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UNDER THE WATER POWER ACT

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TUESDAY, MARCH 17, 2015

UPON COMMENCING AT 9:30 A.M.

THE CHAIRMAN: Good morning. Welcome back, on a special day for those of us with some Irish heritage. Later on some of you may go in search of green beer. You may find it in the algal filled waters of Lake Winnipeg.

This morning, we have the third of the Commission witnesses who will be talking to us a bit about coastal wetlands and, in particular, Netley Marsh. He's known to a number of us, Dr. Gordon Goldsborough from the University of Manitoba. And I'll turn it over, we'll swear you in, Dr. Goldsborough, and then you can make your presentation

Dr. Gordon Goldsborough: Affirmed.

THE CHAIRMAN: Go ahead.

DR. GOLDSBOROUGH: Good morning. I thank the Commission for the opportunity to speak this morning. I look forward to the opportunity to speak with you all about coastal wetlands. I have been spending much of my academic career in coastal wetlands, over the last 33 odd years. I like to think that over that time I have learned a little bit about them. I would, however, hasten

to point out that I still feel that I have a lot more to learn. And hopefully, by the end of my presentation, I will leave open some possibilities for things we have yet to learn about coastal wetlands.

The background of this photo shows the dredge Red River, that in the early part of the 20th century played a fairly prominent role in the life of the Red River, and also the Netley-Libau Marsh at the mouth of the Red River where it drains into Lake Winnipeg. And it will factor into my remarks a little later on. So I just wanted to note that. And as some of you will know, I have an abiding interest in history, and so I will try to weave together a little bit of the science along with the history in telling the story of Netley-Libau Marsh.

So an outline of my remarks this morning, first of all, I'm going to deal with coastal wetlands in a general sense. I'm not sure that everybody knows what they are, so I thought I would best define them. I'll tell a little bit about what the benefits of coastal wetlands are. And unfortunately, I will have to describe a little bit at least some of the threats that they

face to their ecological integrity.

Then, once having set the general stage, I'd like to turn to a very specific example of a coastal wetland, Netley-Libau Marsh. And talk a little bit about what it is, what changes it has undergone, at least in the last 30 or 40 years, and what are the causes that we believe are contributing to those changes. And then ultimately what I'd like to conclude my remarks with are some recommendations for what I believe would best happen in order to sustain coastal wetlands in general, and hopefully to restore the Netley-Libau Marsh in particular.

So let's start with a definition. I often find that people don't fully understand what we mean when we say a wetland. And unfortunately, there isn't any real consensus. Internationally, around the world, we disagree as to what wetlands are. Canada and the United States are mostly in agreement. However, we diverge quite remarkably from Europe, for example. So, therefore, it behooves me to first provide the definition that I will use, and it's the one that is recognized by the Canadian Wetland Classification System, this little book that was published back in the late

1980s. And it recognizes wetlands as having three main characteristics. One is they have water; and by definition, water that is less than two metres in depth. Now, that's sort of a fuzzy boundary. And, in fact, we would not exclude something as being a wetland if it was slightly deeper than that. And it can be considerably less deep than this and, in fact, can be almost nothing. Water doesn't even have to be visible for it to be a wetland. It can, in fact, simply have water saturating the soil of the environment.

Second of all, a related characteristic is that the abundance of water typically eliminates or substantially reduces the amount of oxygen in the environment. And that means that the environment is a rather hostile one for life. Most of us, of course, require oxygen. Most other forms of life likewise require oxygen. So the sorts of species that occur in a wetland are adapted to those realities. They are adapted to the abundance of water, they are adapted to the scarcity of oxygen. So all of the wetlands that I'm going to describe this morning follow this criteria.

Coastal wetlands, as a specific kind

of wetland, are ones associated with a large body of water. And I realize there is a certain preconception of the word "coastal". It's sometimes thought to mean the ocean, the seacoast. In reality, it simply means a large body of water. And of course, here in Manitoba we are well-endowed with large bodies of water, and I will call them the Manitoba Great Lakes, Lake Winnipeg, Lake Winnipegosis and Lake Manitoba, in descending order of size. So coastal wetlands are ones that are associated with the boundaries of a large body of water.

And then finally, because of course in my title of my presentation I mentioned the Netley-Libau Marsh, I think it warrants a clarification as to the difference between a wetland and a marsh. And they are different, they are not synonyms, although many people tend to use them as such.

A wetland is very general term to describe what I have just listed, the criteria. A marsh, on the other hand, is one specific kind of wetland. In fact, in Canada, we recognize five kinds of wetlands, of which one is a marsh. A marsh is defined by the basis of the abundance of

vegetation that it contains, and specifically emergent plants, so cattails, bulrushes and those sorts of things. That's what makes a marsh a marsh.

Now, having said that, I also should clarify that sometimes names aren't altogether clear. So, for example, the Netley-Libau Marsh, despite being called a marsh by its name, most of it is not a marsh. Most of it, in fact, is another one of the five classes referred to as shallow open water. And that's another type of wetland that is defined by the abundance of submersed plants as opposed to emergent plants. I just wanted to start with some definitions.

Likewise, I will show you momentarily a list of the various kinds of wetlands we have around the Manitoba Great Lakes. And a few years ago, we did an inventory of those wetlands. We divided them into three general kinds of coastal wetlands using a system that had been developed for the other Great Lakes we have in North America, what I would call the Laurentian Great Lakes. The Laurentian Great Lakes, of course, are east of us. They, of course, straddle the Canadian and U.S. border. And they are in fact,

of course, a very prominent water feature on the continent. I will argue, though, that they are actually not as important in terms of coastal wetlands as the ones we have here in Manitoba.

A few years ago, though, an inventory was made of the coastal wetlands of the Laurentian Great Lakes, and they recognize three main kinds. Lacustrine ones, which were basically associated with the shoreline of the lake; in other words, they were exposed to the water of the lake and were, therefore, exposed to the waves crashing in and so on; as opposed to riverine ones which are at the mouth of a river that discharges into the lake and, therefore, have some greater degree of protection afforded by the river channel itself. And then the third kind is what we refer to as barrier protected, meaning it is not directly connected to the lake by way of a channel. It is, however, still under the influence of the lake, usually because of groundwater flow through the soil or overland spray through wave action and so on.

Now, I won't go into the detail. If you want to know about this, I'd suggest you take my Wetland Ecology class, and listing some of the

characteristics that distinguish them, they are listed there. So, literally, this would be an entire class if you want to really get into the nitty-gritty of the different kinds. But just rest-assured, there are different kinds. And if you look at the statistics then, these are the results of an inventory that we carried out the last few years. There are roughly 140,000 hectares of coastal wetlands around Lake Winnipeg, 74,000 hectares around Lake Winnipegosis, about 56,000 hectares around Lake Manitoba.

Now, I should point out, however, that the numbers themselves are, let's say estimates. The reality is that we purposely excluded a class called treed muskeg which is, in fact, a wetland, it is truly wetland. We just weren't certain to the degree it was a coastal wetland. You know, because there has to be an influence of the lake and we weren't certain we could distinguish that. So, in other words, what I am saying, I suppose, is that these numbers are conservative. They are smaller than the reality, likely, because we weren't able to fully assess. The availability of data, unfortunately, is limiting. We don't have, for example, very good high resolution imagery for

some parts of the shorelines that would allow us to distinguish them.

Notice also, I'll just show you a couple of examples of coastal wetlands. One of course that I'll come back to and talk more fully about, the Netley-Libau Marsh. The other one that you made not even know is a coastal marsh, that's Grand Beach. Of course, many of us go there to enjoy the beach, and many of us probably don't think about the body of water that's immediately south of that beach. In reality, that was a nice lagoon of riverine and barrier protected coastal wetland.

So there are coastal wetlands all around the lake, I emphasize that. One of the largest ones inevitably is the Netley-Libau Marsh at the south end of the lake. But as you can see from this map, there are ones that stretch all the way up to the north end of Lake Winnipeg and, in fact, all the way around the other two lakes as well.

The other large coastal marsh, though, that I will draw your attention to a little later is the Delta Marsh, which is on the south end of Lake Manitoba. I put a little red dot there to

indicate the location of the former university station that was situated at Delta Marsh, the Delta Marsh Field Station. I was the administrator of that facility for 16 years, and I have a great affinity for that site, I have done much of my research there. But because that station is now closed, gradually I find myself sort of moving over to the Lake Winnipeg coastal marshes and studying them a little bit more.

Anyway, the statistics for Lake Winnipeg are given in a little chart there in the bottom right corner, and it tells us that the single largest category of those three that I listed a moment ago, lacustrine, riverine, and protected, is the riverine category. And this is partly because there is the vast Netley-Libau Marsh, which is partly a riverine marsh. There are others associated with the other large lakes, or rivers rather, that discharge into Lake Winnipeg. So it is the largest category of the three on Lake Winnipeg. And I said, I want to emphasize that there are quite a number of coastal wetlands around the lake.

So to put this into context then, we combine the results from those three large lakes,

Winnipeg, Winnipegosis and Manitoba, we get a total for the province as a whole. And just to put it into context, I calculated the total on the basis of the amount of shoreline. Because of course inevitably these wetlands are associated with the shoreline of the lake, and we have roughly one square kilometre of coastal wetland per kilometre of shoreline, a little bit less than, but pretty close.

Now, to put that into contrast with the Laurentian Great Lakes, not only do we have almost twice as many coastal wetlands as a whole, if you compare it on a per area of, or per kilometre of shoreline, we have anywhere from two to four times as many. So, in other words, what I guess I'm saying is that we are exceptionally well-endowed in Manitoba with coastal wetlands. I suppose it's a function of our topography. We have a relatively flat landscape, and of course it means there's a lot of opportunity for shallow water environments to develop along the shores of our large lakes. So we are literally the coastal wetland province. And in fact, if you generalize even further, Manitoba has a greater proportion of its land area covered in wetlands as well. So we

are really the wetland province of Canada.

Now, I don't mean to go into an awful lot of detail, but I do want to leave you with an impression that these are not worthless places. There is a widespread public perception, I think, that wetlands are not valuable. In fact, I would argue that there are quite a large number of values, not all of them can be put in financial terms. There are some that are actually monetary in value, but I thought I would first list some that aren't as easy to quantify. Now, arguably, the things I am listing here do have value. And I think most of us would agree, for example, that flood control is a valuable thing. Whether we can put a dollar figure on it or not is a little bit more difficult to quantify. But in terms of the protection of water quality, in terms of the amelioration of climate change by storing carbon as opposed to having it go into the atmosphere, to provide habitat for valuable plants and animals that we might wish to eat, or photograph, or simply enjoy for their own intrinsic value, to do research, to provide education, these are all benefits that accrue from these coastal wetlands.

I realize, however, that that's not

always a compelling argument and sometimes we simply have to put things in economic terms. And there are economic values of these coastal wetlands.

This photograph, for example, was taken around Gimli in the early 1930s. And it's not an uncommon photograph. In fact, there are large numbers of views of people harvesting what they called wild hay. And wild hay was simply the vegetation of the coastal wetlands. They would go into these wetlands, typically in the late part of the summer, they would cut the vegetation, they would bring it back on their vehicles and use it to feed their livestock through the winter. And this is still, to a large extent, practised around many of the parts of the large lakes. Lake Manitoba, for example, the farmers there still readily use wild hay as a source for their livestock. So that's a true economic value.

And there are others. Spawning and feeding habitat for the commercially important lake fish. We know, for example, that fish do spawn in coastal marshes. Those fish then leave the marshes later in their lives. They spend the remainder of their life, or perhaps the majority

of their life in the lake, but come back to those marshes again later to spawn. And that means that the health of the lake fishery, the commercial fishery as well as the sport fishery, would depend on the health of these marshes. If they cannot spawn, clearly the populations of the fish stocks would deteriorate.

Likewise, waterfowl, migratory birds use these as breeding habitats, as staging habitat as they are migrating north, migrating south.

Shoreline stabilization, the reality is that by buffering wave action, these coastal wetlands reduce the severity of shoreline erosion. And of course, we are always concerned, for example, when people lose their property along shorelines due to erosion.

And then finally, of course, and we heard, of course, an allusion to the quality of the water in Lake Winnipeg earlier, the green that it often is, that's a direct function of the water quality in the lake which unfortunately is deteriorating. We know that because over the last few decades, the levels of phosphorus and other chemicals have been slowly tracking upwards. And in reality, that's something that is in part

attributable to the deterioration of wetlands, both the coastal wetlands around the lake, as well as the wetlands far away from the lake in sort of the landscape.

And over the next few years, you're going to be hearing an awful lot about the expression keeping water on the landscape, because it helps to offset the deterioration of lake water quality.

So in a general sense, wetlands are nature's kidneys. They help to purify water, and as a result, water that passes through wetlands inevitably has better quality than water that did not.

So, I hope I left at least the impression that there is some value there. I also, however, want to say that there are some threats to wetlands. They are not, unfortunately, widely perceived as valuable habitat. And in fact, we see numerous examples around the Manitoba Great Lakes where there is domestic encroachment on the wetlands. Here, for example, is a site just south of Victoria Beach on the east shore of Lake Winnipeg, we have a little barrier protected wetland. Here it's separated from the lake by

this ridge of land. There is a connection, so there is flow of water through from the lake into this marsh. And inevitably, someone has built a residential development on the edge of it and provided a channel out into the wetland. So not only is there an opportunity for vehicles, probably boats and the such, there is of course also the likelihood for chemical contamination. If you can see the colour here, you can see that it's markedly greener than the vegetation back here in the natural habitat, which is inevitably an indication that there's some chemical enrichment going on there. There's probably some fertilizer being applied, which inevitably means some of it is going to drain in through here and into the little coastal wetland.

So, domestic encroachment is a reality in much of the Laurentian Great Lakes. Agricultural encroachment, farmers of course want to farm every acre to get the maximum yield they can. Industrial encroachment and then the inevitable contamination that occurs from that.

We also have very good evidence, unfortunately, of invasive species entering coastal wetlands. We see for here, of course,

there is an opportunity for direct connection. And so for example, common carp, which are an introduced European fish, can swim in and out of the marsh by way of that channel. And that's becoming increasingly a problem, along with other species like the hybrid cattail, the soon to be problem invasive phragmites, perhaps other species like the zebra muscle and so on. When there's a connection, then species can follow.

As I will talk about a little later, dredging is inevitably an issue. That body of water immediately south of the beach at Grand Beach has been dramatically deepened as a result of dredging. So at one time, it was probably no more than a metre or maybe two metres in depth, probably not enough for some boats to be able to travel it. Now it's deeper as a result of the dredging.

And then finally, and perhaps where I'd like to spend a little bit of time discussing, altered hydrology. Hydrology, of course, is the study of water flow and alteration of hydrology is the alteration of the quantities and timing of water.

Now, I won't go into all the nuances

of it, but I would like to leave an impression of the importance of water level variability. Variability is, in fact, the key part of the story. That water levels, in fact, if they are stable, are the problem. What the coastal wetlands absolutely require, and I emphasize require, is variability.

So to illustrate that, I will show you an example from where I used to work quite regularly at the Delta Marsh. This is a little area over on the far east side of Delta Marsh, a place called Clandeboye Bay, and this is how it looked in 2001. I'm standing in the bay up to about my knees in water. And this is the situation. You can see shallow water in the foreground, and then in the background is some emergent vegetation, some cattails. In 2001, the water levels were about average. Two years later, as a result of a prolonged regional drought, the environment changed rather dramatically. This photograph is taken from the exact same spot. In other words, I'm not standing with my knees in water. In fact, I'm standing now in some dense Scirpus or bulrush. And as you can see, it is so dense that in fact we can't even see across the

bay anymore. You can get a sense of how tall it is from my colleague standing there. And the other important thing to draw to your attention in this photograph is all of this stuff. This is the seed heads of the bulrushes, and it is literally covered in seeds. That is, to the mind of a botanist like me, absolute heaven. Because it means all of this seed is going to rain down come fall, to the soil. And then the following year, there is an opportunity for those plants to come back. In other words, this is an investment in what we call the seed bank. The bank is the collection of seeds that occupy the soil in virtually every wetland. Every wetland is defined, in fact, by an abundance of seeds in its soil. And what it needs, therefore, is a periodic lowering of water levels to enable that seed to germinate.

So, for example, going back to Delta Marsh yet again, this is a photograph in a less well-vegetated area in the early spring of 2003, that drought year. And you can see that, in fact, there was large areas of mud flat that were exposed. And literally within few days of that mud being exposed, you can even get a sense of it

perhaps, there's sort of a green fuzz on the surface of this mud, which are little seedlings that are starting to sprout. And within a few weeks, they will start getting taller and taller. And in fact, if I can show you this same area today, in fact this whole area is filled in with tall cattails that are almost as tall as I am. So it really does illustrate why low water is valuable to these wetlands.

Now, at the same token, high water is also part of the story. And during periods of high water, the vegetation drowns. Just like you and I would drown if we're in deep water, these plants can't tolerate deep water. Cattails tend to top out at about one metre in water. Anything deeper than that and they will eventually drown, and that leaves open the environment. So typically, the cycle is that during low water, the vegetation ingrows, and during deeper water it tends to drown out. So, a healthy marsh, you have fluctuations of vegetation growing in and being flooded out cyclically over a long period of time.

So, I will just draw your attention again to Delta Marsh in the south end of Lake Manitoba, and then draw your attention over to the

south end of Lake Winnipeg, the Netley-Libau Marsh, which is more or less straight north of Winnipeg, about a half an hour's drive. And this is where I will spend the remainder of my presentation.

I have been working here since the early part of the 2000s. We were first encouraged to work here, in fact, by a fellow who had been a long-time waterfowler. He had been a fellow who hunted here each fall. And what he told us was that he was seeing dramatically fewer waterfowl than he could recall having seen in decades before. And he wanted us to find out what had happened. And he was insistent. We initially weren't convinced that it was worthy of our study. To be honest, I wasn't sure that it was really something that was interesting. It was only when we started visiting the marsh and seeing the dramatic change that it really got our attention.

What we're seeing here is a mosaic made out of about a hundred photographs that were stitched together digitally, and it's taken with infrared film. That's why the odd red colour. Red colour indicates the reflection of infrared light rather than visible light. And the

brightest red, in fact, indicates cattails. So you can distinguish different species of plants based on their colour.

We have here the Red River that goes through the middle of the marsh. And it essentially bisects this large complex into two basic units. I'll call the western of those two the Netley unit, or the Netley Marsh, and the eastern unit, I'll call the Libau unit or the Libau Marsh. And so to refer to them all collectively, I'll simply call that the Netley-Libau Marsh as a whole.

Now, we have done some analysis based on an initial survey of vegetation that we did in 2001. We collected imagery from that 2001 year and we had an analysis done of the area of vegetation. And this was the area in hectares for open water, for bulrushes, for cattails, and for the giant reed. We fortunately had another such analysis that had been done, not by ourselves, but by a group supported by Ducks Unlimited Canada in 1979. These are the data from that study. And if you just do a cursory comparison, there are some differences. There are some similarities. For instance, the cattails haven't shown much dramatic

change over that period. Likewise, the giant reeds, not so much. But what is really demonstrating a major change is the open water area which increased dramatically, and a corresponding decrease in bulrushes over that time period. So that was the thing that really got our attention, this dramatic change in the quantity of emergent vegetation decreasing while the area of open water, in other words unvegetated area, increased.

So I want to draw your attention then to the northern part of what we'll call Netley Lake. That's the body of water that occupies much of the Netley part of the marsh. And I am just going to zoom in on this part and show you a vegetation map, the one that was done in 1979. Each of these colours denotes a different species of plant. And for the sake of time, I won't go into all of them, though. The green is the cattail, the gray is the bulrush, the gold in colour is the giant reed, and this is how it looked in 1979. You can make out the bodies of water, you can make out the land, it bisects them. There is a channel right here that winds its way up to the lake. It's what the old-timers call the

Salamonia Channel. And then there's the main stem of the Red River coming up to here. This is what they call The Forks. And I'll come back and mention The Forks in just a moment.

That's how it looked in 1979. That's how it looked in 2001. That in fact, much of that vegetation that we saw in that previous map is gone. In fact, that Salamonia Channel is all but gone, there are just a few remnants of it visible anymore. So as a result, what we seem to have had happen is that the Netley Lake that used to be this large expanse in water on the south end of the marsh unit, has now expanded to more or less fill the entirety of the west unit. In other words, it's coalesced into one large body of water.

