in fact, what you stated in your report, correct?

DR. HOLLAENDER: Hollaender speaking. That is exactly what is given on -- on Slide 9. So, the reasons for the drawdown should be -- are leaking conditions. The leaky conditions can be to different systems. It can be a fracture, it can be wells, it can be the non-existence of information. There have a reasons which are not completely clear.

MR. DUNCANSON: Duncanson speaking. And -- and you mentioned a few times earlier before lunch, the -- the dots on the map that we're shown in the Kennedy thesis, showing roughly 500 interconnecting wells. And you're aware as well, that the Wang et al study claimed over 1,000 interconnecting wells in the region?

DR. HOLLAENDER: Hollaender speaking. There's considerable number of wells which are interconnected. Probably, that's what we can agree on.

MR. DUNCANSON: Duncanson. Based on this, and -- and I -- I guess, what I understood you to be saying this morning and in your report, is that the shale layer is not currently acting as an effective barrier to intermixing between the aquifers, and that's why the Winnipeg Sandstone should not be considered a confined aquifer. Is that right?

DR. HOLLAENDER: Hollaender speaking. It is a leaky aquifer shown by the drawdown data carried it out by the pump test by Sio Silica.

MR. DUNCANSON: Duncanson. And would you agree, Dr. Hollaender, that what that means for people like myself who aren't familiar with terms, leaky aquifer, that means that the shale is not currently acting as a barrier to intermixing between the -- the aquifers. Is that right?

DR. HOLLAENDER: Hollaender speaking. Partially correct, partially not correct. It's again, the reasons what -- what -- what is the reason for the leaky behaviour? If it's an intact formation, we can still have a drawdown of 1 or 5 metres, I would agree because there could be some exchange. We have seen pictures last week from Sio Silica, but you cut into the knife as a shale. So, it is very soft, but it's obviously full of water. You also stated last week that the water inside the sandstone and the carbonate is (inaudible), but the one inside the shale is not. That's ancient. That is (inaudible) it. That means that there's no flow through this. So, it seems to be that the best discussion would be the interconnected wells that water can go through to connect to wells and allow this drawdown. However, this is only assumption of this point because I have not looked further into all this data, but that would be the most --

yeah, would probably be my assumption at this point.

MR. DUNCANSON: Duncanson speaking. So, Dr. Hollaender, you do agree that there is currently intermixing of water between the two aquifers, correct?

DR. HOLLAENDER: Hollaender speaking. That could -- could happen. It could be easily identified by looking at ground water elevation maps, table maps, from the past and the present.

MR. DUNCANSON: Duncanson speaking. Just so that I'm making sure that I'm getting a clear answer to my question, it was not whether there could be intermixing, it's that, based on the -- the information that you have, there is in fact, intermixing of water?

DR. HOLLAENDER: Hollaender speaking. I expect that happens on local scale, yes.

MR. DUNCANSON: Duncanson. Thank you. On Slide 26 of your presentation, you state there that failure of the Winnipeg Shale was not considered in the HAFR. And then you note that -- that it was addressed in the updated groundwater model that was presented last week, but you did not have time to review that work. Do you understand Dr. Hollaender, that Aecom used the same modelling parameters in the HAFR that it did in the updated modelling work that was presented last week?

DR. HOLLAENDER: Mr. Miln mentioned last week that the properties of sandstone was used instead of the shale, if I remember right.

MR. DUNCANSON: Duncanson speaking. But you -- you understood, sir, that, that was the case for both models? The -- the model parameters did not change between the original HAFR and the updated results last week?

DR. HOLLAENDER: Yes. However, sandstone information is equal to a void. A void, we discussed, has, first of all, on anisotropy, we're talking about 10:1, That means, the value from the shale would be reduced from, I think it's at three 3×10^{-5} to 3×10^{-6}. And also, the value would be unlimited. So, it has very, very large values. So, that was not -- still not considered.

MR. DUNCANSON: Duncanson. Perhaps

we're speaking past each other, Dr. Hollaender. I thought I heard you say this morning, that this concept of shale failure was not considered in the original HAFR, but it was considered in the work that was done last week, but it was just recently provided, and so, you hadn't had time to review it. But I just want to make sure that I'm clear on this. You do understand that the parameters of the model were the same in the original HAFR work that was done, and the updated model run that was presented last week?

DR. HOLLAENDER: Hollaender speaking. I understood, Mr. Miln that way, that 200 metres new, that they were smaller before. So, that's what I expected would be a change. However, I might have misunderstood that.

MR. DUNCANSON: Duncanson speaking. Thank you, Dr. Hollaender, for clarifying that. And this is a similar theme as to what I asked Mr. Wiatzka -- we asked about yesterday. But you recall that before you finalized your technical review report for the Sio project, you met -- you had a meeting with Sio's technical advisors, including Aecom?