Now, I understand that this is not something you're going to be able to see. I purposely show it to you only because I wanted to make a point about how we have addressed trying to understand the changes that we are seeing. And all this demonstrates, I suppose, are the factors that we believe have contributed. So in the middle of this diagram is a box that's labeled the loss of emergent vegetation. That's the thing

we're trying to explain.

Around the outside of this diagram are some gray boxes, which indicate what we believe may be the contributing causes. And then the white boxes are things that result, are effects of those causes. So, in other words, you start with a gray box, you follow the arrow to a white box, sometimes to another white box, and then ultimately to the black box, the loss of emergent vegetation. So it's sort of a conceptual model, if you will, of how we think this change has taken place. And I will come back to this diagram periodically to try to illustrate what I think is going on here. I just wanted to show you the entirety, first of all, just to give you a sense of what it is, and we'll see parts of it later.

Okay. I believe there are four main causes that have contributed to the changes in the Netley-Libau Marsh. I have listed them here in chronological order. That's the order in which I will describe them. Please don't infer from the numbers that I put some kind of priority on them. I do not consider the first one to be the most important and the fourth to be the least important. I really don't know. And by the end

of it, I hope I will be able to convince you that I don't necessarily think they are in any particular order. I think they are simply four of the contributing factors, and I'll look at them each in turn.

Starting with the first, that we believe goes back to 1913, so just a little bit over 100 years ago, the dredging of something called the Netley Cut by the Federal Government. The Netley Cut is located in the south part of the marsh, in fact, it's just off of the Red River Channel at the south end of the Netley Lake, right there.

And to illustrate why it was cut, I just want to give you a little bit of a historical context. So I just want to jump back up here, back where that map was that I showed you the vegetation change earlier for, and I am going to just enlarge that area by way of showing you a map. This is a map that was actually made back in the early 20th century. So you know that, of course, because if you look, you'll see that the northern part of that marsh that is now a large body of water was still fairly heavily vegetated. There is that Salamonia Channel that I made

reference to before. There is the Red River coming out here. In fact, the reason I wanted to show you this map is that it shows the three main channels that arise here at The Forks. The Forks is where the river literally breaks into three main channels. I tell you that because through the last 120 or so years, these channels have been varyingly important for navigation. Now, of course, if we think about it today, we don't really think so much about navigation on the Red River, mainly because we have found other means to get materials around the province. If we need to get things transported to Norway House, we can take them by road, we can take them by air. Rarely do we consider taking them by boat. But, of course, 130 years ago, 120 years ago, that wouldn't have been the case. In fact, river transport and then lake transport was essential.

So in the early days, in fact, very early on from 1884 to 1893, and I know the 1893 by the way -- 1884, I should maybe start with that, is the year that the Federal Government began dredging. They brought a dredge from eastern Canada, they deployed it on the Red River and they began doing dredging. So that's really when the

story of dredging begins. 1893 comes from a newspaper story which says we have stopped using the west channel, that's the one on the left-hand side, because it is now completely silted over. We can't get down there because it's full. And so, therefore, they began moving down the east channel. So from 1893 to around 1903, I'm not altogether certain of the 1903 date, mainly because I haven't yet found the definitive proof, but it's around 1903, and I'll explain in a moment why, they started going down the east channel out into the lake, mainly because this one was no longer navigable, it was too shallow. And then around 1903, they started going down the central channel. And in fact, you'll notice there's this little jag over to the northwest. That's a channel that was excavated around this time, around 1903. I haven't pinned it down exactly yet. They used to go out this original channel, the original natural channel. The federal engineers, however, decided that there was perhaps some virtue in going out this direction. I suspect because they hoped that this would alleviate some dredging problems they were encountering. And in fact, this is the main

channel now that is the majority of transportation. Whatever boats that tend to use the river, tend to use the central channel, or they'll use the eastern channel. Very few, in fact, use the western channel. In fact, one of my colleagues was up there a couple of years ago and reported that in places the water is only about a foot deep in the western channel.

So what it illustrates, these three channels, is that dredging has gone on for a very long time as a result of the necessity to facilitate navigation for commercial and also for recreational purposes.

So one of the consequences of that dredging activity was this Netley Cut. This photograph, which actually is not from the first appearance of the cut, in fact, this photograph comes about 10 years later. And by the way, it's a remarkable photo because photography was in its infancy in the early years. If you think about it for a moment, 1923, we still had very poor film to be used in a moving vehicle. And with an aircraft, this of course was taken from an airplane, to get a clear photograph from an airplane was itself an achievement. So this

picture is from 1923, but it illustrates the Netley Cut, which is right here. We are looking south, this is the Red River, and it's sending its way to Winnipeg. Netley Creek is over here. And what you can see is, first of all, the south end of Netley Lake, which is abundant in emergent vegetation, and there's this little channel going through. It was excavated over the course of about two weeks in late fall of 1913.

You probably also can appreciate there's something sitting right there, it looks like there's probably also something sitting right there. And I will come back to those momentarily.

But first of all, a question that often is asked, what was the purpose of this cut? Why did the federal government dredge it? Well, unfortunately, the historical record isn't entirely clear. I found in the national archives references to requests from local farmers. They wanted to be able to get into that part of the marsh to cut hay. Remember, I showed you earlier the cutting of wild hay. And that's something that continues right to the present. So they wanted the means to get in and cut that hay. There's also references to getting in and cutting

firewood. I'm not altogether certain that that was a valid one because I am not convinced there was an awful lot of wood there to be cut, unless it was driftwood I suppose. But the other reason was to facilitate boat access. And that one isn't immediately clear as to why boat access would be important, until you consider the broader, probably the context of what was going on around this time.

In the newspaper of 1908, there is a reference to a little difficulty the City of Winnipeg was facing at that time finding something to do with their garbage. And the City of Winnipeg wanted to find some place to dump their garbage. So they queried the Federal Government and asked, could they dump it in the Netley Marsh, because it's worthless anyway, so why wouldn't we dump it into a worthless wetland, turn it into dry land, and make it valuable farmland? And that was the thinking at the time. They could enable access into the Netley Lake for the barges of garbage that would be shuttled down the Red River. And the dominion engineer thought there would be no objection to doing this.

And of course, as a biologist, I'm

horrified to hear about that, because that would be the worst possible thing that could happen to this nice wetland. Fortunately, they decided this wasn't the best thing to do, mainly because it was something they could only do for a few months of the year. Once the river is frozen, well, then you'd have to ski it over the river, I suppose. And so ultimately they never ended up using the channel as an entrance for garbage scows.

Unfortunately, they began to notice things had started to change. Soon after the dredging of that cut, it began to widen. So, in fact, what you're seeing here is a sunken barge. In fact, a little bit of the irony, it's one of the old dredges that they no longer require. They sunk the dredge diagonally across the channel. That didn't work -- well basically, I should say the reason they sunk it in the first place was to try to close the channel. That didn't work, so they put in a sheet pile dam across the mouth of it, and that didn't work. So what we are seeing evidence of, visual evidence of is the attempts they were making within 10 years to close this structure, because they began to see erosion of that channel beginning very soon after its

construction. This photograph, in fact, is taken from almost the same angle as that previous picture. And it basically jumps forward 80 years. So 1923, 2003, you can see now that there is a considerable widening of that channel.

In fact, remember 2003 was the year of the low water, and what that low water reveals is that there's an enormous deposition of sediment here on the inside of that channel. And in fact, you can almost sort of make out, it appears that there's sort of an arc occurring right here that, in fact, things seem to be kind of turning. And in fact, that's what I believe is happening. There's sort of a 180-degree turn that the water in the river is taking, and as it's turning, it's slowing down. And as it's slowing down, it can't carry the same amount of sediment. It's dropping that sediment and creating this little sand bar right here that is getting shallower.

Now, I should point out that you notice, by comparison to the 1923 picture, much less vegetation. And as a general statement, that is a remarkable change, that there's been a dramatic loss of vegetation, not just since 1979, as our map showed, but in fact going back much

earlier to the 1920s, that much of the vegetation that once characterized this Netley Lake is now gone.

Correspondingly, there's not nearly as much change in the Libau unit, in the east part of the marsh, which does not have the same sort of channel as the Netley Cut. So it seems awfully circumstantial, but convincing, that the changes that we see occurring in the west unit can be at least in part attributed to the Netley Cut. Because we see the changes occurring where the cut exists, we don't see them occurring where there is no corresponding cut.

This is just an architectural, or an engineering drawing, showing the old dredge trying to plug that cut. It shows the sheet pile dam that was constructed. It shows the dimensions of the channel. It shows the depth of the channel. And I show it to you because at this time in 1923, the channel was thought to be something in the order of about 80 to 90 feet wide. I tell you that because our more recent estimates show that it, in fact, by 2003, the cut had enlarged to 1,300 feet wide. By 2009, it had enlarged to 14, almost 1,500 feet wide.

Now, unfortunately, I acknowledge that it's based on only three measurements. But if you do a quick calculation, if, for example, you look at the difference in width over this time period and then calculate it on an annual basis, it's likely that it hasn't progressed equally in every single year. But if you just do a simple calculation of this much change over this period of time, it works out to about 15 feet of widening a year. If you do the same calculation over this six year period, you get a number that is almost twice as high. In other words, it appears anyway to us that the widening of the channel is accelerating, and accelerating especially so in the 2000s.

So whatever erosion is taking place, and has been taking place since at least the 1920s, has been increased over the last few years. And that's something that interests us in terms of what has caused that increased widening.

But just to go back to what the consequences are, this photograph is a satellite image taken on a band that shows water temperature. The idea being is that darker colours denote cooler water. Lighter colours such

as here and here denote warmer water. And so what you can see, I think very conspicuously, is the nice warm water plume that comes off the mouth of the Red River. So what it illustrates, of course, is that the water in the Red River is warmer than the water in Lake Winnipeg. And as it discharges out into the lake, it bends to the east, probably representing sort of the counter-clockwise currents that sweep along the south end of the lake.

There is, however, a very large sort of warm spiral of warm water that comes in right next to the Netley Cut, which initially then indicates that there is substantial flow of river water going through this cut. The visual impression at least is that there's a lot of flow going through there.

Now, up until fairly recently, that was our only indication of water flow that actually was going through that cut. Fortunately, however, one of my colleagues at the university, Dr. Sean Clark in the Faculty of Engineering, had the opportunity recently to do flow measurements. And some of his data is shown here, thanks to Dr. Clark, showing the proportion of the total flow in

the Red River. In other words, the flow that came up the channel here, that in 2009 went up the main stem and out the centre channel, versus out the east channel, the west channel and the Netley Cut. Now, he did measurements over the course of the summer. Depending on the particular day and the direction of the wind, and the level of the lake and the level of the river, he got varying estimates. So these are the range of the estimates that he got, the proportion of flow in the river that went up each of those channels. You'll notice, by the way, that that west channel, the one that has become very shallow, carries very little of the flow, less than one percent overall.

And if you do just a simple mathematical average of those numbers, what you see is that the Netley Cut is the single largest contributor to flow. The single largest volume of river water goes through the Netley Cut, and then gradually winds its way northward and then out into the lake through the remains of the old Salamonia mouth right there. That the east and centre channels represent each -- obviously represents the largest single quantity of flow, together representing over half of it, but in

terms of the portion going up the Netley cut, it is clearly significant.

So it sort of underpins our argument that the widening of the cut makes for a greater opportunity for flow to go that direction. In fact, today, the cut is now wider than the river itself. There is a larger volume of water that potentially could go through that cut than through the river itself.

Just another bit of evidence, this is from a map of the topography, sort of the bottom contours of the Netley Lake. This is the south end of the Netley unit. Here is the Red River. There is the Netley Cut. And I think what it shows rather visually is the little deep trench that was excavated right inside the mouth of the cut. But then there is that deposition that I showed earlier in that aerial photograph right there, another one right there. So what it seems to be showing is the water spilling in here, turning southward, sort of circling around and heading its way north out into Lake Winnipeg.

So, how does this contribute to vegetation loss? Well, the increased flow of water passing into the marsh brings with it an

associated load of nutrients. We know that the Red River is the single largest contributor of nutrients to Lake Winnipeg. It is the single largest contributor to the deteriorating water quality in Lake Winnipeg. It's the single biggest threat to Lake Winnipeg. So the fact that we have this Red River nutrient load that is bad, and increasing, combined with this increasing flow through the lake, means we're getting deeper water, we're getting scouring action from this greater flow of water, and that together facilitates the growth of algae. Algae fills the water, just as it does in Lake Winnipeg, and algae reduces light penetration. When you get less light penetrating into the water, it means that the plants that are growing from the bottom up don't get light at a critical point in the early part of the summer.

So we think, therefore, that one of the contributing factors is that the abundance of nutrients, the scouring action of all of this water is contributing ultimately to the loss of the emergent vegetation. So the Netley Cut, we believe, is one of the contributing factors to the deterioration of this marsh.

Second factor, and again this is in chronological order, that since 1976, the regulation of Lake Winnipeg for electric power production by Manitoba Hydro is also a contributing factor.

Now, I would refer you to this diagram, that I would acknowledge Manitoba Hydro for providing this to me, not necessarily knowingly, I pulled this off your website. We see a hydrograph for the lake that shows the various ups and downs of the lake going back to about 1913, and what it shows, I think very visually, is that the lake is very dynamic. That over the last hundred years or so, there has been a considerable range of variation from, let's say a low of around maybe 710 feet above sea level, up to maybe a high of about 718 feet, so roughly perhaps somewhere in the order of about eight feet of range. And there have been prolonged periods of low water, there have been periods of high water. And this is something that has been occurring, I would assume, not simply through the period of record, but going back into the past as well. Of course we don't have measurements before 1913, but it's likely that it has occurred for millennia. And this

fluctuation from low to high is something that the coastal wetlands of the lake have not only adapted to, but have become essentially dependent upon.

What we see, of course, is that since the regulation began in 1976, the magnitude of the variation has been reduced. I would hasten to point out that in this diagram, there has been a record of the average level of the lake, 713.4 feet above sea level before regulation, 713.6 post regulation, with the assumption made that that means the lake has not been changed. Unfortunately, from the perspective of a biologist -- well, the analogy that's sometimes used is an electrocardiogram. If you were hooked up to a heart monitor and it's rhythmically beating up and down, you're good to go. When it flatlines, you're not. And arguably, although it's nice to see that the average has been maintained, for the health of coastal marshes, they have essentially flatlined. So there is less variation.

Now, I will hasten to point out the variation that we're seeing is still in the order of about one, two, three feet or so. And that is actually a fairly decent range. In fact, as

compared to Lake Manitoba, which is another lake that is regulated, albeit not for power production, the range there is considerably less. It's only on the order of a foot or less. So we are seeing considerably more range on Lake Winnipeg than we're seeing on some of the other regulated lakes. Unfortunately, however, we don't believe it's long enough or great enough.

We see, for example, in 2003, that year that I showed you that image of Netley-Libau Marsh, and that was a remarkable year for the marsh. It was an exceptionally good year for the marsh. There was another period here in the late 1980s, there was another one here in the late 1970s, and those are good. I want to emphasize that. We don't, unfortunately, have yet any evidence of what the vegetation response was here. We do have that map from 1979 that gives us an insight to there. What we would like to get and, in fact, what we're working on right now is to look at what the marsh looked like here and here, if we can. Because then that gives us insight to what that the marsh could look like when the water levels are exceptionally low. And then correspondingly, what it looks like when the water

levels are high. So we want to get some insight what the vegetation looks like here and here. And also that high points like here, we actually have been, just in the last few months we have been looking at the vegetation of the most recent decade based on a detailed analysis of satellite imagery. One of my former graduate students is working on that. And I'll actually show you some of her results a little bit later. So what we want to get insight to is what is the impacts of those lows and those highs on the vegetation.

So the two years that we have the vegetation maps for correspond to these two years, and the '79 map shows a year that was coming off a low period. The 2001 map, on the other hand, was coming off a fairly prolonged high period. So that means that the comparison of those two years is affected by the preceding history. In other words, the vegetation in the '79 map probably showed a really good marsh that had been well-vegetated as a result of that low water. The 2001, on the other hand, probably shows a marsh that has experienced drowning of vegetation. So we need to fill this in with more years to be able to tell a better story of the impact of water

levels.

But what I think it shows, and I will show you another bit of evidence a little bit later, that Lake Winnipeg Regulation has resulted in fewer periods of exceptionally shallow water, and also narrower periods. If you recall back, if I go back for just a moment, the periods of low water had occurred in the 1930s and '40s, and to some extent also in the 1950s, were of prolonged duration, were in the order of several years successively. And that's something that I think is important to the story as well, and I'll come back to that a little later.

But what happened in a that 2000 year? Well, I showed you a little bit of the story already, that map and the aerial photograph. This is that northern part, this is the forks again, three are those three channels out into the lake. This is an area that they call Hardman Lake. And this is what it looked like in 2001, this is what it looked like in 2003. I think what you can see fairly convincingly is that this little body of water that was mostly open water in 2001, essentially completely filled in with vegetation. The western part of Hardman Lake likewise filled

in, in 2003. So we did see when water levels came down, vegetation came up. And so I think it does show that there is a linkage between vegetation success and water level in Lake Winnipeg.

So I mentioned a moment ago that one of my former students had been doing an analysis of the last few years based on an analysis of satellite images. Now, unfortunately, satellite images are not always good quality. I mean, imagine taking a photograph from space of something on the ground. That technology has improved remarkably over the last few years, to the point where you can now distinguish objects on the ground that are less than half a metre in size. So I always tell people, you know, when you're sitting out in your lawn chair in the backyard, wave when you're looking up, because it's probable there's a spy satellite going overhead looking at what book you are reading on your chaise lounger. And of course, the technology we have available to us as the public is probably much poorer than actually is available to militaries.

Inevitably, the vegetation that we can analyze based on this satellite imagery is

actually not too bad. But if you go back further in the past, the quality of the imagery starts to deteriorate. So as a first cut, as a first attempt to understand the vegetation change in the Netley-Libau Marsh over the last decade or so, what we simply measured was the open water area.

This, by the way, is the name of that former student of mine, Elise Watchorn, who has been doing this analysis, and she's looked at the open water area of the marsh. Essentially think of open water area as the reciprocle of vegetated area. So, in other words, where there is more open water, there is less vegetation. When there is more vegetation, there is less open water. So, in other words, when this number goes up, it means there is less vegetation. When this number goes down, it means there is more vegetation.

So she started with images that began in 1990 and she tracked, she basically measured -- it was laborious work, I don't know the kind of patience that it takes to do this kind of work -- laboriously measuring the areas of open water that were visible in the Netley-Libau Marsh over this period, starting in 1990. And what you see is that from 1990 -- now, remember there was that low

water period in late 1980s, so that's probably a period when vegetation was recruited, when we got vegetation growing in. We see there's been a dramatic and, in fact, over a period of just a year or two, dramatic loss of vegetation. That the vegetation declined dramatically and then reached a more or less stable value. It didn't quite stabilize, in fact it kind of kept tracking upwards. In other words, we continued to lose vegetation over a period of about five or six years. And then we had the 2003 drought, and you see this dramatic decrease, in other words, increase in vegetation that corresponded to that drought. So it really did illustrate the importance of that low water period to recruitment of vegetation.

Now I was, I suppose, a pessimist at the time, because I anticipated that that 2003 drought would be short-lived, and of course I was more or less right. The levels of water went back up in successive years. And what I predicted, therefore, was that we would see a corresponding loss of vegetation again. And if you were a real pessimist, what you would anticipate is that the vegetation would kind of go back to the level that

it had been before, or at least would go through this slow or maybe fast regression.

In fact, what we found was actually surprising. When Elise showed me this data, I was astounded. Because what I saw was, of course, that we did see a dramatic loss of vegetation in the years immediately following that drought, but it didn't continue. In fact, it reached a stable value that remained, or has remained more or less stable for the last decade or so.

What it illustrates, I think, is the value then of having periodic low water. Even one as short as a single year, there can be a significant improvement in vegetation. And although we didn't quite get back, we didn't go back to the level it had been before, we did lose some. Arguably I suppose we could say, well, why couldn't we have simply had it go horizontal at this point? Why didn't the vegetation just stay where it was? Well, I think that probably is because of the single year.

We have to keep in mind that the vegetation that we're talking about in this marsh are what we call perennials, meaning these are plants that live their lives over many years.

Just like the trees around us, they spend their life over decades. And that means then that in the first year, they are really just establishing themselves. They are producing the above ground leaves that help to provide them with food from photosynthesis, but they are also starting to send out roots. And cattails, for example, are notorious at sending out networks that can be tens, maybe hundreds of metres in diameter. Their root mass goes out in all directions. And in fact, that's usually what sustains them from one year to the next is that underground network. Well, unfortunately, that network doesn't establish itself instantly and it takes time.

We have been doing some studies over the last couple of years, in fact, of trying to establish cattails. And I will show you a picture near the end of my presentation of that work. And we find that, in fact, in the first year they grow to a certain level. But it isn't really the level that we expect them to be in the long-term, because they really still have to put that root network on. And so we are thinking that because of a single year of flood, we got them established, but unfortunately not as fully

established as they would need to be to be able to hang on. So we lost a little bit of them, but remarkably, enough of them survived that they were able to persist over a decade.

So two important features of this graph: One is it illustrates what happens when water levels go down and you get remarkable encroachment and recovery of vegetation; two, that when water levels back up, you lose vegetation. And I would say maybe even third is that the duration of the low water period might be important to how much vegetation hangs on in the successive deeper water period.

So this is literally hot off the press. Elise just provided to me this -- in fact, it was literally days before I was asked to provide a report to the Commission, and it was very fortunate timing. Because up to that point, I wouldn't have been able to say with any confidence what had happened post 2003. We now have at least a little bit of information.

This, by the way, is work that is continuing. And I hope that over the next year or two, we'll have quite a bit more to be able to say about the vegetation changes in the marsh.

Third factor is going back to 1999. Remember I said when I showed you those three channels that branch out into Lake Winnipeg, the west channel, the middle channel and the east channel, I said that that had begun in 1884, and it did. Every year, pretty much, the Federal Government went out with its dredge fleet and dredged, among other places, at the mouth of the Red River, to sustain a channel that was navigable for commercial traffic and for recreational traffic.

This is the dredge crane -- that's actually its name, I don't know why they called it crane -- the dredge crane. And it turns out, based on -- I found the information in fact last week in the national archives -- this is the dredge that did the work at Netley Cut. It's the one that cut the Netley Cut. And so they would have brought it out there, they would have used the -- it's a type they call an orange peel I believe is the terminology. I'm not enough of an engineer, I'm afraid, to know. But anyways, it's the technology they used to dredge the Netley Cut, and was one of the dredges that operated on the river. But the one that was most active at the

mouth of the river -- this by the way is another one of those photographs from 1923, the one that I showed you another photograph of, of the Netley Cut itself, this is the mouth of the Red River. This is where it actually enters Lake Winnipeg. In the background, I'll just draw your attention, there is the other, the centre channel of the Red River. The west channel is back there. And then there is the north end of the Netley Marsh. And you can see, I think, just how heavily vegetated it was. Even, you know, the entirety of that west unit was heavily vegetated. But I wanted to draw your attention to the mouth here. And you can see that there's also an awful lot of vegetation here at the mouth, which again illustrates just how shallow it was, that even right here at the mouth, probably the water is only about a metre or two in depth, and that would have probably been too shallow for most of the lake ships to navigate.

So, over the course of time, another one of the dredges, the dredge Assiniboine, dredged at the mouth of the river predominantly. In fact, these are data from 1884 to 1925. Unfortunately, I am at the mercy of the available data. And the Federal Government used to provide

very thorough annual summaries of its dredging work. Now in 1925, it kind of petered out. And it's really unfortunate because it would have been so nice to be able to continue the story to see how dredging continued into the 1930s and '40s. Because, of course, the '30s and '40s were a period of prolonged low water on Lake Winnipeg. So it would have been nice to see what they had to do for dredging during that low water period. But even in this period, from 1884 to 1925, fully half, half of all of the dredging that took place anywhere in Manitoba occurred at the mouth of the Red River. It illustrates just how important dredging was to water flow in the Red River. It had to be done or you simply couldn't navigate on the river.

On top of that, there was quite a considerable amount that took place at Selkirk, there was a little bit at Winnipeg. There was a few places around Lake Winnipeg they dredged. What I always find remarkable, though, is that there's hardly any dredging anywhere else. There wasn't hardly any dredging on the Assiniboine River, hardly any dredging on Lake Winnipegosis or Lake Manitoba. Lake Winnipeg, the Red River, were

really the focus of that federal dredging activity.

There's the Assiniboine then. That's the dredge that did the work on the mouth of the channel, particularly between 1910 and 1922. I don't know, I haven't been able to confirm whether this is the same Dredge Assiniboine that they sunk in the Netley Cut. Because if you remember from that map that I showed, it actually was labeled "Dredge Assiniboine." I'm thinking there may have been two Dredge Assiniboines, and it was the older Dredge Assiniboine, not this one, that they sunk. I don't know that for a fact yet though. But 90 percent plus of all the dredging at the mouth was done by this single dredge.

So, what does the absence of dredging that was done up until 1999, the Federal Government stopped its dredging on the grounds of the associated cost, that it was simply an expense they didn't feel was warranted, given the decline in the lake shipping activity. There weren't the same boat numbers going up and down the Red River, going out into Lake Winnipeg. They didn't feel that the expenditure was warranted.

Well, the result, therefore, is that

without that dredging, inevitably we have seen from the past that sedimentation occurs. The west channel, sedimented up a single year. The west channel basically became unnavigable on the basis of a single year sedimentation.

So essentially then, it is not hard to imagine how the absence of dredging for the last 15 years would inevitably lead to sedimentation, that the mouth would start to sediment up. That in turn would presumably create an impediment, would have created a natural dam or a levy that would cause water to back up. And of course then we invoke the Netley Cut again, because it's a means by which water can get from the Red River, if it's being backed up by the sedimentation at the mouth of the Red River, in other words, that middle channel and that eastern channel which took literally over half of the flow, backs up and then sends through the Netley Cut. So the lack of dredging at the mouth of the river, we believe, is contributing to the erosion of the Netley Cut.

Remember I said before, we think that the rate at which it's widening is accelerating. I said we think, because one of the things we don't have good information on is actually the

precise width of the Netley Cut through its entire history, and that's another thing that we're working on literally right now. I have a student, she should be there working at the archives, collecting the information that will hopefully tell us the width of that cut over the last 50 or so years. So the Netley Cut, more water going through the cut, and it basically then simply exacerbates the story that I gave before about the impact of the Netley Cut.

And then finally, the fourth factor is Red River flood mitigation. Now, I can't put a precise year on it, mainly because I haven't been able to determine when activity on the Red River by the Provincial Government began. I don't know whether that information was retained, it certainly hasn't been made available to me. I assuming it was begun at least in the 2000s, it may have even begun in the late 1990s. That's something else that I'm hoping to find out in the near term. But the Red River flooding, of course, is something that I think any Winnipeger knows. And of course, you only have to think back to the flood of the century in 1997 to know, of course, what can happen when flooding occurs in the Red

River Valley.

Well, it's worth keeping in mind that flooding in the Red River Valley is not a new phenomenon. In fact, there are written records of flooding that go back a very long time. We know, for example, there was a catastrophic, absolutely devastating flood in the 1820s that literally almost wiped out the Red River Settlement. The Red River Settlement, of course, was the beginnings of agriculture in Western Canada. And it's arguable that if that flood had caused those hardy Scots to vacate, we might not be here today, because they were the beginnings of the settlement here, at least the settlement of agricultural settlement here in Winnipeg. And at that time, the landscape was very different than it is today.

This is a reconstruction of what the Red River Valley looked like in the 1870s, largely before widespread European style agriculture got underway. And now this remarkable map was compiled by Irene Hanuta, who is doing this for her doctoral dissertation at the University of Manitoba, and she based it upon a series of maps that were drawn in the 1870s. The reason those maps were drawn is that the surveyors of the

Federal Government were preparing Western Canada for farmers to arrive, and they were basically going around, therefore, and dividing the land up into that grid of land we now know today, the sections, townships and ranges of the agricultural landscape.

Well, those maps still exist, and you can see them. There's a copy of them over at the Provincial Archives. There's another copy over in Provincial Air Photo Library. And you can look at those individual sheets, or you can do, as Irene did, and you can digitize them and stitch them all together.

And what they show is the nature of the land that the surveyors found as they were going out with their survey equipment, deciding where to put the lines for the sections, townships and ranges. By the way, the names of the towns, of course, do not indicate that those towns existed then, it's mainly just to orient you in space. The only place that was really anything of any consequence at that time was the Red River Settlement, and it's up here at the confluence of the Red and Assiniboine Rivers. All these other places have come later. But what it illustrates

is that there was an awful lot of change between what we see today and what was there in the 1870s.

So, for example, the green areas, these areas over here, but maybe more significantly even than that, this green area over here was forest. And I don't know about you, but I think most of the area that I encounter west of Morden now is not forest, it's farmland. And what it illustrates then is that in the ensuing 140 odd years, farmers have been very diligent at removing that forest in the interest of turning it into farmland.

From the perspective of our story, on the other hand, what is perhaps even more important are these blue areas here and here and here and up here, that were wetlands. And those also were seen as impediments to agriculture. My own family, for instance, farmed in the area right around here. My great grandfather was very active in doing his darndest to drain it. And of course, he felt he was doing what he needed to do to raise his family, to turn what was otherwise perceived as wasteland into productive farmland. So they did. They drained it as best they could. They turned it into a landscape that by 1995 looked

like that.

So, in other words, all of that forested land is more or less gone. There's just little vestiges of it here and there. The wetlands that defined a lot of this area in here are gone. In fact, the statistics that Irene compiled is that in the 1870s, in this area, there were about -- 11 percent of the area was occupied by wetlands, that by 1995 represented only about .1 percent of that area. So, in other words, there was a dramatic loss of wetlands in this area.

Now, you're perhaps saying at this point, so what? What does this change have to do with the coastal wetlands of Lake Winnipeg?

Well, inevitably, if you harken back to what I said earlier about keeping water on the landscape, these wetlands were not worthless, despite what my great grandfather thought. That they were places that did all of those things that I listed before. They were places for waste to be stored, they were places for carbon to be stored, they were places for water to be stored. And maybe that's the most important part of the story. Water kept in these wetlands caused it to run off

slowly and eventually make its way northward up into Lake Winnipeg, but there would be a prolonged period of lag. In other words, it wouldn't rush off in the early part of the spring.

We have just seen, of course, one of the most remarkable springs. There wasn't much runoff. But, of course, in some years, there's a remarkable volume of water. It appears to me anyway that it's happening more frequently. The incidents of those big flushes of water down the Red River seem to be getting more frequent.

Well, wouldn't that make sense if you had lost all of the capability to hold the water on the landscape? The net result would be that when all that water started to run, it would drain into the river quickly and then rush up the river quickly. And so if you look, for example, at a map of the drainage channels of Southern Manitoba in the Red River Valley, there are some natural ones. You can see that because they are actually still rather convoluted in shape, but you can also see all of the straight ones that are, of course, artificial, that have been dredged. And the net result of all of this is that we have dramatically dried the Red River Valley, to the benefit of

farming, but to the detriment of the downstream interests. In other words, there's a larger volume of water coming down here.

Well, inevitably, this is, of course, something that concerns the Provincial Government, it concerns the people who live along the river, the people whose homes, whose cottages, whose farms are along the river, they face imminent flooding because of the amount of water coming down the river.

So this, for example, is a piece of the Provincial Government's flood fighting infrastructure. It's a small machine, about the size of a bobcat, on the back of which is essentially a saw blade. And this device can go back and forth across the river. In fact, this photograph was taken just south of the Netley Cut. The Netley Cut is right there. This is going criss-crossing back and forth across the river from bank to bank, cutting right through the ice to weaken the ice. And the net result of it is that when this river ice starts to shift, as it is doing now, as the water is getting warmer, as the sun is beaming down on it, this ice will start to break more quickly, and the result will be that

when that river water starts to pulse down the Red River, it will encounter the ice on Lake Winnipeg.

The river typically opens up sooner than the lake does. Where does this river water go? Well, increasingly it goes into the Netley Cut, into the south end of the Netley Marsh. So it appears, therefore, that this activity of breaking ice or weakening ice immediately south of the Netley Cut is also contributing to the erosion of that channel, and causing more Red River water, nutrient rich river water to go into the south end of Netley Lake, contributing to the decline of the vegetation.

So my feeling, therefore, is that it is not as simple as saying that one of these factors is the sole cause of the changes in the marsh. In fact, I believe that it is portions of all of them.

If you would ask me which of the four is the most important, I really genuinely could not tell you. There is, however, a way of teasing them apart. It is possible, I think, and this is something that we are working on right now, it is possible, I think, to tease apart the relative importance of the Netley Cut as opposed to the

level of Lake Winnipeg. And we are working on a project, we are just hoping to get underway shortly, that will address that.

But in the meantime, I would offer some recommendations on what I believe is necessary to sustain the coastal wetlands of Lake Winnipeg. And I should emphasize, my views are about the importance of coastal wetlands generally. While it is important that we try to do what we can for the Netley-Libau Marsh, if we acknowledge that, for example, the regulation of Lake Winnipeg is a contributing cause to the decline of the Netley-Libau Marsh, we would have to equally acknowledge that it is likely contributing to the decline of other coastal marshes on Lake Winnipeg, and there are many others.

So what I would offer as a recommendation for maintaining the health of Lake Winnipeg coastal marshes is a decrease periodically in the level of the lake to sustain or to enable the regrowth of vegetation. And as a general statement, what I would offer is perhaps something in the order of two feet for a period of up to two years on a cycle ranging in duration

from somewhere between 10 and 20 years. And I'll try to explain the basis for that in just a moment.

This is, again, that hydrograph that I showed you earlier. Again, I would emphasize to you that it shows periodic ups and downs. If we just look at it and say, well, what kind of defines the periods when the water levels were low when, for example, in 2003, we saw a dramatic recovery of vegetation? What was the level of 2003 when we saw all that improvement? Well, it was about two feet, from the average level of the lake, which was 713.5, down to the low value of about two feet. So I said, okay, let's take as a starting point that being the desirable goal of two feet.

So we get a two feet decrease. We extend the line across and say, when then did the lake achieve that goal of a two foot reduction? Well, of course, it achieved it there and there and there and there and there. So we mark in those years and say, well, what was the period? How long was there between successive low water periods? Well, it was in the order between about, a low value of about nine years, a high value of

about 22 years. And hence then, I get to my two feet, and over about a period of between 10 and 20 years. In fact, if you take an average of all of those numbers, you get a value of about 14 years.

So purely for argument's sake, if you say imagine a period of 14 years, that would argue that the next period should occur in 2017. In other words, two years from now.

Whether or not that could happen, whether or not it will happen, I don't know. I simply offer it as what I would like to see happen.

Now, coming back to the two years part, I would refer you back to my earlier discussion about the establishment of the vegetation. In order for plants to truly establish long term, these perennial plants, it seems to me that in order to simulate what we have seen before, the low water period in the '30s, the low water period in the '40s, not so much in 1962, but in 1977 there was a couple of years there, in the 1980s there was a prolonged period of low, I think it's valuable, I wouldn't necessarily say essential, but certainly valuable to have at least

a couple of years so we can establish that vegetation as thoroughly as possible so that it can hold out against inevitable increases again. So, hence the basis for my suggestion of a two decrease over a period of perhaps as much as two years, over a cycle of anywhere from 10 to 20 years.

So those are what I'm suggesting for the Netley-Libau Marsh. But on top of that, as I suggest, that would help benefit the coastal marshes around the rest of Lake Winnipeg. But there needs to be something done, I think, about the other conditions that are taking place that are probably unique to the Netley-Libau Marsh. So, for example, we have the Netley Cut. We know that it's getting wider. If we believe, and I do, that the Netley Cut is contributing to the degradation of the marsh, we have to envision measures to at least be able to control that flow. Maybe not stop it entirely, maybe there's a necessity for some amount of flow through there, but at least regulate that flow through some kind of structure.

I am not an engineer. I cannot venture as to how that could be done. I could

only say that I have seen works done elsewhere where it has been done. I know my colleagues in the United States that work with the U.S. Corps of Engineers, the Army Corps of Engineers, they have done works where they have been able to regulate flow. So I do think it can be done.

Then the other factor which I think does contribute to the effect of the Netley Cut is the lack of dredging at the mouth of the Red River. And therefore, the way to address that would be in some way to resume the dredging that occurs, or did occur up until 1999. That, in turn, would increase the flow out into the lake and, therefore, decrease the flow that would go necessarily through the Netley-Libau Marsh.

So those are recommendations that I leave you with to consider for possibly restoring the vegetation to the Netley-Libau Marsh.

But in order to just leave you with some other things that are going on because, inevitably, as a scientist, this is the state of what I understand now, but I will be the first to admit that I am open to new ideas and new interpretations as we get more information. And inevitably, we don't know enough.

I mentioned earlier about those Laurentian Great Lakes. And unfortunately for us, they have been subject to enormous amounts of research over the last several decades. They have, of course, enormously larger sums of money to do that work. They have enormously larger populations around the lake to invest in that work. And we need to do something similar, perhaps to a less advanced scale as around the Laurentian Great Lakes, but we need to do more work around our Manitoba Great Lakes. And we are, but we just can't do as much as we would like to do.

So we are, for example, right now looking at what was the vegetation in the Netley-Libau Marsh before that map that we have from 1979? What was it especially during those low periods of the 1930s and '40s, and what was it during those high periods of the 1950s? So we are looking at that through things like the analysis of aerial photographs, of historical ones, on the marsh.

We want to try to tease apart the effects of the Red River from those of Lake Winnipeg Regulation. And I think there is a way

of doing it, if we take the argument that in the Netley-Libau Marsh, there are two factors acting simultaneously. The Netley-Libau Marsh is being degraded by the Lake Winnipeg Regulation and by the Netley Cut. So you can't really separate the two directly.

If, however, you argue that the Netley Cut, or the Netley-Libau Marsh changes are the same as in other marshes around Lake Winnipeg, in other words, if Lake Winnipeg Regulation is having an impact, it should be happening in those other ones as well. So if we look at the state of vegetation in those other coastal marshes, we can take that as an indication of what is happening as a result of Lake Winnipeg Regulation. And if we can say then that proportion of the change is caused by lake regulation, we can then subtract that from what we see from the Netley-Libau Marsh change. And that then indirectly gives us an indication as to what is caused by the Red River, because, of course, the Red River does not affect those other marshes.

So what we are hoping to undertake is a comparison, essentially, of the changes in the Netley-Libau Marsh historically, compared to a

variety of other marshes around the lake, around the south basin. So we are in the process right now or acquiring imagery, we're hoping to get other imagery, we're hoping perhaps that there are other sources than what we already know about. We're thinking perhaps that Manitoba Hydro might have some imagery they could make available to us. And I think this would be a very good way of trying to tease apart those two.

Meanwhile, however, we are open to the possibility that it may not be possible to create the kind of conditions necessary to restore vegetation in the Netley-Libau Marsh through the regulation of the level of the marsh. And therefore, we are thinking of other ways of restoring the vegetation.

One of the difficulties, however, is that deep water is a challenge. Vegetation, like cattails, will not grow in the depth of water that presently prevails in much of the Netley-Libau Marsh. And our first thought was, well, we can maybe make the marsh shallower. And we looked into the possibility of that. It would be a fairly elaborate engineering undertaking to basically bring in large quantities of fill to

level up the bottom of the marsh. It's starting to look a little better, all that garbage dumping. No, I kid. That wouldn't be a good thing because, of course, garbage isn't just fill.

But if you can bring the bottom up, you can make areas that were shallower. But on the other hand, we know that erosion occurs. If erosion occurs, it's likely to continue to occur and, therefore, any kind of raising up of the bottom would have to be an ongoing activity.

So the thought was, if we can't bring the bottom up, maybe you could grow the plants in deep water by having them float on the surface. And what this idea arose out of is that in 2011, so four years ago, we saw at Delta Marsh some of the deepest flooding that had occurred in centuries. And remarkably, the cattails were not completely extinguished by that deep flooding. I had expected that. I thought every single cattail was dead because of how deep the water was.

Ironically, where they did not die was in the deepest water. And that just made no sense, until I thought about it a little bit. The deepest water, because cattails, when they are invading into new territory, they float. They

actually are not rooted to the bottom. The mats they produce are attached to the cattails behind them, so its kind of like an invading army. But at the leading edge of that invasion, in sort of the front of that invasion, they are actually floating freely. And I know that now because I have been out walking, and you actually can stand on cattails that you think are firmly rooted to the bottom, and you suddenly find yourself sinking into the water, because they are actually floating.

So our thinking was then, well, maybe you can grow cattails hydroponically, in other words without soil. So this photograph in the background is taken at FortWhyte Alive, where we are testing these floating cattail bio platforms. Now, these are small prototypes. The idea would be that we would scale this up to a much larger size. But the thinking is that if they will grow effectively on these platforms, then they could potentially grow in any depth of water.