DR. HOLLAENDER: Hollaender speaking.

That is correct.

MR. DUNCANSON: Duncanson. And do you recall Dr. Hollaender, expressing that concern during the meeting? That it did not appear as though Aecom had considered shale failure in their model?

DR. HOLLAENDER: Hollaender speaking. This meeting was pretty short. I think we had, if I remember right, a three hours meeting, the geotechnical part. After that was 1 1/2 hours already gone. So, we not able to discuss a lot of things at that meeting.

MR. DUNCANSON: Duncanson. So -- so that I'm clear, Dr. Hollaender, you do not recall specifically raising that as a concern to Aecom that it did not appear as though, to you, shale failure had been considered as a possibility in the Aecom model?

DR. HOLLAENDER: Hollaender speaking. I would need to review the -- the recording for that.

MR. DUNCANSON: Duncanson. And you may have the same answer to this question as well, Dr. Hollaender, do you recall that Mr. Mills explained to you during that meeting that while the scenario is assessed in the model were characterized as assessing degraded shale, what that meant was, the shale layer was eliminated for the purposes of the model? Do you recall?

DR. HOLLAENDER: Hollaender speaking. We talked about degradation. And so, degradation in failure is -- is the difference. And so, failure is -- it is not there anymore. Degradation means I apply a new hydraulic connectivity. That's what (inaudible) was done. So, by changing the parameters from shale to sandstone. And to change is certainly large. I think remember right. If we were the order of 10^{-8} afterwards, we have an order of 10^{-5} divided by 10. So, 10^{-6}. But still, that is an effective barrier of one aquitard.

MR. DUNCANSON: Duncanson speaking. So, did you understand, Dr. Hollaender, based on the meeting you had with Aecom before your technical review was finalized, did you understand that in fact, when they talk about degraded shale, what the meant was, they assumed in certain scenarios that the shale would be eliminated?

DR. HOLLAENDER: Hollaender speaking.

Degradation of shale by changing the properties from shale to sandstone is not a failure.

MR. DUNCANSON: Duncanson speaking. So, just so that I'm clear, sir, from a groundwater flow perspective, eliminating the -- the shale layer and effectively converting it to the sandstone, your view is, from a groundwater flow perspective, that is not assessing the potential for shale failure?

DR. HOLLAENDER: Hollaender speaking. I like to try to give an example. So, when we assume the 10^{-8}, I don't know the exactly the number. Mr. Miln might be able to help me. And we would have over a certain stretch. Let me say, one hector in exchange of one cubic metre per year. If we exchanges to the sandstone, properties of 10^{-6} vertically just becomes 100 times more. So, it would come from in a year then for the (inaudible) 200 cubic metres per -- per year. However, if we would extend this to a non-existent shale, this value would be much, much larger, and it would be much faster because it would reach the equilibrium very, very fast, and the value would be another five, six magnitude larger in the first moment.

MR. DUNCANSON: Duncanson. Dr. Hollaender, would you agree that the sandstone around the void would still provide resistance to exchange of water between the two aquifers?

DR. HOLLAENDER: Hollaender speaking. We saw on the geotechnical pictures last week, that there are some area, which was supported by sandstone. We saw some areas which are not supported by sandstone.

MR. DUNCANSON: Duncanson. So, just so that I'm getting my -- an answer to my question, in those void spaces, do you agree that the sandstone around those void spaces would still restrict movement between the two aquifers?

DR. HOLLAENDER: Hollaender speaking. In the area of collapse, there would be no support. In the area outside collapse, there would be a support.

MR. DUNCANSON: Duncanson. And Dr. Hollaender, just so that we're clear on this, that -- that sandstone surrounding the void would provide resistance to groundwater flow, correct?

DR. HOLLAENDER: Hollaender speaking. Dr. Harvey explained last week that the mesh around this well would be 5 metres. You saw cavities with this span of 40 to 60 metres. So, it would be possible to apply to some of the notes, the hydraulic connectivity, which is very, very large to mimic the system. That was not done.

MR. DUNCANSON: Duncanson. Dr. Hollaender, you'll -- you'll be happy to hear, I've almost finished my questions. But to make sure that Aecom understands your position and can respond to it properly next week, is your view that, that intact sandstone would provide resistance to groundwater flow around the voids?

DR. HOLLAENDER: Hollaender speaking. The intact sandstone would provide support. The area where the sandstone is not intact anymore cannot provide. I think that is obvious.

MR. DUNCANSON: Duncanson. And sorry, if I wasn't clear. My question, not talking about support from a geotechnical perspective, but providing resistance to groundwater flow, do you agree that, that intact sandstone would provide resistance to groundwater flow?