So my vision is that some day in the not too distant future, we may in fact have cattail farmers here in Manitoba, farmers who grow cattails in, among other places, the Netley Marsh.

They could have large expanses of these bio-platforms that not only grow cattails for the purposes of restoring vegetation, and that in turn would provide some of the habitat that it provides to fish and waterfowl and other life, but also provides some of that nutrient storage capability. We know, for example, based on one of my colleague's at the university work, Nazim Cicek, that the vegetation in the Netley Marsh could take up a substantial quantity of nutrient that would otherwise go into Lake Winnipeg. So by providing this amount of vegetation, we could help offset the City of Winnipeg, for example, and its nutrient inputs. We could also produce a marketable, harvestable, renewable, sustainable crop. In other words, the cattails couldn't be left in place, because otherwise they would just die and return the chemicals to the water. You need to harvest them. And if you harvest them, you can then turn them into biofuel.

So our thinking in the long term is that this is really a solution that may, in fact, not just provide benefits for the Netley-Libau Marsh, but for water quality improvement in the municipal wastewater treatment and so on.

So a lot of potential there, but I just emphasize potential. We are still in the early stages of evaluating this technology, and I am not going to say that next year we will see vast numbers of bio-platforms out on Netley Marsh, because I just don't know if it will work.

And then finally, I have to admit that quality of our wetland inventory is poor. So when I say there are other wetlands around Lake Winnipeg that are threatened by levels on the lake, I can't say exactly to what extent they are affected, because we need better information. The quality of the imagery that we used to do that inventory I showed you earlier was necessarily crude, as compared, they have just released, as of a few weeks ago, a new inventory for the Laurentian Great Lakes. And I have to admit to being incredibly envious. It's very detailed. I would like to see something similar to us here in Manitoba.

So with that, I will conclude. I will thank you for your attention and try to answer any questions that you may have. So thank you.

THE CHAIRMAN: Thank you very much, Dr. Goldsborough. We will take a 15 minute break,

come back about 10 after, and we'll turn to questioning then. Thank you.

(Proceedings recessed at 10:58 a.m. and reconvened at 11:10 a.m.)

THE CHAIRMAN: Okay. Can we get back to work. Okay, first up, Manitoba Hydro. Questions?

MS. MAYOR: Yes. Thank you. Good morning, Dr. Goldsborough, you and I spoke briefly, I introduced myself this morning. I feel the need to apologize particularly with, well maybe not with that frog staring at me, I did not even take grade 10 biology.

DR. GOLDSBOROUGH: Neither did I.

MS. MAYOR: And in particular, it was because I could not fathom dissecting a frog. So that little guy looking at me is giving me good reason why I didn't do it.

DR. GOLDSBOROUGH: There, he's gone.

MS. MAYOR: So I have a few questions for you this morning. Your report summarizes some changes to the Netley-Libau Marsh that have been noted by local residents over the last three decades, since Lake Winnipeg Regulation came into

place. However, you also state in your report, and I think in your presentation this morning, that changes to that marsh have actually been occurring for decades; is that correct?

DR. GOLDSBOROUGH: That is correct.

MS. MAYOR: One of the comments in your report is that a marked reduction in the extent of emergent plant has occurred since the early 20th century?

DR. GOLDSBOROUGH: That's correct.

MS. MAYOR: There have been other reports that you have co-authored that describe upland and island losses that have taken place over the past 80 years?

DR. GOLDSBOROUGH: Yes.

MS. MAYOR: And even between 1965 and 1975, emergent marsh habitat declined, I think in one of your reports it said 41 percent?

DR. GOLDSBOROUGH: That sounds about right.

MS. MAYOR: All of those alterations would have occurred prior to the implementation Lake Winnipeg Regulation?

DR. GOLDSBOROUGH: Yes in fact.

MS. MAYOR: One of the main factors

affecting the level of a lake or other water bodies is inflows.

DR. GOLDSBOROUGH: Yes, I'll take your word for it.

MS. MAYOR: Do you agree with that?

DR. GOLDSBOROUGH: Inflows, yes, inflows do change.

MS. MAYOR: Now this commission has heard from both Manitoba Hydro witnesses and from at least one expert hired that we heard from yesterday that inflows into Lake Winnipeg over the past several years have increased dramatically, especially from the Red River. That would be your understanding as well?

DR. GOLDSBOROUGH: Yes, it is.

MS. MAYOR: Those increased inflows also increased the water levels in the Netley-Libau Marsh?

DR. GOLDSBOROUGH: Yes, they would.

MS. MAYOR: Now are you aware that Manitoba Hydro does not regulate inflows into the Netley-Libau Marsh area?

DR. GOLDSBOROUGH: That's correct.

MS. MAYOR: Nor does it regulate the majority of inflows into Lake Winnipeg?

DR. GOLDSBOROUGH: I would agree.

MS. MAYOR: It only regulates outflows in the northern basin of Lake Winnipeg and Manitoba Hydro only has controlled flows when Lake Winnipeg is between 711 and 715 feet.

DR. GOLDSBOROUGH: Yes.

MS. MAYOR: Now inflows are affected by both climate and land use, as I think you were describing, at least in part, this morning?

DR. GOLDSBOROUGH: Yes, absolutely.

MS. MAYOR: From a climate perspective, we have heard from both Manitoba Hydro witnesses and a different expert hired by the Clean Environment Commission attesting to the fact that the Lake Winnipeg region, including the Netley-Libau Marsh area, has been in an extended wet period, perhaps the longest on record.

DR. GOLDSBOROUGH: I have heard that, yes.

MS. MAYOR: And obviously despite its desires to the contrary, Manitoba Hydro has no control over the climate.

DR. GOLDSBOROUGH: I think that's a save assumption, yes.

MS. MAYOR: Now we also learned

yesterday about isostatic rebound and the impact it has on increasing water levels in the south of Lake Winnipeg including the Netley-Libau Marsh. That's something that you are aware of?

DR. GOLDSBOROUGH: I'm aware of it. I'm not an expert in it at all.

MS. MAYOR: Again, no connection to Manitoba Hydro though?

DR. GOLDSBOROUGH: I think that's also a safe assumption.

MS. MAYOR: And even without Lake Winnipeg Regulation, increased inflows into Lake Winnipeg over the last several years from a variety of sources would have contributed to higher water levels at Netley-Libau Marsh?

DR. GOLDSBOROUGH: That's certainly possible, yes.

MS. MAYOR: Now, Manitoba Hydro witnesses attested to a study that was done, and it's contained in appendix 4 of the Lake Winnipeg Plain Language Document. It was work done by Manitoba Hydro with Mr. Hesslein and Mr. McCullough. Now are you familiar with that study?

DR. GOLDSBOROUGH: No, I'm not.

MS. MAYOR: So that study indicates that in the last 30 years since Lake Winnipeg Regulation, there have only been a few instances where Lake Winnipeg Regulation held water levels higher than would have occurred naturally.

DR. GOLDSBOROUGH: I can't speak to that. I don't know anything about it.

MS. MAYOR: And you have no information to refute that?

DR. GOLDSBOROUGH: I don't.

MS. MAYOR: Now are you aware that Manitoba Hydro supports various marsh and lake research initiatives by providing funding to research institutes such as international institute for sustainable development, Water Innovation Centre Lake Winnipeg Basin, that is a mouthful, which has a Netley-Libau Marsh management project?

DR. GOLDSBOROUGH: Yes, I'm aware of that.

MS. MAYOR: Now over the past few years, a number of experts and stakeholders have also participated in workshops put on by the Lake Winnipeg Foundation Science Advisory Council looking into rehabilitation and restoration of the

Netley-Libau Marsh. Are you aware that Manitoba Hydro also provides funding for those workshops?

DR. GOLDSBOROUGH: I am not surprised by it. I'm not sure I knew the details of it, yes.

MS. MAYOR: You were aware, as one of the participants yourself, that Manitoba Hydro staff also participated?

DR. GOLDSBOROUGH: Yes, indeed. I saw them there.

MS. MAYOR: Okay. And Manitoba Hydro staff, in particular Mr. Swanson and Mr. Hutchison that testified before the commission, participated along with representatives of government, the International Institute for Sustainable Development, Lake Winnipeg Foundation members, and Ducks Unlimited?

DR. GOLDSBOROUGH: Yeah, there's a few other people but that's a fair assessment of the group.

MS. MAYOR: And the last workshop was held in September of 2014?

DR. GOLDSBOROUGH: Yes, I think so, at the University of Winnipeg.

MS. MAYOR: And it's my understanding

that one of the breakout sessions at the last workshop, and there have been a few over the last few years, but one of the breakout sessions at that workshop was designed to, my words, brainstorm or create a list of the most feasible strategies to rejuvenate the marsh?

DR. GOLDSBOROUGH: Yes, that's right.

MS. MAYOR: And it's fair to say that a number of options and strategies were discussed but no consensus as of yet has been reached on the most appropriate strategy for rehabilitation.

DR. GOLDSBOROUGH: That would be a safe statement, yes.

MS. MAYOR: So certainly no consensus that drawing down the lake, as you suggested, for extended periods was the most appropriate response yet?

DR. GOLDSBOROUGH: No, it wasn't. There was no consensus that came from that.

MS. MAYOR: And the reason that there's been no consensus reached yet is that much more research and analysis needs to be done before this type of significant decision could be made?

DR. GOLDSBOROUGH: I would certainly agree that there is more research needed, yes.

MS. MAYOR: In fact, a proposal is being put forward, or perhaps it's already been put forward for funding from the Lake Winnipeg Basin Stewardship Fund, as the next step towards Netley-Libau Marsh restoration?

DR. GOLDSBOROUGH: My understanding, yes, it's to hold another sort of information workshop.

MS. MAYOR: And continue on the path towards perhaps even reaching consensus on what the next best steps were?

DR. GOLDSBOROUGH: Possibly, yes. The first workshop was an information gathering one. There was a certain raising of awareness that had to occur. Because to be honest, quite a few people around the table just didn't know very much about the situation.

MS. MAYOR: Okay. Now when you discuss your recommendation in the report, you state that in your opinion, restoration of vegetation in the Netley-Libau Marsh is ecologically feasible?

DR. GOLDSBOROUGH: Yes, meaning that it could be done because we have seen it happen during periods of low water such as in 2003.

MS. MAYOR: And when determining if a recommendation is feasible from other perspectives, operationally, environmentally, other types of factors must be considered. Would that be correct?

DR. GOLDSBOROUGH: I would assume that's the case. I simply don't have any weight on those factors. I'm a scientist and that's it.

MS. MAYOR: Now your recommendation that you discussed this morning with respect to Manitoba Hydro was for it to draw down the lake such that the water level in the marsh goes down about two feet below average for at least two years in every 10 to 20 year period. Have I described that accurately?

DR. GOLDSBOROUGH: Not quite. You said that it would require Manitoba Hydro to draw down which entails active management. 2003 was not as a result of drawing down the lake, it simply happened naturally as far as I know. And so long as those sorts of events could occur, there wouldn't be any need for active manipulation on the part of Manitoba Hydro. So my proposal was that there would be a low water period. If it could be achieved naturally, I think that would be

just as acceptable as if it had happened as a result of management.

MS. MAYOR: So we heard yesterday from Dr. -- from Greg McCullough.

DR. GOLDSBOROUGH: Doctor.

MS. MAYOR: Thank you, I couldn't remember. That in his estimation we're very likely to undergo a very dry period in light of the fact that there has been an extended wet period. If that was to occur, there would be no requirement on the part of Manitoba Hydro to do any sort of engineering of lake levels. Do you agree with that?

DR. GOLDSBOROUGH: If there was a dry period and it caused the lake levels to fall, that would have benefits for the marsh, yes, absolutely.

MS. MAYOR: And that would eliminate the need for Manitoba Hydro to act?

DR. GOLDSBOROUGH: Absolutely.

MS. MAYOR: If that wasn't to occur, you are suggesting that there is actual steps taken by Manitoba Hydro to change the lake levels?

DR. GOLDSBOROUGH: If it couldn't happen within the time frame of 10 to 20 years, if

we were in a prolonged period of high water, then it would be desirable, I suppose, to initiate some kind of management where the levels could be brought down somewhat.

MS. MAYOR: Have you had an opportunity to review the report prepared by Dr. George McMahon?

DR. GOLDSBOROUGH: I have heard of it. I have not been able to review it, I'm sorry.

MS. MAYOR: No apologies necessary. In his report, he has a brief discussion on the Netley-Libau Marsh and he reviewed your recommendations. He states that it presents a set of complex issues and suggests that a considerable amount of work would need to be done before it could be seriously considered. And he was talking about an engineering lowering of the lake.

DR. GOLDSBOROUGH: I would agree with that conclusion, yes.

MS. MAYOR: He also stated that the potential impacts of implementation could be severe such that it might be advisable to investigate other less drastic approaches to improve the Netley Marsh.

DR. GOLDSBOROUGH: I have no basis to

refute him. I just don't know.

MS. MAYOR: Now in order for Manitoba Hydro to carry out your recommendations, it can only increase outflows, correct?

DR. GOLDSBOROUGH: That would be my understanding. It can't increase inflows -- or decrease inflows rather, so yes.

MS. MAYOR: So your recommendation would then require Manitoba Hydro to operate within a much narrower band than currently between 711 and 715 feet?

DR. GOLDSBOROUGH: Yes, that would probably have to happen, yes.

MS. MAYOR: And that would necessitate going to maximum discharge the outflow more often during any sort of draw down period?

DR. GOLDSBOROUGH: I don't know whether it would have to be maximum discharge. It would presumably have to be increased discharge. My forte is not measurements of water flow so I'm afraid I couldn't tell you how much it would have to be increased. But I'm assuming it would have to be increased over what it is otherwise.

MS. MAYOR: Are you aware that Manitoba Hydro has already been at maximum

discharge for a considerable number of years in the last several years?

DR. GOLDSBOROUGH: Well I understand the lake has been high as a result of this wet period we are in, and therefore it's had to compensate by increasing outflow. Yes, I understand that.

MS. MAYOR: Manitoba Hydro gave evidence during the course of this hearing that in above average or high water years, low levels, such as you are suggesting, would not be possible from Manitoba Hydro's perspective.

DR. GOLDSBOROUGH: I would agree. I mean if nature is giving you high water levels, you basically go with it. And that's been the result of, you know, millennia. I mean the lake has fluctuated as a result of variations from year to year and inflow versus outflow.

MS. MAYOR: Now conversely, in low water years, attempting to lower the lake levels puts energy reliability at risk with potentially devastating consequences such as electrical outages. Were you aware of that?

DR. GOLDSBOROUGH: Well, I don't know the magnitude of it but it certainly would not

surprise me. If the amount of electricity that could be generated is a function of outflow, if the outflow was reduced, I would assume that leads then to a reduction in energy production. As to the quantity of that, I am not an expert. I'm assuming Manitoba Hydro has people that could speak more reliably about that.

MS. MAYOR: But you do recognize, from an operational perspective, an engineered drawing down of the water may simply not be feasible?

DR. GOLDSBOROUGH: It's certainly possible. I have never been able to fully understand what determines the lower limit of Lake Winnipeg discharge, whether it is a political limit or whether it is an engineering limit. I don't know the answer to that. I'm sure Manitoba Hydro does.

MS. MAYOR: I think you, in one of your last slides, actually acknowledged that carrying out that particular recommendation may not be possible. And for that reason, you're looking at other more feasible alternatives such as the cattails?

DR. GOLDSBOROUGH: That's correct. I have only about 10 years left in my career and I'm

hoping to have an answer in that period of time. I realize how long political machination sometimes takes, so I would like to have a solution regardless of what happens.

MS. MAYOR: Have you, during the course of your research, recognized that implementing your recommendation may also have other environmental consequences or raise other concerns?

DR. GOLDSBOROUGH: Well, environmental consequences I'd agree. Concern may be another issue. Environmental consequences could be both negative and positive. But yes, I acknowledge that the recommendations I suggested could have consequences, yes, absolutely.

MS. MAYOR: So, for example, if Manitoba Hydro was required to draw down the lake levels to restore the marsh, and then a natural drought occurred after that drawing down, that could lead to significant environmental and other costs?

DR. GOLDSBOROUGH: I'd presume it would, yes.

MS. MAYOR: Now, you would accept that engineered low water levels could affect fish

feeding, spawning and egg incubating habitats?

DR. GOLDSBOROUGH: Yes, it would.

MS. MAYOR: And because of the potential impact on fish and fisheries, the support of DFO, Department of Fisheries and Oceans, may not even be granted?

DR. GOLDSBOROUGH: That's possible, although they have been less active in enforcing their regulations lately.

MS. MAYOR: Commercial fishers would also be concerned by this potential impact on fish populations?

DR. GOLDSBOROUGH: I'd assume it would, yes.

MS. MAYOR: And those that use the lake for fishing or recreation and travel may have concerns as well about the navigation and use of docks by lower lake levels?

DR. GOLDSBOROUGH: Yes, I would assume that would apply, yes.

MS. MAYOR: There would also be potential environmental effects downstream as greater discharge at the north end has the potential for more frequent flooding and increased erosion, sediment transport and deposition?

DR. GOLDSBOROUGH: I suppose that's possible. I don't know enough of the channel morphology downstream to know whether the capacity of the channel would be exceeded. But it's certainly conceivable, yes.

MS. MAYOR: I have no other questions. Thank you very much.

DR. GOLDSBOROUGH: Thank you.

THE CHAIRMAN: Thank you, Ms. Mayor.

How did you know I was going to go to you, Mr. Williams?

MR. WILLIAMS: Good morning, members of the panel, and I apologize for jumping to the cue.

And certainly good morning, Dr. Goldsborough.

DR. GOLDSBOROUGH: Good morning to you.

MR. WILLIAMS: And I should introduce Ms. Desorcy, our executive director, as well as Ms. Nielsen are here and both have been at the hearing on and off for a number of days.

I'll indicate that I'm going to be asking a few questions on behalf of CAC Manitoba and then Pimicikamak has asked that we ask a few

questions on their behalf. So when I move from one set of questions to the other, I'll try and remember to advise the panel.

And there should be two documents. And they are from the literature and I'll just indicate that they are excerpts, they are not the full documents from either of these.

Dr. Goldsborough, you characterized Manitoba as being the coastal wetland province; is that correct, sir?

DR. GOLDSBOROUGH: That would be a correct assumption, yes.

MR. WILLIAMS: But despite our preeminent stature in that regard, it would be fair to say that the research levels in this province are relatively modest as compared to perhaps Laurentian Great Lakes?

DR. GOLDSBOROUGH: I would go further. They are trivial in comparison to Laurentian Great Lakes.

MR. WILLIAMS: And one of the points you made in your written evidence at page 5, you do not need to turn there, but that is that the best evidence of the connection between lake level management and coastal wetlands comes from studies

of the Laurentian Great Lakes; would that be fair, sir?

DR. GOLDSBOROUGH: There has been study over at least two decades of the response of vegetation to lake level. And a lake level, because it has gone through quite a long range of variation. Now to what extent that has been as a result of management, I can't speak to it. All I can speak to is the water levels on the Laurentian Great Lakes and how that has affected the vegetation.

MR. WILLIAMS: And you cited a number of studies including the one of Hudon and Wilcox "Modeling Wetland Plant Community Responses"?

DR. GOLDSBOROUGH: Yes, I'm familiar with that study. I know both of its authors.

MR. WILLIAMS: And do you have a copy of that or an excerpt of that on your table, sir?

DR. GOLDSBOROUGH: I don't think so, no.

MR. WILLIAMS: Just one second. Thank you, Ms. Johnson.

And, Dr. Goldsborough, this is one the authorities that you cited in this paper, correct?

DR. GOLDSBOROUGH: Yes, I am familiar

with this paper.

MR. WILLIAMS: I just want to draw your attention, because time is short, to the abstract which appears on the second page of the excerpt that I provided to you. And this study was compiled at a particular point in time at which the International Joint Commission had completed a five year study with regard to the operation of structures as well as how they may affect coastal wetlands. Would that be fair, sir?

DR. GOLDSBOROUGH: That's correct, yes.

MR. WILLIAMS: And at a high level, what this report does is describe the scientific methodology to quantify response of wetlands to hydrology. That's an important contribution of this study?

DR. GOLDSBOROUGH: Yes, it is.

MR. WILLIAMS: And just to draw your attention to the bottom of the abstract, another important contribution of this study would be that it contributed to performance indices or metrics which were then able to be used to assess the effects of different regulation plans under current and future water supply scenarios.

DR. GOLDSBOROUGH: That's right, yeah. Performance metrics are very useful because they can help to you quantify the actual change that you are measuring. One of the difficulties we are confronting right now is that we have no real metrics other than just sort of indirect ones, and that's what we are continuing to work towards. We are still years away though.

MR. WILLIAMS: Okay. And if I can just direct your attention for a moment to page 324 of this excerpt, which is the second last page, sir.

DR. GOLDSBOROUGH: Um-hum.

MR. WILLIAMS: And I know you are familiar generally with the work but, sir, you'll agree with me, and I will direct your attention to the second last paragraph, but one of the conclusions of this report was:

"The importance of natural water level variations including the annual range in level recurrence of high and low water levels over longer time spans in sustaining wetland abundance and diversity."

That was an important finding of this report?

DR. GOLDSBOROUGH: Yes, it is.

MR. WILLIAMS: And I wish time gave us a bit more time to spend on that report, sir. But at a high level, you are also familiar with some of the deliberations with regard to the Lake Ontario plan, sir?

DR. GOLDSBOROUGH: In a very general sense. I know the people who have been involved and they have certainly told me a bit about it. I am not familiar with the specifics, no.

MR. WILLIAMS: I wonder if I can, just in terms of the Lake Ontario plan document, direct your attention to the bottom of page 42 on the right-hand side. And I'll let you look at that last paragraph on the right-hand side for just a moment, sir. But there you'll see a conclusion by the International Joint Commission about the significance of water level fluctuations in shallow water in terms of its effects upon that wetland environment. Is that correct, sir?

DR. GOLDSBOROUGH: Yes, and it refers specifically to the exposure of sediment to the air which of course dovetails nicely with what I just showed you in one of my slides, the exposure of the mud at Delta Marsh during the 2003 drought.

MR. WILLIAMS: And I just want to ask you to turn to page 44 of this excerpt and figure 20 in particular. You will see a headline, sir, Compressing Natural Water Level Variability Reduces Plant and Animal Diversity. Do you see that, sir?

DR. GOLDSBOROUGH: I do.

MR. WILLIAMS: And you spoke in terms of the impacts of the compression on wetlands. I wonder if you have any commentary in terms of the bigger picture here as well in terms of compression as it may affect riparian habitat?

DR. GOLDSBOROUGH: Well, I mean the net result of having less variability in the water level gives you less diversity of plants because some plants are adapted to water, abundance of water, some plants are adapted to very little water.

What you see, for example, in this diagram is a gradient from dry land on the left to basically wet land on the right. And as a result of that, different plants have different degrees of adaptation to that water. So you therefore have a greater diversity of plants. Well that, in turn, has sort of a cascading effect. The more

plants you have, the more different types of animals you can have to exploit those plants. Of course animals use plants as food, they use the plants as habitat. So necessarily, a greater diversity of plants will translate into a greater diversity of animals.

So I think that's what the caption is getting at, that you need a range of water levels to have a range of plants, and that in turn will dictate a range of animals.

MR. WILLIAMS: Okay. And, sir, at a high level, would it be your understanding that the International Joint Commission and its plan 2014 for Lake Ontario recommended both more frequent low and more frequent high Lake Ontario water levels?

DR. GOLDSBOROUGH: In general sense, yes. I am quite familiar with one of the authors, in fact, of that previous study you referred me to, Douglas Wilcox. And he has spoken at length about the virtue of both high and low. Douglas is a plant biologist. That's his forte. And he basically reiterated some of the things that I had said this morning, that low water periods are periods of recruitment. The high water periods

are periods of drowning. And in order to maintain a healthy marsh environment, you need both.

MR. WILLIAMS: And at a high level plan 2014 looked at alternatives to the existing status quo with a variety of performance indicators including ecological, economic and social. Is that your understanding, sir?

DR. GOLDSBOROUGH: In a very general sense. I am afraid I do not know the details to know in detail what it proposes.

MR. WILLIAMS: Thank you. Given time limitations, if my clients had their druthers, I would be up here for hours.

I have three or four questions on behalf of Pimicikamak.

DR. GOLDSBOROUGH: Okay.

MR. WILLIAMS: Dr. Goldsborough, has there been any study of riparian habitats and vegetation growth and aquatic vegetation on Lake Winnipeg other than in the major southern wetlands?

DR. GOLDSBOROUGH: Not to my knowledge, no. That's an illustration of what I referred to as the difficulty in drawing too many conclusions. There have been not many studies

done. The Netley-Libau Marsh has frankly been the focus of our work. And prior to that, there had been almost nothing done on the Libau Marsh. So I think it's a safe statement to say we know very little about the coastal wetlands of Lake Winnipeg as compared to the ones on the Laurentian Great Lakes.

MR. WILLIAMS: So in terms of analogy, is the best information out there, apart from your team's work, really relates to the Laurentian Great Lakes?

DR. GOLDSBOROUGH: That's right. That's why I make the comparison to the Laurentian Great Lakes. It's geographically the closest to us. Morphologically, because the lakes themselves are large bodies of water that have wetlands around them, the fact of course too that the lake levels do fluctuate both because of natural factors and because of artificial manipulation, that there's some relevance to our situation too. So all in all, it's as good an analogue as we can find, at least in North America.

MR. WILLIAMS: Okay. And do you have any thoughts on the effect of flow regulation from Lake Winnipeg on the smaller downstream marshes,

downstream of Jenpeg, sir?

DR. GOLDSBOROUGH: I'm afraid I am not familiar at all with the downstream area. I can't speak to that at all, I'm sorry.

MR. WILLIAMS: Okay. And in drawing your conclusions and recognizing your totally legitimate focus on wetlands upstream of Jenpeg, have you considered what, if any, effect a two-year draw down period to Lake Winnipeg would mean for downstream habitats?

DR. GOLDSBOROUGH: Well, relating back to the questions I was asked before, it would presumably lead to greater flow downstream which would presumably translate into greater water levels on those wetlands. So those would be probably periods of drowning. So that would be the other end of the spectrum for those wetlands, yes. But beyond that, I can't speak to any specifics.

MR. WILLIAMS: And a robust spectrum of alternatives no doubt would factor in both upstream and downstream?

DR. GOLDSBOROUGH: It should, yes, absolutely. We obviously don't want to devastate downstream areas if it could be avoided. So you

would try to find a solution that could hopefully achieve all your objectives. But I think you would need the wisdom of Solomon to do that.

MR. WILLIAMS: Okay. And on behalf both of our clients, Dr. Goldsborough, as well as Pimicikamak, I thank you for your time.

DR. GOLDSBOROUGH: Thank you.

THE CHAIRMAN: Thank you, Mr. Williams.

Ms. Whelan Enns?

MS. WHELAN ENNS: Gail Whelan Enns, Manitoba Wildlands. Good morning, Dr. Goldsborough.

DR. GOLDSBOROUGH: Good morning.

MS. WHELAN ENNS: I would like to ask you a little bit about your comments you have made since questions have started.

DR. GOLDSBOROUGH: Okay.

MS. WHELAN ENNS: And that is there was a reference when Manitoba Hydro was asking questions from you about how we are in a prolonged period of high waters.

DR. GOLDSBOROUGH: Yes.

MS. WHELAN ENNS: That was also in your presentation.

DR. GOLDSBOROUGH: Yes.

MS. WHELAN ENNS: You have also made references to a pattern of lowering waters for the benefit of all the coastal wetlands in the lake, focusing on Netley Libau. What do you think would be needed when, going to your recommendations, if the prolonged wet period that we are in now continues and we do not have a dry period?

DR. GOLDSBOROUGH: Well, we don't know how long vegetation will tolerate prolonged flooding. But it's likely that the vegetation loss will continue. We know, for example, from that graph I showed of the open water area of the Netley-Libau Marsh that, you know, from the 1990s into the 2000s, there was a dramatic loss of vegetation. And then it kind of stabilized but it continued, the graph kind of continued to track upwards at a slower rate. It's likely that that would continue.

If we were in a prolonged wet cycle, it's likely that vegetation loss would continue at some rate. But I can't know for sure. It of course depends on the specifics of how much and how long.

MS. WHELAN ENNS: Thank you. Your

answer then would apply to other wetlands?

DR. GOLDSBOROUGH: Absolutely.

MS. WHELAN ENNS: Okay thank you. On slide 10 and in other places in your presentation, including your conclusions, you have been referring to four causes, okay?

DR. GOLDSBOROUGH: Each of which I believe contributes somewhat. I don't know by what quantity for each, but yes.

MS. WHELAN ENNS: Would it be reasonable to add, and I think this happens later in your presentation, to add to these causes the regulation of both the Red River and Lake Winnipeg?

DR. GOLDSBOROUGH: The regulation of the Red River?

MS. WHELAN ENNS: Um-hum, as in regulated water flows.

DR. GOLDSBOROUGH: I'm not sure I understand. How is the Red River regulated?

MS. WHELAN ENNS: Well, the Red River goes through a floodway and is part of a floodway system.

DR. GOLDSBOROUGH: That just redirects the water, does it not? It doesn't actually

change the quantity of flow?

MS. WHELAN ENNS: It certainly affects the levels of flow, the timing of flow.

DR. GOLDSBOROUGH: By the time it reaches the Netley-Libau Marsh, is it not the same as it would have been if it had gone through Winnipeg? I'm speaking in ignorance.

MS. WHELAN ENNS: Thank you.

DR. GOLDSBOROUGH: I don't know. I'm a biologist. I think that requires somebody with more expertise.

MS. WHELAN ENNS: We'll continue, thank you. Okay. On slide 13, and I think this was the first point in your presentation where you began to refer to boats.

DR. GOLDSBOROUGH: Okay.

MS. WHELAN ENNS: Okay, in terms of using the channels in the marshes. Are we talking steamers?

DR. GOLDSBOROUGH: Not anymore I don't think. I think we have probably moved over to things like diesel-powered vehicles like the demayo (ph) for example. That would be an example of the kind of vessel that would be comparable in size to the early steamboats.

MS. WHELAN ENNS: And my apologies, I probably wasn't clear. So in terms of slide 3, the top one is 1893 to 1903. And then the lower one is 1903 to now.

DR. GOLDSBOROUGH: Yeah.

MS. WHELAN ENNS: So if we take the top one, were these channels used by steamers?

DR. GOLDSBOROUGH: Yes, they were. Most of the supplies that were delivered to northern communities in Manitoba were delivered by boat during the summer time. Simply because these ships could carry larger amounts of cargo than you could probably carry by, I guess by sled or whatever in the winter time.

MS. WHELAN ENNS: Great, thank you.

DR. GOLDSBOROUGH: Would it be possible to get a copy of the presentation so I could see what she means when she talks about particular slide numbers?

MS. WHELAN ENNS: This is a question that basically relates to the sequence of the Netley Cut slides and came forward as a result of understanding the chronology we're talking about. In your research, did you come upon any information in terms of the benefits to or effects

on the fishery around the marsh?

DR. GOLDSBOROUGH: No.

MS. WHELAN ENNS: From the dredging and the cuts?

DR. GOLDSBOROUGH: No information. In fact, we know relatively little of the fishery in the marsh. There was a study done by Joe O'Connor of the Provincial Fisheries Department quite a number of years ago. But it didn't really provide the kind of detail we would need to assess the impact of the cut.

MS. WHELAN ENNS: Thank you. On page 5, this is the second start on your numbering of your pages. This is the slide that's the Hardman Lake slide.

DR. GOLDSBOROUGH: Okay.

MS. WHELAN ENNS: I wanted to ask you whether or not, and again this is 2001, 2003, but you were explaining to us the change when the water levels go down and how much more vegetation. And I would say plants on land. In your estimation then, when we're in a low water part of the cycle, when it was natural and since regulation, does the ability to go in and hunt or gather increase?

DR. GOLDSBOROUGH: When the vegetation grows in?

MS. WHELAN ENNS: Um-hum.

DR. GOLDSBOROUGH: To be honest, I don't know. I'm not aware of what hunting and gathering activities occur in the marsh anymore. I know that it has decreased dramatically in the last several decades, I suspect as a result of the changes in the marsh, but may also be because of changes in cultural practices. I am afraid I don't know.

MS. WHELAN ENNS: This may be a question that has to do with Aboriginal activity in the marshes but also recreational hunting because I believe it's also dramatically decreased.

DR. GOLDSBOROUGH: The only thing I know is that when we had conversations with the people at Brokenhead, they did advise us that considered the marsh to be a useful source of medicines and country foods. But as to the specifics, as to the quantities and the types of things that they were collecting, no information.

MS. WHELAN ENNS: Thank you. Thank you for taking us through the decades of dredging

and up to the time when it stopped. Did you take into account or is this a question that shows lack of knowledge of biology, does dredging and has dredging contributed to vegetation decline?

DR. GOLDSBOROUGH: Well, in the sense that it has contributed to the flow through the Netley Cut and therefore into the Netley Lake, which has deepened conditions, that in turn has caused impacts on the vegetation, yes. Indirectly, dredging would have a negative impact on vegetation, yes.

MS. WHELAN ENNS: Thank you. Finished. I have identified some questions previously asked and thank you, Dr. Goldsborough.

DR. GOLDSBOROUGH: Thank you.

THE CHAIRMAN: Thank you, Ms. Whelan Enns.

Mr. Stevenson, do you have any questions?

MR. STEVENSON: Lloyd Stevenson from Peguis. In your introduction for your presentation this morning, you said you also had an interest in history so I imagine you are fairly knowledgeable about the history in the --

DR. GOLDSBOROUGH: I'm sorry, I didn't

catch the word. Did you say estuaries?

MR. STEVENSON: Knowledgeable about the history in the Delta Marsh area?

DR. GOLDSBOROUGH: Oh yes, history of the Delta Marsh, yes, sure.

MR. STEVENSON: I imagine you are familiar with the Netley Creek and the settlement of Chief Peguis back in the late 1700s?

DR. GOLDSBOROUGH: Yes. I understand that this was one of the first areas that the Peguis band occupied.

MR. STEVENSON: And Netley Creek, the former name was Duck River Nibosibi (ph) and later changed to Netley Creek?

DR. GOLDSBOROUGH: Yes. In fact, I saw a large map last night just to the east of the Netley Creek outlet that was shown as being a reserve for the Peguis Band.

MR. STEVENSON: So that was the St. Peter's settlement reserve.

DR. GOLDSBOROUGH: Was it?

MR. STEVENSON: Yeah. And they were surrendered back in 1907 and they were moved north.

DR. GOLDSBOROUGH: I see.

MR. STEVENSON: But they were remnants of the St. Peter's reserve along the Netley Creek area, between Netley Creek and Selkirk. And as a matter of fact, there are still reserve lands in that vicinity.

In your presentation this morning, you talked about the economic values of the coastal wetlands. And you said it would assist in the spawning and feeding habitat for commercial lake fish. I'm just wondering what kind of lake fish you had in mind when you mentioned fish in general?

DR. GOLDSBOROUGH: Well, the sorts of fish that tend to spawn in shallow waters would be things like pickerel or walleye, pike, yellow perch, probably whitefish.

MR. STEVENSON: Okay, fine. Thank you. You talked about the bulrush and the cattail where they take the pollutants from the water and I guess they filter out the pollutants from the water in trying to refresh the water in a way you referred to them as kidney or renal function.

DR. GOLDSBOROUGH: Yes, that's right.

MR. STEVENSON: I'm not sure the distinction between a cattail and a bulrush. I'm

not that familiar with those two plants, but I know they do exist.

DR. GOLDSBOROUGH: Um-hum.

MR. STEVENSON: In terms of properties of the two are they fairly similar?

DR. GOLDSBOROUGH: Well, no, they are actually rather different. The cattail is the one that has branching leaves with a spike at the top when it's producing flowers. That's sort of a brown one that people tend to collect for floral arrangements and so on. Bulrushes, on the other hand, usually have sort of a cylindrical stem that is a single vertical sort of cylinder. The one that people often interchange those names though, that's why I prefer to call them Typha for the cattail and Schoenoplectus for the bulrush. Those are the scientific names for them.

MR. STEVENSON: I know in our culture, the Anishinaabe, we used to collect those years back and used them for a mattress. Like you have your tents where you move fairly frequently to hunting and gathering, so you take them as a mattress to sleep on. So that was the function of I guess the cattail in those years.

DR. GOLDSBOROUGH: Probably the

cattail, yes. I have heard that that's one of its uses, yes.

MR. STEVENSON: You talked about the three plants, the cattail, the bulrush, and --

DR. GOLDSBOROUGH: Giant reeds.

MR. STEVENSON: Giant reed, yes. I'm just wondering if another plant would serve the same function. And I'm thinking of a plant that grows in that kind of a shallow water. We call that wild rice, if wild rice would serve that kind of function?

DR. GOLDSBOROUGH: Yes and no. Wild rice is kind of different than the others because the others, cattails, bulrushes and phragmites are all perennial species that establish themselves and actually will then persist over decades. Wild rice, on the other hand, is an annual species that every year must set seed and re-establish itself all over again the following year. So wild rice unfortunately tends not to do so well in these sort of fluctuating water environments. I know there is wild rice in these environments but it tends not to be the dominant element, unlike cattails or bulrushes.

MR. STEVENSON: So where water

fluctuates, that would affect the growing of the wild rice plant?

DR. GOLDSBOROUGH: Presumably if there was any flow, any kind of erosional scour could take away the seeds of wild rice, that's true. Because the only way that wild rice can establish itself is from seed. Whereas cattails, very routinely, establish themselves from the underground roots.

MR. STEVENSON: You talk about the delta of the Red River where it flows into lake Winnipeg. I'm just wondering if you're familiar with the Netley Creek delta? And it has certain wetland in itself where it goes from the, where it flows into the Red River west from there.

DR. GOLDSBOROUGH: I don't know it terribly well. I've been down that channel a couple of times. But I would defer to, you have probably been there many more times than me.

MR. STEVENSON: You said the dredging stopped, and was it '93?

DR. GOLDSBOROUGH: To my understanding, it was 1999.

MR. STEVENSON: Ninety-nine. Do you think that was due to the economic industry or

lack of that caused the dredging?

DR. GOLDSBOROUGH: I'm told the rationale was that there just wasn't enough shipping to warrant the expenditure of money on the dredging, that there weren't enough boats that were large enough to require dredging travelled on the river and therefore the government felt that it just wasn't necessary to do the dredging.

MR. STEVENSON: Were you aware of the shipment of gravel for making glass from Black Island?

DR. GOLDSBOROUGH: No, I'm not actually. I would be interested to know more about that. But no, I don't know about that. As I say, I am simply reporting what I have been told. I wasn't privy to the decision about the dredging and the cessation of it. I was simply told that it was justified on economic grounds. There just wasn't enough economic activity to warrant it, but I don't know that for a fact.

MR. STEVENSON: Those are all my questions. Thank you.

DR. GOLDSBOROUGH: Thank you.

THE CHAIRMAN: Thank you, Mr. Stevenson. Ms. Riel, do you have any

questions? No? Panel members? Mr. Yee?

MR. YEE: No.

THE CHAIRMAN: Ms. Suek?

MS. SUEK: I do, yes. When we were travelling around to communities, a number of people were aware of your study and perceived that Lake Winnipeg Regulation had a significant effect on the demise of the Netley-Libau Marsh. So I just wanted to clarify a few things. I can understand that the marshes need fluctuation in order to survive and over a period of time. But when I look at the slide that you had from Manitoba Hydro about the fluctuations before and after Lake Winnipeg Regulations, it appeared to me, and that's why I'm clarifying this, is that after Lake Winnipeg Regulations, there still were reasonable fluctuations?

DR. GOLDSBOROUGH: Yes, there were. In fact, if you look at the periods of red, which denote the periods of low water, there was one in the late 1970s, there was one in the late 1980s, and of course the one in 2003. So there have been at least three periods of low water.

MS. SUEK: Right. And Lake Winnipeg Regulation is to regulate between 711 and 715.

And so it looks like 713 is enough to give that regeneration. Is that --

DR. GOLDSBOROUGH: I'd say the average level of the lake is 713.5, or thereabouts. And it looks to me, just based on what I know about what happened to the vegetation in 2003, that that was a level of water that was roughly two feet lower than the long-term average of the lake. It's on that basis that I suggested a two foot reduction in lake level that would correspond to those events that took place in those three years during regulation.

MS. SUEK: Right. And that's still within the range of Lake Winnipeg Regulation as it exists?

DR. GOLDSBOROUGH: They were. As you can see those two horizontal lines that denote the 711 and 715, each of those three low periods were within that range.