DR. HOLLAENDER: Intact sandstone certainly provides resistance to groundwater flow. It's the same most likely than before. The place where this was mined out, we cannot provide resistance to groundwater flow.

MR. DUNCANSON: Duncanson. Thank you for bearing with me on that, Dr. Hollaender. So, we talked about the fact that there is likely intermixing between the two aquifers today. Are you aware of any negative impacts to water quality associated with that intermixing?

DR. HOLLAENDER: Hollaender speaking. The example which I gave from (inaudible) showed drastic change of groundwater quality. I have no -- so, that is, as I said, south of Winnipeg. In that area, we have not studied any case.

MR. DUNCANSON: Duncanson. And in fairness, I -- I -- I probably should have put some geographic bounds around my question. Within the area of the groundwater model domain, are you aware of any negative impacts on water quality that have resulted from intermixing between the two aquifers?

DR. HOLLAENDER: Hollaender speaking. I have not studied this. Was also not part of my analysis.

MR. DUNCANSON: Duncanson. Based on the information you have reviewed, it's true that the water in both the carbonate and the sandstone aquifers is today considered fresh (inaudible) water. Yes?

DR. HOLLAENDER: Hollaender speaking. It is obvious from the Betcher report that this is correct for most of the parts of that study. Yeah -- yeah.

MR. DUNCANSON: Duncanson. And based on that, Dr. Hollaender, it would be fair to say, that if there is additional intermixing of those waters, either as a result of this project or some other reason, it would be reasonable to expect, that would not cause either aquifer to be unsafe for drinking water, correct?

DR. HOLLAENDER: Hollaender speaking. Discusses based on the mixing of the aquifers salt water, we also tried to find some conclusion on the trace metals, but I think we are not at a point to finalize that at this point.

MR. DUNCANSON: Duncanson. So, just so that I'm clear on my question, Dr. Hollaender, it would not be reasonable to expect that the water quality in the two aquifers would remain safe for drinking water purposes if there was additional intermixing between the two?

DR. HOLLAENDER: Hollaender speaking. You limit your questions to the two aquifers, but we have also to consider the concentrations in the acquitard in between. And I think this has not fully covered inside the geochemical model.

MR. DUNCANSON: Duncanson. Okay. So -- so that I'm clear, you would agree with me that if we're solely talking about intermixing of -- of water between the two aquifers, there would be no reason to expect either aquifer would become degraded from a water quality perspective? But your concern is, the material in the shale layer and whether that's adequately assessed?

DR. HOLLAENDER: Hollaender speaking. That correct?

MR. DUNCANSON: Duncanson. Thank you. So, that helps us prepare what we'll be presenting next week. And Dr. Hollaender, in terms of the volume of net groundwater withdrawal associated with the Sio extraction project, would you agree that the -- the volumes we're talking about in terms of net ground withdrawal are relatively low compared with other groundwater users in the region?

DR. HOLLAENDER: Hollaender speaking. This depends on the amount of water, which is going back into the aquifer. There were different scenarios. And before the operation started, it is very difficult to comment which one would be the adequate one.

MR. DUNCANSON: Duncanson. So, if I -- if I heard you correctly, Dr. Hollaender, you're suggesting that in your view, there's some uncertainty about how much water will be reinjected as a result of this project. But based on the numbers that Sio has presented around net groundwater withdrawal, you would agree that if you compare those with other groundwater users in the region, it would be a relatively small volume as compared for example, to the RM water supply and large industrial operations?

DR. HOLLAENDER: Compare -- Hollaender speaking. Compared to the -- as an example to the RM water supply is definitely not a large amount.

MR. DUNCANSON: Duncanson, thank you very much, Dr. Hollaender. Those are all the questions that I have. Thank you Mr. Chair for allowing me to go a little passed my 45 minutes this afternoon.

THE CHAIRMAN: Chair. No worries. Are there any members of the public that wish to ask questions at this time?

(NO VERBAL RESPONSE)

THE CHAIRMAN: Chair. I'll take that as a, no. So, here's our situation. It's 2:28. There are two hours left in the day. And following a questioning of the Sio Adviser, on groundwater, Dr. Hollaender, we proceed to the participants. Yes, Mr. Williams, I saw your head go up. OLS and MBN are up first. Are you prepared to go at this time, or are we adjourning for the day?

(NO VERBAL RESPONSE)

THE CHAIRMAN: Mr. Secretary, any thoughts on my adjourning for the day?

MR. CROCKER: (No verbal response).

THE CHAIRMAN: We are adjourned for the day. We'll resume at 9:30 tomorrow morning. Thank you, folks.

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March 07, 2023