MS. SUEK: I guess I'm kind of looking at cause and effect. Is Lake Winnipeg Regulation the cause of the problem or is it the climate? I mean the fact that in the last number of years we have had a very wet climate, that levels haven't fallen. As I understand it, Manitoba Hydro has

been at maximum discharge for quite a while now, so it just isn't going down to that level because we have just -- the climate is just too wet.

DR. GOLDSBOROUGH: That's right. And I advocate for trying as much as possible to work with nature. You know, if we are in a prolonged wet period, then it's in a prolonged wet period. You wouldn't try to counteract that. In other words, if I was saying in 2017 we needed a low water period, and it happened to be an unusually wet year, I'm not going to stamp my feet and say it must be low and dammit, it's going to happen. You know, that's rather silly. You deal with it as you can.

And that's why I think there needs to be sort of flexibility to allow for the possibility that we are going to have prolonged highs and prolonged lows that are beyond the control of Manitoba Hydro or anyone.

MS. SUEK: Right.

DR. GOLDSBOROUGH: And that we, as much as possible, try to have low periods that benefit the marshes that work with existing conditions. So I am not sure, I don't know what explained those two other low periods that

occurred during the hydro regulation period. All I know is the one in 2003 corresponded to a period of regional drought. And it's likely, I'm assuming, that the other two were likewise.

So so long as those sorts of natural events, if in fact they were natural events, could occur on a cycle of anywhere from 10 to 20 years, I don't anticipate we would have problems. It's more if there was a prolonged maintenance of high or a prolonged maintenance of stable, that would be bad.

MS. SUEK: Okay. And I guess I'm trying to figure out what Hydro could do. I mean we have been in a wet period, they are at maximum discharge. They can't get the level down more than it is. I mean I don't know what you think that they might be able to do to get that level down in wet periods like we are in right now.

DR. GOLDSBOROUGH: If we look at the hydrograph of the last few years and we see that it's tracking relatively high and consistently from year to year, I would assume there's nothing that could be done. I'm assuming they aren't intentionally keeping it high.

And on the other hand, I think if we

were to subsequently go into a prolonged dry period, as long as it's within that range again, it would likewise not be adjusted either.

I guess my hope is we would go to a more natural, if that's a possible way to describe it, natural sort of oscillations of water level. Natural in the sense that it's determined by the natural variations between years of inflows and outflows. You know, and if you look at say the pre regulation period, there have been highs and lows. And those are the things that I would like to see continue.

You know, maybe not to the extremes of the 1930's and '40s of lows or extremes of highs of the 1950s, I don't think anybody is advocating those. I think what we would want, however, is enough lows to enable the vegetation to re-establish itself. And enough highs too frankly to allow the vegetation to be prevented from overgrowing.

MS. SUEK: You know, I understand it needs fluctuation, but it seems to me that post regulation, there has been fluctuations too. And the only we're not getting fluctuations is more about climate than it is -- I mean because you

made the four factors that contribute to the marsh and one of them you said was Lake Winnipeg Regulation. I'm not sure how you make that cause and effect to Lake Winnipeg Regulation.

DR. GOLDSBOROUGH: Well, let me say this. What I'm referring to is the lake level. And I think the lake level has been the contributing factor. To what extent that is driven by the management of the lake, I will be the first to admit I am not an expert.

I'd also like to point out though that there is an awful lot of discussion about the current wet cycle that we are in and how that has been the main driving factor. And I know that, for example, Dr. McCullough advocates that as a primary factor. I think it should also be acknowledged though that landscape is continuing to change. The landscape of the prairies, especially the Red River Valley, are continuing to undergo change, especially drainage.

We are seeing, for example, in Canada, the widespread adoption of tile drainage as a means of draining land. And that's something that continues right to today.

You know, so yes, it's true that we

are experiencing a wet cycle. I think it is also however true that part of the contribution to the high levels that we are encountering now is the increased efficiency of drainage that is occurring in that same area. So you have greater run-off, and you have greater water coming in. That necessarily leads to greater water volume.

MS. SUEK: Yes. And I found that very interesting. The wetlands have disappeared and the drainage I think from farmland has been a big contributor.

DR. GOLDSBOROUGH: That's right. Well, the provincial government has recently announced a surface water management strategy that is hoping to address that very question. Because we do of course face the prospect of imminent drought. You know, the global climate change scenarios do predict drier conditions in the future.

And the irony here in Manitoba is we do confront periods of flood and periods of drought sometimes in the same year. You have an abundance in the spring, you have a shortage in the summer. And therefore, to hold the water on the landscape in some way that it could be put to

useful purposes later in the year seems to me to make imminent good sense. And that's why this policy the provincial government is on the cusp of announcing I think is a very good start in doing exactly that.

MS. SUEK: Yes, exactly. That makes good sense to me too. Thank you.

THE CHAIRMAN: Mr. Harden?

MR. HARDEN: Just a few questions. Number one, it strikes me that, you know, with the dredging required for over 100 years, then the natural state of the outlet for the Red River must be relatively shallow?

DR. GOLDSBOROUGH: Pre dredging, pre 1884, most likely yes. Although on the other hand, there would have been likely change from year to year. So, for example, in the 1820s when we had this enormous flood, there would have probably been some erosion of that sediment that was deposited too. So inevitably, it would have been a very dynamic system. I suspect that the channels of the Netley-Libau Marsh have undergone dramatic change over millennia.

MR. HARDEN: Fair enough. But then it would also strike me that the marsh itself must

have been stable with that sort of changeable relatively shallow sort of channels?

DR. GOLDSBOROUGH: I wouldn't necessarily use the word the marsh would have been stable. In fact, the marsh would have been quite changeable. And that's really I guess the point, is that the marshes are not ever going to stay the same. They are going to wax and wane. And you would get a dramatic loss of vegetation just as we are seeing, but then it would have been gradually brought back over time as well. So that's the condition of things.

You know, the photos I showed you from the 1920s, for instance, where it showed a vast area of vegetation, we don't have anything before that. We have no clues because there just is no information. But I am willing to bet there have been times, perhaps in the 1820s, for example, when there was just a vast open water area because the flooding was sufficiently prolonged that it would have wiped out most of that vegetation.

So it took place over decades and the vegetation grew back, and then it was flooded out, it grew back. And that's just a natural cycle that continues.

MR. HARDEN: Okay. But my logic was heading towards that perhaps the Netley Cut might be more of a factor than say the shallowness of the river mouth itself.

DR. GOLDSBOROUGH: That could be the case. Well, for one thing we would like to see done is a model, sort of a hydrologic model of the Netley Marsh that could manipulate the various flows in various places. And well if, for example, we were to dredge the mouth of the Red River and increase its flow, what would that do to the flow through the Netley Cut? You know, that kind of model I think would be quite helpful because it would allow us to know better what the benefit of resuming dredging would be, the actual amount of change.

I can tell you right now it would benefit but I can't tell you how much. And we now have that bathymetric map. One of the slides that I showed you was a bathymetric map for the south end of the Netley Lake. This map from 2011. And the fact the map is for the entire marsh, I am just showing you a portion of it here. Well, the usefulness of this then is that you can calculate the volume of water that sits in the various

parts. If you measure the flow, as Dr. Clark has done, you could then develop a model using, you know, software to actually predict what happens when you change this or change that.

You know, so if, for example, you wanted to know if we resume dredging, what would happen? You say well, we'll take the channel, we'll reduce its depth or increase its depth and then see what that does to the slow pattern of water. I think that would be very useful in this discussion.

MR. HARDEN: I would agree with that. Now, the Libau side hasn't received a whole lot of discussion but it is one that's not directly influenced by the Netley Cut.

DR. GOLDSBOROUGH: No, it's not.

MR. HARDEN: Is it in a better state than the Netley side?

DR. GOLDSBOROUGH: Well, better is a hard thing to measure. But if in terms of simply the loss of the vegetation, the emergent plants, the cattails, yes, it is in better condition. We haven't seen the vast opening up. In the east or the west side, we have seen a vast area of what used to be vegetation turn into open water. We

haven't seen the corresponding change in the east marsh. And so it's tempting to suppose that that's because we have a Netley Cut on the west side and we do not have anything equivalent to it in the east side. But there have been changes there too.

We know, for example, that there's a lot more hybrid cattail around the marsh than there used to be the entire marsh, both east and west. It has causes related to the high nutrient load of the water.

So to say that it's better, yes, it generally has more vegetation. But I, as a biologist, would be loath to want to say that it's in good condition because I am not sure that it is.

MR. HARDEN: Okay. Thank you, those are my questions.

DR. GOLDSBOROUGH: Thank you.

THE CHAIRMAN: I just have a question or two around the dredging. And given your response just now to Mr. Harden, it might be too soon. Your suggestion that what we could really use is some hydrologic modeling.

DR. GOLDSBOROUGH: Absolutely.

THE CHAIRMAN: But if dredging were to resume, would it need to be done every year?

DR. GOLDSBOROUGH: That's something that I think I would defer to the modeling, because I don't know. I know that when they were dredging, however, it was an annual activity.

THE CHAIRMAN: Yeah.

DR. GOLDSBOROUGH: I tried at one point in my research through the historical records to see what correlated to the quantity of dredging that they did. So, for example, I thought it perhaps had increased when the water levels were lower because there was more necessity because the water was shallower. And it would decrease when the water levels were higher. So in other words, there would be an inverse relationship between dredging and water levels. I also looked at the flow in the Red River thinking that it would be related to that. But in neither case could I find a good correlation. So therefore I'm wondering if it's more complex than that.

It may have a basis, for example, in the financial situation in a given year. They suddenly find themselves with some dollars and

they throw it into dredging. You know, it's a question I think really begs to be answered, but it's one that I cannot answer.

THE CHAIRMAN: I suspect that given it is now 15 or 16 years, there's probably not an operating dredge left in Manitoba?

DR. GOLDSBOROUGH: And again, that's a question I can't answer. I was told, however, that as recently as about a half a dozen years ago, the dredge was still at Dry Dock in Selkirk and it was being maintained. In other words, the annual maintenance that it required was being done. Because like anything, of any machine, if you don't maintain it, it will not resume function.

I was told as recently, about a half a dozen years ago it was still being maintained annually. But as to the degree it is now, I couldn't speak to that.

THE CHAIRMAN: Well, let's hope it still is if and when it might be needed again.

That's the only question I had. I'd like to thank you, Dr. Goldsborough, for first taking the time to prepare the paper that we have all reviewed and then for taking the time to come

out here this morning.

DR. GOLDSBOROUGH: I appreciate the opportunity, thank you.

THE CHAIRMAN: It's an important topic and your presentation and your paper have made a valuable contribution to our review. So thank you very much. And I think we have left you plenty of time to get back to the campus in time.

DR. GOLDSBOROUGH: Yes.

THE CHAIRMAN: Good. We'll break now until 1:30.

(Proceedings recessed at 12:18 p.m.
and reconvened at 1:30 p.m.)

THE CHAIRMAN: Good afternoon. We now come to the fourth of the CEC expert witnesses, Dr. George McMahon, who will talk about hydrologic and operational matters. So, Dr. McMahon, I will have the Commission secretary swear you in.

Dr. George McMahon: Sworn.

THE CHAIRMAN: Go ahead.

DR. McMAHON: Thank you. And I would like to thank the Commission for giving me this opportunity to review this material and provide some recommendations.

My voice tends to drift off, so if I'm

ever becoming inaudible, please, somebody raise a hand or something. Can everybody hear me okay? Okay. Thanks.

So the topic of this discussion is the hydrologic and operational models, in particular the capabilities and limitations of the tools developed by Manitoba Hydro to assess primarily the things that they document in the July 2014 report, in support of the final licence application.

One is the effects of Lake Winnipeg Regulation on Lake Winnipeg levels and outflows, which is primarily addressed in appendix 4 to the report, and the assessment of looking at alternative power ranges for Lake Winnipeg, which is addressed in appendix 10 to the July 2014 report, and looking at the effects of these two different alternative power ranges, which I will talk about in a minute, on Lake Winnipeg levels and outflows as well, and also some of the downstream effects of those power range alternatives.

The other thing that I wanted to look at was the modeling implications of information requests and other issues raised in the licensing

process and in expert reports. So these are either implications to the modeling or things that might be informed by the modeling. Sorry, I keep hitting the wrong computer.

So, as I've said, the objectives are really to assess the adequacy of the models and data in support of the current licence application for the application for the final licence, and to make recommendations to the Commission on potential improvements or modifications to the model in support of the current licence application, which I would call near term modifications or near term recommendations, and then looking at studies and development, and model development basically that might be needed in the future to address other issues, other aspects of Lake Winnipeg Regulation in the long term. And some of those issues have been discussed in previous presentations regarding sedimentation, erosion, the Netley-Libau Marsh, other sorts of things.

So the documents and data I reviewed are basically the Manitoba Hydro report, the July 2014 report, and four appendices to that report: Appendix 3, the effect, the hydrometric

analysis of the effects of Lake Winnipeg regulation; appendix 4, which I talked about, is the application of models to assess the effects of Lake Winnipeg Regulation on Lake Winnipeg itself; appendix 7, the hydro climate study; and appendix 10, the assessment of alternative power ranges.

I also looked at, not in any quantitative sort of way but just to look to see how these other issues raised by stakeholders and experts in this process might relate to modeling, what their linkages to modeling might be. So I looked at about 20 or so of the information requests pertaining directly to modeling. I looked at some of the summaries of the community meetings, and some of the expert reports as well on these different things, erosion processes, climate change, wetlands ecology and ice management. Some of these reports were prepared in conjunction with the licensing process, others were just outside reports that I happened to come across that I thought might have some bearing on this as well.

And then Manitoba Hydro was generous enough to provide, actually provide me with the models that they used for these purposes. They

were Excel spreadsheet, water budget accounting tools, and there is really two models, and a set of models for each of the different power ranges evaluated, 711 through 715, which is the current power range, and 711 to 714 reduced power range, and expanded 711 to 716 power range as well. This is right out of, I think appendix 4 of the report. I can't remember if it is appendix 4 or 10. But basically the models are broken into two parts.

There is the Lake Winnipeg routing model, or regulation model, which basically just covers inflows, total inflows to Lake Winnipeg, and then releases through the Jenpeg station.

And then there is a Nelson River routing model which was used for the evaluation of the alternative power ranges to extend the -- basically to route the Jenpeg releases downstream through Kelsey and through Split Lake.

I just want to make sure I don't forget anything here.

And by routing, I guess I mean to -- I probably should point out at this point, what we are talking about routing is really storage routing. And I think that Dr. Thorleifson yesterday brought up the idea of the analogy to a

bank account, where your change in your balances is equal to your deposits less your withdrawals. Well, storage routing is essentially the same thing. Inflows to a reservoir or to an impoundment, less the outflows, equals the change in the storage, change in the -- so, basically storage routing was used throughout both reaches in this case.

So, the capabilities of the spreadsheets, basically, in both cases they do basic water balance accounting. The Lake Winnipeg routing model addresses, again, Lake Winnipeg change in storage and releases through Jenpeg power station through the generators and through the spillway. And also looks at historical, or it looks at uncontrolled releases through the east channel as well. It does storage routing based on wind unadjusted, you know, level pool conditions. It doesn't make -- it doesn't track effects of wind. And it looks at total historical Winnipeg inflow since the project was put into operation. And I think that was 1977, is when the model starts. And then looks at historical outflows rather than -- so, in effect, this model is basically what you would call a specified release

model. In other words, the model doesn't tell the operator how much to release or how much it should release. Following a set of rules it just simply -- the operator tells the model how much it releases based on what has happened historically. And then for those cases that exceed the range of historical experience, the operator basically intervenes and makes manual adjustments to the outflows. So the important thing here is the point of the first bullet. There is really no logical or at site -- excuse me, logical or conditional operating rules that define how much water has to be released, either to meet an outside stand-alone objective for that particular site, or for the system as a whole. So, in that case, in that sense, these models are not really what you would call rule-based operational models, they don't really advise or provide any information as to what should be released.

The model, again, is a specified release model. It allows you to, without operating rules, it is actually a perfectly appropriate way to model the system if you don't have operating rules, and you are looking to just track what has happened in the past. Because you

can just say what was released in the past was obviously, you know, within whatever constraints we had to operate or whatever releases we had to make. And it does allow for some sort of minor intervention by the operator or the modeler to make changes to when they would be, when those changes would be deviations from historical releases, when they would be dictated by a change in the operating range or some other consideration that may not have been complied with, you know, for some reason historically.

And then the Nelson River routing model simply takes the outflows determined by either input to or output by the Lake Winnipeg routing model and sends those downstream to look at the impacts on downstream flows and other lake levels through Split Lake.

There is an exception to this, which I will get to, there is one sort of rule based exception to this which I will talk about here in a minute.

So if you look at this diagram here, in a sense all reservoirs, or most multi-purpose reservoirs have really three, minimum three components. There is a flood pool or flood

storage, which basically is seeking to either minimize downstream flooding or prevent the dam from overtopping, or basically to minimize flood damages. And that could be flooding in the lake itself, above the lake, or flooding downstream of the lake. So it has to balance lake levels and downstream releases to minimize flooding.

In this range, basically, the spreadsheet -- excuse me, the spreadsheet models do actually compute project releases because they are basically defined. There is a -- Q stands for flow here, so the flow is the maximum penstock, plus the spillway capacity at Jenpeg. So the model can calculate what that is and it can determine a release, because that's what you would call a rule.

In the conservation pool, now this is particularly when you are not in a flood situation, so you are making releases for a variety of purposes, to generate power or to potentially augment downstream flows or lake levels for different reasons. So you are either, you know, if it is in a low flow period, you are trying to augment flows, and if it is -- basically you are trying to capture all of the water and put

it to productive use, in this case, probably for the most part generating power.

So in this range of the pool we don't have a rule per se. We have got some constraints. There is -- the minimum flow has to be greater than or equal to -- the minimum flow has to be 25,000 cubic feet per second. And the maximum rate of change is 15,000 CFS per day.

So in this case, because there aren't really any operating rules per se, the model doesn't have enough information here to identify a release. What was done was the historical releases were applied. And then if different power ranges were looked at, like for example 714, they would go to the flood rule, the flood storage operation at 714 instead of 715, if they are looking at that power range. However, if it was 716, you could operate using historical operations up to the point when it reached 715. Then historically a different set of operating rules would have been applied, which would have been a flood operation situation where they are trying to release the maximum through Jenpeg, which wouldn't apply if you actually had a higher power range.

So what was done here is a target was

set, I forget what the number was, I think it came out to be 160,000 cubic feet per second or so released from Split Lake downstream. So that would be what you would consider an at site target for Jenpeg. Jenpeg is making releases between 715 and 716, the model could compute releases needed to be maintained from Jenpeg to maintain 160,000 CFS downstream at -- I forget -- well, Split Lake anyway. Kelsey -- I forgot the name of the powerhouse there. So that's an effective operating rule that says operate to maintain 160,000 CFS at Kelsey.

The question is, is that a sufficient rule to prescribe operation? Could you apply that same rule throughout the 711 through 716 operating range, or 711 to 715 operating range, the existing power range, and replicate in effect historical releases? That's a question.

I suspect there is probably a lot more rules than just that that would govern those releases because, for example, if the downstream projects were already in kind of flood stage or flood operations, you wouldn't want to be compounding the problem by releasing 160,000 CFS minimum, if you could, you know, cut back if you

could. Anyway, it is an example of an operating rule.

Then down below 711, releases are determined by the Water Power Act Minister. And of course, since the historical period that Jenpeg has been in operation there has not been a case where that's actually been triggered. So we don't know what -- there is no rule there either. We don't know, we have no idea with this model whether to put in -- you have no historical precedent to follow and we don't have a rule, so there is really no way to know what would happen there.

Typically in reservoir system operations, you generally don't want to pull below the conservation pool. So you would have tiered or sort of layered rules such that you start to conserve water so you never get below this point, 711. And if you did, you know, actually you might consider this almost an inactive pool or a dead pool that you really don't get into except in an emergency sort of situation.

In any case, it hasn't really been defined. But for the purposes of this, looking at historical operations, fortunately, it wasn't

needed to be triggered either.

So, the first application of the Lake Winnipeg routing model, just to look at the effects of Lake Winnipeg on -- excuse me, of the LWR on Lake Winnipeg levels, lake levels, outflows and hydraulic residence time, which is an important component of water quality parameters.

So, what was done there is basically take -- remove the effects of Lake Winnipeg Regulation off of the record, the hydrologic record. And that was done, you know, it was basically done in an appropriate manner by basically removing the effects of Lake Winnipeg Regulation by looking at, in effect, naturalizing inflows and outflows as if Lake Winnipeg had not been there.

And so there is two different methods used for computing Lake Winnipeg inflows and this band, the gray band, I guess, sort of measures the difference between those two methods of computing inflows, naturalized inflows. And so these show pretty well that during these -- during the period from 1977 through 2013, that Lake Winnipeg levels would have probably been higher than what they actually were, and that hydraulic residence time

and average flows downstream of Jenpeg would not have been significantly changed.

So, well, yeah, so from that standpoint that's a reasonable application of the model. However, there are some other things that I will get into in a little while that would make this conclusion maybe a little bit more strong, or more strongly supported.

A second application of the Lake Winnipeg routing model was to look at the -- to basically simulate Jenpeg releases under these different power ranges. And the power ranges that were evaluated were just something across the, you know, constant throughout the year, basically just changes in the top of conservation pool. So changing the current 715 foot top of conservation pool to 716, or reducing it to 714. And again, that was done by simply tracking historical releases, modifying where necessary to either prevent, or to minimize exceeding 714 in the reduced conservation pool alternative, or to allow conservation releases to continue up through 716 in the expanded power pool. Again, the results of this are kind of summarized in Manitoba Hydro's report in terms of incidence of time and

exceedance of the applicable pool range. So you can see with the 714, the maximum pool is exceeded more of the time than under the current operating range, and then it is exceeded less of the time when the operating range is expanded to 716.

Again, these conclusions are in a sense supported by this modeling, but I think they probably -- they could be more strongly supported if we could extend the possibilities, also the conclusion as to the efficacy of, for example, lowering the power range or raising the power range could be made a little bit more -- what am I trying to say -- I guess in terms of -- there may be a little bit more complexities to this than the simple raising or lowering of the pool. For example, the efficacy of raising the pool has certain benefits to power generation and that sort of thing. It also may have certain adverse impacts to other things, such as ice management or other seasonal, if you had other seasonal flow or lake level conditions downstream that you are trying to maintain. So you could potentially also look at seasonally adjusted power ranges, where if you need to hold back water in the fall for ice formation, you could have a rule curve in effect

that draws down in advance of that period to allow you to impound water later, and restricting it. And that drawing down water may be conjunctive with other uses that may need more water downstream, or lower lake levels. For example, Netley-Libau Marsh or something, there could be some benefits to seasonal drawdowns. And seasonal drawdown is actually a pretty common situation, or it is commonly practiced.

Another thing that could be looked at is adjusting the operating rules, effectively adjusting the targets, power generation or minimum flows or ramping rates, or whatever, as you pull down in the pool, as you go up and down in the pool. So as you have more water, you can do more things. And when you have less water, you become more restrictive and conservative in the operation.

So the Nelson River model basically just takes the results of the Lake Winnipeg routing model for these three alternative power ranges and routes those downstream. It looks at the impacts on Cross Lake, Sipiwesk Lake and Split Lake.

So, anyway, that's just kind of what I

hope is a plain language overview of the models.

The bulk of my presentation, basically, is talking about the limitations of the models with respect, to some extent, the current application, although more importantly towards future things that might need to be considered. So the most serious limitation is basically the lack of operating rules, and you need a set of current operating rules or baseline operating rules to be inferred from historical operations and verified against historical operations. To look at things like how does power demand effect system operation, not only the system load but imports and experts of power? So there is economic considerations, there is non-power demands on water and storage, to manage flood and drought risks, to manage, you know, ecosystems and aquatic habitats, that sort of thing.

It is also good for the public to understand the rationale for how the project is operated. Particularly if you get into an extreme either drought or flood situation, it is good if the public understands why things are being done and they can understand the logic, you know, and it is less of sort of a black box to them.

Another really important thing would be to synthesize and extend the baseline rules, to look, to actually hindcast Lake Winnipeg Regulation operations all the way back to 2013 or whatever the hydrologic period record is. Because then you can really assess over a period of a century or so the impacts of Lake Winnipeg Regulation on the natural condition. And that would really strengthen the conclusions regarding climate effects and other long-term effects. Because if you simply compare a pre and post Lake Winnipeg Regulation operations, you are really comparing two different periods and you are -- it is not entirely clear that, you know, what other things may have influenced the range of elevations, the range of discharges, versus just the operating rules itself.

And the other thing is having a defined baseline operating rule allows you to compare, truly compare operational alternatives over this entire hundred year period of record.

So then you can really look at and determine, is it really beneficial to lower the power range or to raise the power range? And can we raise it or lower it or change it in more

complex ways, ways that are more -- not just simple raising or lowering of the pool by a foot.

It also allows you to look at, like I say, a longer period record allows you to look at a better way to look at how would you adapt the rules to climate change, or even long-term climate cycles? Like you say, you may be in a wet period now, but there may be, you know, a long dry period that you will have to also adapt these rules to.

What are the justifications? What is the need for these minimum release and ramping constraints? You know, how firm are they, and are they practical in all conditions, or should they be adjusted depending upon, you know, wet, dry years, or something on that order?

The other effects you want to look at are the effects of physical system operations. For example, the proposed Lake Manitoba drainage channel, the Keeyask station addition, all of these things could be looked at if you had a set of, if the model itself could inform you as to the release decisions on any particular project, and so then you could look at the effects of changes to the system. And then, of course, these models eventually could be adapted to real time water

control decision support and, you know, water, hydro system operations using forecast. And of course, tracking Hydro operations planning goes kind of hand in hand with, you know, water resource system operations planning. So they pretty much go together. So it would probably improve the economic performance of the system, or at least the power generation aspects of it.

And then all of these other studies, or all of these other issues that we've talked about, the Netley-Libau Marsh and hydrostatic rebound, and all of these other issues, climate issues, changes in hydrology, changes in water uses, and social preferences, they can all be looked at using this model, not only by itself but also linking with other tools to do that.

And I think some of the stuff that was mentioned on the Netley-Libau Marsh, there are tools that already exist that can be in a sense linked with a model that could do rule-based operational simulation.

So another limitation of the model is, which that doesn't -- again, it doesn't make it inadequate for this purpose, but currently it only considers really Jenpeg to Kelsey. And of course,

there is a whole lot of other components to Manitoba Hydro's system that regulate inflows to Lake Manitoba and that make use of outflows releases from Jenpeg. So the ability to coordinate all of those together, you know, you don't really have that in the current set of models.

I've already talked about the flexibility to analyze operational alternatives. You really have to have a baseline rule to compare those to, and if you have that rule based simulation capability, you can also then impose more complex alternatives and compare those to the baseline as well.

I talked about extending the hydrologic record back to, all of the way back to 1915. Certainly it looks like, you know, the variability in lake levels has been reduced by LWR, but, you know, you don't know for certain if that's the only reason, or to what extent it would have happened naturally. And it would be good basically to extend this baseline operation all the way back to 1915, and see how it would have affected things back in this period. I think it would give you a little bit stronger, enable you

to draw a stronger set of conclusions.

Another thing, of course, is you don't really have capability for simulation of drought operations. I come from -- the background that I come from is most of the focus of reservoir system analysis and river basin studies is on drought management more so than flood management. So it is harder to -- in a lot of ways it is harder to manage scarcity than surplus in some respects. I guess everybody kind of agrees on what to do about too much water, but when you don't have enough, how you allocate it is a big problem. And unless you have some sort of idea of how you would actually operate in droughts, and how you would prevent the lake from drawing down to these levels, it is hard to assess how these extremes might have been actually also altered by Lake Winnipeg Regulation in the past, under more extreme conditions potentially.

So then I looked at, you know, these are the summary of the information requests that I looked at. And those are in my report as well, just the sort of things that, only in so far as they relate to modeling or potentially could relate to modeling. I am not sure if all of these

information requests, they may not have even had any intention of relating these to models, but they potentially could, either in a sense identifying a need for expanded or enhanced modeling capabilities, or they might inform the development of such models, in other words, provide a set of issues that need to be addressed within the operating rules of LWR. So I'm not going to, you know, read all of these things.

Another thing I looked at, or some of the community issues that could potentially be addressed by the models themselves directly, or they could provide information, boundary conditions or time series data that could be used by special purpose models that could look at things like water quality, water currents, shoreline erosion, ice formation, navigation, and influence of Jenpeg releases on flood risk downstream on the Nelson River, and lake levels downstream.

Some of the reports that I looked at, some of you have heard presentations on in the last couple of days. The one that is not probably associated with this -- this last report here on ice conditions, this is, you know, related to the

Nelson River and it -- the interesting thing about this is the potential effects of climate change and climate cycles on ice management, you know, when you actually restrict releases for ice formation, and when the melting season begins, you know, the seasonality of that, and how you might change, you know, how you might raise or lower the pool, either induce a drawdown or induce a refill of the pool of Lake Winnipeg, for example, to basically improve, you know, the management of ice and potentially improve the releases, you know, make it more efficient from a standpoint of power generation, and maybe some other things as well.

So, my overall conclusion, which I also think I state in my report, is that the focus of modeling to date in support of the final licence application is hindsight. It is basically -- and because the intent in the licence is not to change, basically, to continue the current operation, you know, the focus is to demonstrate that LWR hasn't compounded problems, greatly exacerbated problems or changed historical conditions. And I would say that the inherent limitations in the routing models limited to the post LWR application, or period of analysis,

doesn't really invalidate these assertions. It just -- I think they could be more strongly supported if you could extend, essentially extend the baseline, define the baseline operation and extend it back through the entire period of hydrologic record. And that might make it a little bit more clear, or at least more statistically better supported.

But in the future, you know, there is a lot of issues being brought up that are going to really require a full rule based system operational simulation capability. Because the focus of the future wouldn't be just looking at what has happened in the past, but how are we going to adapt LWR to meet future demands on water and storage, address these issues. And certainly they are not issues -- a lot of these issues are externally imposed, they have nothing to do per se with Lake Winnipeg Regulation. But obviously the regulation plan should try and accommodate those, or mitigate those, or even improve things if possible.

So the near term recommendations, I would sum up as seeing if there is a way to sort of convert the spreadsheet models to rule based

operating models. I mean, they could be relatively simple, but at least define operating rules in the conservation pool and in the drought pool, or below 711. And then, you know, take these rules and run through some simulations and sort of calibrate it, or compare it with historical operations to see how it does. When they do pretty well, they are not going to be perfect, but when they get a reasonable replication of historical operations, then you can probably say you have got a rule base, or a set of baseline rules.

So, once that happens, then it could be -- the model could then be applied over the entire century of hydrologic record. You could then look at changing those rules or making them, in effect, zone rules where you have a tier of rules that either constraints go up or down or something through the pool, and see if there is ways to -- there is ways that maybe operations could be improved to maybe improve both flood protection and power generation objectives, or to better meet those objectives. And that could be, like I say, it could include seasonally adjusted power range alternatives, or zone rules, as I was

saying.

The other thing is you could apply climate adjusted hydrology, and that could be in the form of -- it wouldn't have to be just an average of conditions, but it could be a series of ensembles, you know, of basically different traces of hydrologic, of inflows to look at how under different climate assumptions and down scale GCM model results that you could, in effect, change the operating rules, or adapt to how they would affect things. And then based on that sort of extended period of analysis, then revisit the conclusions and, you know, confirm or better confirm the results that you come up with.

And then in the long-term, again, as I was saying, I would implement a rule based water control decision support system. And there are generalized models. My experience has been coming from the Corps of Engineers. I've actually worked on the development of HEC5, which is the predecessor to ResSim many years ago. ResSim is the corps' reservoir system model. ResSim is actually a component of a bigger system call the Corps Water Management System, which involves hydrologic, hydraulic, hydrodynamic, water

qualities, statistical. And there is another model that gets into some of the stuff that's being done elsewhere that I saw from some of the papers this morning, an eco-system functions model which basically looks at statistical as well as physical spatially distributed measures of ecosystem health and how reservoir operations could potentially improve, or at least not exacerbate certain things. And there is some commercial products as well which I'm not as familiar with, CADSWES has RiverWare which is -- both ResSim and RiverWare are in pretty widespread use around the world.

The model, of course, should probably incorporate the major components, all major components of not only the Manitoba Hydro system, but other water control structures that would affect system operations. The model could be used in a planning mode to allocate flood and conservation storage system wide. In other words, to balance storage among the projects throughout the system to make sure it is, you know, meeting its objectives as efficiently as possible.

I never use the word optimization when it comes to reservoir systems because there are no

optimal solutions, but there are some that are less bad than others, I guess, is a good way to put it.

So, again, with a model like this, you can formulate both at site and system operating rules and, you know, priorities of constraints. You also have the capability of imposing external, what they call state variables, or things that would influence operating decisions. You know, if you want, if you have seasonal targets, flow targets for protection of endangered species, for example, or for limiting lake level of other lakes rising and falling, or if you are looking to adjust levels in marshes, you can have those things that are -- or wind setup or ice formation or anything else, you can actually formally state variables upon which operating release decisions can be triggered. So these could be input as timed series, or they could be results of other models, special purpose models developed external to the reservoir system model, that would basically trigger release decisions.

And the other thing is identifying stakeholder performance measures for, basically to incorporate as many other measures of performance

into the rules as possible. So you can set these things, even if they are not direct, they may be conjunctive or competing or complimentary, I guess might be a good way to put it, to rules for power generation or other purposes.

So, as I mentioned, it would be good to expand the model domain to include all of the major components of the system, especially the components that regulate inflows to Lake Winnipeg on the Winnipeg River and the Saskatchewan, and all the downstream projects as well. Because all of those projects will have release decisions that they have to be made, and made in concert.

This is an example of a ResSim model that's developed in the southeast. This is in the ACF basin, ACF stands for Apalachicola Chattahoochee Flint. So this says there are five federal reservoirs, multi-purpose reservoirs, all power projects, and there is five non-federal or private power projects that are all interspersed within this system, extremely complex environmental flow regimes. We have threatened and endangered species, there is two known species. They have vastly different flow requirements. They have ramping rate

requirements. They have available habitat, you know, in other words, they need a certain width and depth of stream to survive. And so these rules, each reservoir has a set of rules, and there are literally hundreds of rules in each zone.

So there is a flood -- you probably can't see this on the screen very well -- but there is, you know, there is forest control, there is flood zones, and then there is conservation zones. And within the conservation pool there is lots of other little zones or what they call guide curves. And each one has its own set of rules, they are all defined seasonally. And this model was developed, actually it was originally developed -- it has probably taken about five or six years to fully develop this model. It is being used by the corps now for updating the water control manual for this basin. But you may have also heard that the three states, Georgia, Alabama and Florida have been in a water conflict for about 20 years now, so they had input to this as well, not only in the actual, on the technical side, but of course there is a lot of litigation surrounding this as well. So it is a very -- it

is reservoir management under conflict for sure.

But all of the stakeholders, by stakeholders I mean anybody who has a stake basically in the operation of the system, and generally speaking, for example, Georgia Power owns and operates the five non-federal reservoirs in the system, so they are directly impacted by water control management rules and by release decisions made from corps reservoirs. There are water users in the basin, municipalities that withdraw water. And again, the focus here is on drought, more low flow management than flood, although floods are somewhat of an issue.

So, anyway, all of these have -- in a sense this is a modeling platform that's open to anybody. For example, I'm working for a client that's developing a power plant -- you can't see this, it says Walter George, it is one of the reservoirs on the system, it a Federal reservoir. So I can go into this model and put in the projected water withdrawals of this plant. And then go through, run the model and look at the impacts of that on all of these other components of the system. So built within this is data base, time series date base management tools and

statistical tools, so I can look right within the model to see how this would affect flood duration at some other point in the system, or reservoir elevations, or any other measure I want to look at, power production, even the energy capacity benefits supplied by the system. So, like I say, this is very -- this is something that exists, and this kind of approach is why it is produced.

This model can also link with other tools to look at water quality. There is some interest now in looking at connecting this to the eco-system functions model to look at aquatic habitats and see what sort of flow regimes best maximize aquatic habitats. In this case, the rules might dictate not a minimum flow, but they might dictate a minimum area, or a minimum depth, or a change in depth or something over time. So, basically translating the desired results, which could be some other form than flow, back to the model, for the model to come up with a flow that meets those requirements is a big part of the capabilities of this tool that allows you to really define a broad array of operating objectives and constraints.

And I think the last thing I was going

to talk about was, I have been involved with a few of these too, and this is just, you know, this is not to -- this is just an example of an integrated licensing process. This would be more applicable probably to the real licensing process than to this current licence application. But in the U.S. we -- only the private or non-federal projects are licensed, non-federal hydro projects are licensed. The Federal projects, they go through a water control manual procedure which is really pretty cumbersome and not very efficient, and because a lot of it is controlled by Congress, it doesn't work too well I would say. But this process, it works pretty well. The FERC is a Federal energy regulatory commission. You know, they are the regulatory agency for relicensing of hydro projects, for licensing and relicensing.

In the integrated licensing process, it is a way to get the stakeholders involved from start to finish. The stakeholders actually become cooperators in the study, they become part of it. And even State agencies or Federal agencies or non-govenment agency organizations can become cooperators as well.

Now, the regulatory agencies cannot be

cooperators. In other words, the Corp of Engineers cannot be a cooperator in a relicensing study of a power project on the Chattahoochee River because they have a responsibility for water control manual, and they would have, in effect, a conflict of interest, so they couldn't be a cooperator. As a matter of fact, they would have to actually approve, co-approve with FERC the licence application.

The essence of it is that the regulatory agency doesn't want to come down and make the decision. They want the applicant to work it out with the stakeholders and to reach an agreement in principle. And then, you know, then the agency would approve it. And you know, and this is really essential to, I would say this would be essential to -- one thing Manitoba Hydro would need to know, what sorts of issues need to be addressed with, you know, with the operational models or with the hydraulic models or other kinds of models that might be applied, what needs to be addressed? And this would sort of elicit that information from the stakeholders. So that happens right up front.

The stakeholders form issue

identification groups, and they scope studies needed to address their particular issues of concern. They also help scope, you know, they scope the studies. They also, very importantly, they develop performance measures that can be used either to guide the modeling or to compare the results of modeling to see how well they do. And it, in effect, it forces stakeholders to learn enough about their process and their interest to be able to articulate it and quantify it enough to get it, you know, put into, you know, models and data.

So, in effect, the stakeholders drive the process. The applicant, of course, has their own interest in what they want these projects that are being relicensed to produce. And so in the end they reach consensus.

And I have just gone through one of these, it has been pretty successful, in the Savanna basin. Originally a very large combination of hydro power and nuclear system, very powerful intensive system, and a lot of big water users, and they were able to reach agreement in principle this past summer. And so once that's happened, then they get the final licence

application, then it is just a pro forma, pretty much an exercise. The agency approves it if everybody agree with it, unless the Corps of Engineers finds something that's going to interfere with their water control plan or something.

That's just an idea, it is not a recommendation, it is just idea for, an example, I guess, of a way to involve stakeholders more activity and proactively in the licensing process.

And I think that's my formal presentation.

THE CHAIRMAN: Thank you, Dr. McMahon. I think we will move right into questioning. We will take a break in about a half an hour.

Manitoba Hydro?

MR. BEDFORD: Good afternoon, Dr. McMahon. We haven't met yet. My name is Doug Bedford, I work at Manitoba Hydro. And I observe you have come a long way to assist us with this particular hearing.

With respect to one of your recommendations, and that is the one that someone ought to define some rules that will govern what to do when the level of the lake approaches and

reaches 711 feet above sea level. When I read that I concluded that you probably are not aware that my client, Manitoba Hydro, has a drought preparedness and response plan. Is that the case, you are not aware of that plan?

DR. McMAHON: I'm not aware of it. The only thing I know, or I have heard is the Minister of the Water Power Act makes those decisions. I assume there is some way that you can advise the Minister or something, but I wasn't sure how that happened.

MR. BEDFORD: Well, and I concluded, having guessed it seems correctly, that your real recommendation and concern is not so much the absence of a plan, it is the absence from the licence, from terms of the licence as to details as to what will be done when the level of the lake reaches 711. Have I captured that correctly?

DR. McMAHON: No. I guess my concern was more related to the ability to capture that, to replicate it in a model of some sort. In other words, to define it to where, you know, to where you can actually have the model tell you, you know, based on certain conditions, certain state of the system, what you should be releasing.

MR. BEDFORD: Do you find, with the work that you've done over the years in the United States, that some decisions in operating major public structures like dams, control structures, are so politically sensitive, some would say politically volatile, that a majority of citizens will only tolerate those decisions being made by an elected representative of the people?

DR. McMAHON: Actually, no, I have never run across that. We don't tend to trust our elected representatives very much at all. We probably trust the Corps of Engineers to do things, and the Bureau of Reclamation, but they are trusted in so far as they have a set of rules that are defined up front, everybody knows what they are. So once the water control manual has been approved and is in place, everybody has that assurance that whatever happens they are going to follow those rules. And when they don't, there will be some lawsuits flying or something. But as long as they -- as long as the rules have been approved and in place, everybody has the security of knowing that they will be followed. So they definitely don't want sort of what they would consider arbitrary decisions made by politicians,

especially our politicians.

MR. BEDFORD: Well, I was going to suggest to you, I think you have anticipated my question and I perhaps already have your answer, that conversely to the proposition that I put to you, to paraphrase and to turn on their head, words that I think were spoken by George Clemenceau in 1917, many engineers in the world believed, did they not, that operating dams and control structures is too serious a business to be left to politicians?

DR. McMAHON: I would agree with that, and I can relate a personal experience with that. In these three State water conflicts that I have talked about, I have actually been involved with those longer than anybody else, since actually before they became conflicts. And initially, initially it was mostly technical work, you know, scientific work. We had, there were lawsuits filed, but the lawsuits were stayed pending the outcome of a comprehensive study. And we went through these comprehensive studies for five or six years, and we actually reached, the engineers and the scientists reached an agreement, we had an agreement between Georgia and Alabama in 2001.

The governors didn't sign it at the time because they wanted to see if we could bring in the third state, Florida, you know, try and bring them into it as well. In the meantime, new elections happened and all three governors were replaced, and the new governors came in and tried to tweak it, and it all fell apart, it completely fell apart.

So we lost out, to me it would have been a historical opportunity, you know, a multi-state compact in the southeastern United States would have been a first, but it wasn't to be so...

MR. BEDFORD: I'm sure you appreciate that when the time comes that the level of Lake Winnipeg again approaches and reaches 711 feet above sea level, this part of the world, my province, will be facing drought conditions?

DR. McMAHON: Yes.

MR. BEDFORD: And I think as you told us all during your presentation, when you don't have enough, that's when you really have a big problem.

DR. McMAHON: In the southeast particularly, that's all we care about is, you

know, nobody cares about water until there is a drought every five years or so, and then everybody cares about it. We actually came within 30 days of running out of water in Atlanta in 2007, and the Corps was in the process of changing its rules at the time, and so there was a lot of people upset with that.

MR. BEDFORD: So, accordingly, when society is confronted with those problems, one of the challenges of public policy, if I can put it that way, is to find a balance between the view of professionals that operating dams and control structures is too serious a business to be left to politicians, as measured against the desire, I suggest to you, of the majority of citizens in a democracy that through their elected representatives they ultimately have control over those serious decisions, one must find a balance as opposed to going to one extreme or another?

DR. McMAHON: That's why I don't use the term optimal, because it never is. It is what people will bear, so to speak, is really what is a satisfactory solution as best you can hope for.

MR. BEDFORD: Last week my client's witnesses, including the two engineers that have

joined me this afternoon, gave testimony, and my recollection is you were present here to hear them?

DR. McMAHON: Um-hum.

MR. BEDFORD: So, am I correct when I suggest to you that, at least last week, you learned that in addition to the modeling that my client did to inform the July 2014 document that you've read, it also has a number of other sophisticated models that it uses in operating Lake Winnipeg Regulation and in planning its future resource use?

DR. McMAHON: Well, I know there is an energy operations model, or set of models, decision support systems. And I know they have -- I have heard that there are other models used in the planning and design of Keeyask. I hadn't seen anything related to operational planning for Lake Winnipeg, any other models being talked about. I haven't heard about that at this point.

MR. BEDFORD: Well, you do reference in your paper, although I don't think you did in the presentation today, this model called HERMES. I understand that it is used in operational decision making of Lake Winnipeg Regulation. I

conclude that you are not aware of that?

DR. McMAHON: I thought it was for energy operations, not reservoir systems. I wasn't aware of that.

MR. BEDFORD: And while you don't mention it in the work that you've done for this hearing, you may recall that there was some reference made in testimony last week to a model called SPLASH, which I understand is used for planning future resource development. Do you recall that?

DR. McMAHON: I remember hearing about SPLASH, but I don't know, I'm not familiar with it.

MR. BEDFORD: My engineering colleagues at Manitoba Hydro are quite concerned that you have perhaps reached the conclusion that the models that you did explore in-depth to prepare your presentation in the paper that I read are actually being used by them in operating day-to-day and week-to-week Lake Winnipeg Regulation.

DR. McMAHON: No, I never said that, and I would assume not. Actually, I assumed that they would be -- the reason I assumed they were

the models used for planning for this licence application was because I didn't see any other -- you mentioned HERMES or SPLASH, I didn't see that they were applied for this particular, or documented in this particular report or appendices, so I didn't know they were.

I guess my question would be, if they were online, so to speak, and available, why wouldn't they have been applied for this, you know, for this application?

MR. BEDFORD: So, having learned that these other models exist and are being used, can I suggest to you that when you write in your report that it was a bit extreme of you to say that, or to observe that when Lake Winnipeg is at a level in the normal power range, between 711 and 715 feet, that the release decisions are, your word was largely discretionary. I suggest to you that the choice of the adjective "largely" was a little bit extreme, given what you have now learned that there are other sophisticated models that are used in that decision-making process?

DR. McMAHON: I suppose if I had known that -- but, again, I haven't seen anything in the report that tells me that those other models were

applied. I'm not -- I'm also drawing a distinction between real time reservoir operations and operational planning. And I consider this an operational planning case. We are looking at the effects of some set of rules, you know, applied on average through a planning period, and we are not looking at day-to-day operations. So if these other models are used to support day-to-day operational decisions, that's a whole different matter from operational planning. Operational planning would be reducing whatever techniques you use for determining day-to-day, making day-to-day release decisions to some sort of rule that can be tracked over the long term. And like I say, it is not going to be perfect, but it should reasonably replicate what actually has happened. So...

MR. BEDFORD: And, of course, in the paper that we received that you wrote, and in the presentation that you gave today, I do see that you have given some thought to the reality that my client faces, that this particular licence for LWR will have to be renewed. I'm sure you heard in the last week that the renewal deadline is the year 2026?

DR. McMAHON: Yes, I'm aware of that.

MR. BEDFORD: And I suspect that you, based on what you have written and said to us, that you would readily agree that there are better ways to go about renewing a licence for something as significant as LWR, than what we are presently engaged in?

DR. McMAHON: Yeah. I mean, I sort of consider the data and models presented here. I would say they are, in general they are adequate for this sort of interim period. Because the focus again is showing, I mean, you have had the licence and essentially you have been operating under this set of rules now for a long time. So you are really just trying to show that it hasn't had significant effects. And my conclusion was, well, you know, I can't argue with that, I don't have -- I can't say that that's wrong. I would say, though, if this were a 50-year period looking forward, I would think it would be better to have a lot better, more focus on how to manage things in the future to, you know, to address these issues. So it is going to be a lot more comprehensive set of --

MR. BEDFORD: And you would recommend to us all to have -- if we are looking for a

better process, you have recommended that we considered the Federal Energy Regulation Commission process that governs many projects in the United States and, of course, the acronym for Federal Energy Regulatory commission is FERC, correct?

DR. McMAHON: Correct. But I didn't say that I recommended this, I'm just providing that as an example. I recognize -- I have worked all over the world and I know the U.S. frameworks don't particularly work very well in other places. So I'm not recommending that at all. I'm just saying here is an example of another process, that's all.

MR. BEDFORD: But it is an example that works. And I must say when I read your paper, I knew nothing about that particular process, but I've done some reading on it, and accordingly thought that likely in the room today, there is only two people that have any real familiarity now with that process, and that is you, of course, and me.

So, would you confirm for me that one of the attractions of the FERC process for a utility that seeks relicensing of a major project

is that the process demands and requires an early start to identifying issues and studies that ought to be done?

DR. McMAHON: Yes, it does, it requires early engagement of stakeholders identifying and, you know, and then I guess grouping stakeholders or organizing stakeholders to where they can function effectively. But I will say that it is not just -- it can work, but it puts a burden on the applicant too, which you should be aware of. Because the applicant basically assumes a big part of the risk in this. It is not the agency anymore.

MR. BEDFORD: I am sure that when you say the applicant should be aware, Mr. Cormie beside me is getting slightly nervous, but we are going to proceed.

DR. McMAHON: Right.

MR. BEDFORD: I found a reference to starting 5.5 years before the deadline for renewal in the FERC material, but I'm going to suggest to you that, given what you've now learned about the many complexities and problems with Lake Winnipeg, that we would be well-advised in Manitoba to start even earlier than 5.5 years before 2026?

DR. McMAHON: Yeah, I think it is going to take some time. Like say this model alone took five or six years to develop in that effort alone. There is a tremendous amount of hydrology behind this as well. It is not just the models, but to run these models, they are built on naturalized flow conditions. So to naturalize, you know, 100 years or so of records of daily flows, for example, in a large river basin is a tremendous task, and there is an awful lot of data and hydrology behind it as well.

MR. BEDFORD: And when you say models, what I visualize momentarily when I hear the word in this context is a lot of computer spreadsheets, many rows, many columns, each of them filled with data.

DR. McMAHON: No, no spreadsheets at all. It would be -- this model, for example, has a time series data base management system built into it, and that allows this model to communicate with, for example, HEC-Res, the river analysis system, or HMS, the hydrologic modeling system, or EFM, the ecosystem functions model. They talk to each other and they work interactively so that you can manage the entire -- this can be used not only

for planning, but then you can actually adapt this to real time control, so day-to-day tracking the water, along with tracking the power and the system load, you know, they all talk to each other. So you try and avoid spreadsheets.

MR. BEDFORD: Much more sophisticated then than my incorrect image from statistic classes that I took 15 years ago that were very much based on Excel spreadsheets and putting data in columns and rows.

DR. McMAHON: Like I mentioned, I worked on the predecessor to this, which is HEC 5, and it is a four train program, so it runs on flat files.

MR. BEDFORD: Returning to the FERC process, one of the things that I will suggest to you that should be very appealing to all of us in this room, and to my fellow citizens in Manitoba, and you did touch on this when you commented on the FERC system, is that before the applicant, the utility, my client, really goes about conducting any studies and determining what the issues are, that one consults very, very widely. You referenced stakeholders; correct?

DR. McMAHON: Yeah. I mean, the very

first thing is the notice of intent, and that sort of notice that, you know, gives everybody notice that it is starting, and then all of the scoping and the stakeholder issues, analysis groups form. I would like to say that this is no panacea, I mean, these things can go badly too. I have been involved in some bad ones where the applicant hasn't, I would say, exercised due diligence, and bringing in stakeholders too late in the process, and it can fall apart.

So the other thing, the other essential element of this is that data and models have to be shared. You don't have the applicant going off and running his proprietary models, and then coming back and giving the results to the stakeholders and everybody accepts it. The stakeholders have to see what is going on. I worked for the major stakeholders, and we get involved, and we run the models ourselves, we don't just -- so it imposes a burden on the applicant, you can't just go into a room and do your studies and then come out and tell everybody what the answer is. It is a messy process sometimes is what I'm trying to say.

MR. BEDFORD: But as you just noted

once again, one of the reasons why these licensing renewal processes can go very bad is engaging the public and stakeholders too late in the review process?

DR. McMAHON: Too late, or ineffectually, I guess, is another way to put it.

MR. BEDFORD: So when one is at a very early stage casting the net widely to gather in what the potential issues are, what the potential gaps of knowledge and studies that are needed are, in addition to stakeholders, I would suggest you would likely look to the industry generally, to the regulator itself for any suggestions the regulator may have?

DR. McMAHON: Well, that's why we have cooperators too, which we allow, for example, EPA might be a cooperating agency to a FERC relicense process.

MR. BEDFORD: Casting the net widely in the context of relicensing in the next decade, Lake Winnipeg Regulation, would include giving thought and considering in that wide casting of the net the 20 recommendations you make for long-term studies in your paper; correct?

DR. McMAHON: Yeah, yeah. I mean,

they are not -- they are not meant to be entirely, they are not all-inclusive, some may not apply, you know, they are not meant to be a complete comprehensive, I guess, so...

MR. BEDFORD: While you weren't asked, of course, to look at this, and I suspect may not even be aware of it, but concurrent with the unfolding of this process in this room, there is a process being conducted by my client and the Province of Manitoba, a regional cumulative effects review or study, one of whose purpose is to identify what gaps we have in our knowledge of environmental impacts specifically of my client's operations in Northern Manitoba. So whatever is learned about gaps of knowledge there would presumably feed into a relicensing process.

DR. McMAHON: Right, right.

MR. BEDFORD: One of the things that appealed to me greatly about the FERC process was that once one casts the net widely to understand what the potential issues are, what the gaps of knowledge are, what the studies are, that there is an early dispute resolution process within the FERC process where the applicant, someone in my client's position and the stakeholders can come to

grips with trying to reconcile and sort out what studies are actually to be done, what are the issues that are to be examined. Are you familiar with that?

DR. McMAHON: I guess my -- if the process is done well, there shouldn't be, I mean, dispute resolution is a last resort kind of thing, it rarely, rarely happens. I guess probably the most, some of those come about related to who should be considered a stakeholder, who should have a seat at the table, and determining whether they can contribute to actually be a cooperator and advance the study, or if they are just somebody who is just, you know, trying to throw a wrench into the works or something. I mean, that's mostly -- most of the kind of things that I have seen where it is basically who gets in, who gets to participate and who doesn't.

MR. BEDFORD: But best in life to sort that out as well at an earlier stage than at the final stage of the hearing?

DR. McMAHON: Oh yeah, yeah.

MR. BEDFORD: And the FERC process, as I read about it, has fixed time lines from beginning to end?

DR. McMAHON: Yes, and they are very rigid time lines, yeah.

MR. BEDFORD: So people that run tribunals like Clean Environment Commissions don't have to explain to the world why a reference in the summer of 2011 is only being heard in the spring of 2015?

DR. McMAHON: Yes. I was involved in a case in California where the applicant failed to meet a deadline by a day, and they threw open the licence application. So in other words, they made it a competitive relicensing, and the applicant finally won it back after a lengthy court battle and stuff. But they basically, yeah, you can lose the whole thing if you don't meet a deadline.

MR. BEDFORD: Efficiency is one of the objectives of the FERC process?

DR. McMAHON: I don't know if I would characterize it that way. I think it is, they want it to be more participatory and consensus driven than command and control. They don't want the regulatory agency to have to make decisions and, you know, potentially take the -- be subject to litigation and that sort of thing.

MR. BEDFORD: I will remind you ever

so politely that efficiency is one of the words that you use in one of your slides, and it also appears in your paper. But the suggestion that I wanted to make to you that flows from a process that one wants to be efficient is that it would be sensible if you had an applicant, with say three licences all expiring about the same time, for example, for three generating stations and a set of control structures, to proceed with the relicensing process that combines all of them, particularly when they are linked?

DR. McMAHON: Yes, that's common, they actually consolidate licence applications.

MR. BEDFORD: And I also found of great interest that in the FERC process, an applicant such as my client on a relicensing is generally required, even though it is not being contemplated, but is generally required to consider hypothetical alternatives such as retiring the project and removing it, correct?

DR. McMAHON: That's absolutely true, yeah.

MR. BEDFORD: Another hypothetical which might not be actually being promoted, but is hypothetically possible, and that's transferring

to someone else the operational control of the project?

DR. McMAHON: Right, that's right.

MR. BEDFORD: Now, in the course of listening to you this afternoon my engineering friends have passed me several questions, whose purpose I can see at a glance is clearly intended to demonstrate what I do not know. But I'm going to speak to them momentarily to see if they are still anxious that I ask these questions, so we can see whether or not these are things that you might know.

DR. McMAHON: You said before I used the word efficiency.

MR. BEDFORD: Yes.

DR. McMAHON: In my report or on my slide? I used the worked effective. If I used efficiency, I probably didn't mean it that way.

MR. BEDFORD: Effective would be close enough and I won't take the time to find where I found the note. I find my colleagues are sufficiently distressed with my too primitive recollection of statistics and spreadsheets to risk having me ask you any more questions. So, on behalf of Manitoba Hydro, thank you very much for

traveling all the way from Atlanta.

DR. McMAHON: Pleasure, it is nice up here, it is 80 degrees in Atlanta. I would much rather be up here actually.

MR. BEDFORD: If I may say in return, I was once in my life in Atlanta and I found it to be a remarkably wonderful city too. Although I confess I was in the search of the Battlefield of Peachtree Creek, and like General Hood, I'm afraid I didn't recognize the place anymore because it was populated by men and women carrying golf clubs.

DR. McMAHON: That's right.

MR. BEDFORD: Thank you.

THE CHAIRMAN: Thank you, Mr. Bedford.

In a couple of minutes we will take a break, but before that I would just like to put some comments on record. Mr. Bedford made note about the timing of the CEC hearing, the fact that the reference was made in 2011 and here we are just conducting the hearings in 2015. Just for the sake of some future historical researcher who might be going through the archives and see this and wonder exactly what caused such a delay, I would like to note that we received our terms of

reference in September of 2011. In November of 2011, we wrote to Mr. Penner at Manitoba Hydro with some direction on what we would like to see in the document, the supporting document. Shortly thereafter we were told that it would take about a year to complete this document, which would be to about the end of 2012.

Subsequently, we received a reference on Bipole III. Manitoba Hydro made it clear to us that that had priority over this licence application, so we turned our minds to Bipole III.

With the end of Bipole III, we briefly turned our minds back to Lake Winnipeg Regulation, when we received the Keeyask reference. We were once again told that this had priority over Lake Winnipeg Regulation. So we concluded, or we conducted those hearings.

And it was in the summer of 2014 that we finally received the document in support of this, and we had actually started putting this process in motion before we received that document. So just for the sake of future researchers, that clears the record.

We will take a 15 minute break, come back at quarter after 3:00.

(Recessed at 3:00 p.m. and reconvened at 3:15 p.m.)

THE CHAIRMAN: Okay. We will resume with Mr. Williams from Consumers Association.

MR. WILLIAMS: Yes, and good afternoon members of the panel. And again I have a few questions for CAC Manitoba, and then a few questions that I'm asking -- that Pimicikamak has asked if we could --

THE CHAIRMAN: Are they paying you well?

MR. WILLIAMS: I believe the question was are they paying me well? They are paying me as well as the overall participant funding in this hearing.

Dr. McMahon, in Hydro's cross-examination of you, you heard them make reference both to SPLASH, S-P-L-A-S-H, and HERMES, agreed?

THE WITNESS: Yes.

MR. WILLIAMS: In your meetings with Manitoba Hydro prior to the filing of your evidence in this proceeding, did Hydro offer to share with you any reports or findings by the Public Utilities Board of Manitoba relating to

HERMES or SPLASH?

DR. McMAHON: Well, I don't believe that I asked for any, so I don't recall.

MR. WILLIAMS: Now at page 2.6 of your written evidence, in section 2.2.5, you talk about seasonal redistribution of flows could be extremely important to water management strategies when you are trying to maximize multiple competing and complimentary objectives. Do you recall evidence to that effect, sir?

DR. McMAHON: Yes.

MR. WILLIAMS: And you have talked a little bit I think about seasonal flows both in the context of species at risk today as well as ice flows, but I wonder if you could elaborate upon why that type of insight might be particularly important in modeling?

DR. McMAHON: Well, you know, not necessarily specific to ice flows, but for any reason, if you can find conjunctive uses of storage, in other words, if you can induce a draw down of a reservoir during a time when you need to provide a lot of flow augmentation for environmental reasons or ice reasons or any other reasons, then it becomes sort of a complimentary

use or conjunctive use of that storage. You can also generate extra power with those releases. So if you can time that when all of those conjunctive uses occur at the same time, that's a good thing. Then if you have to cut back flows later in the year or some other time of the year, that also gives you opportunity to refill reservoirs, so you don't have to be trying to refill the reservoirs when you are trying to send more water downstream, or you know, trying to hold water back when you have too much water in the reservoir, so it just gives you some flexibility I guess to make more uses conjunctive instead of competing.

MR. WILLIAMS: And of course if goes to the point of the need to have modern, forward looking modeling tools that allow you to assess those values?

DR. McMAHON: I mean you can conceivably do it with the spreadsheet if the rules were simple enough, but it is not likely, because usually you are considering more than just one project, you are considering the balance of storage elsewhere in the system. In order to piece all of those together, it gets kind of unwieldy in something like a spreadsheet. You

pretty much have to have something, a system dynamics tool or system modeling tool that allows you to look at all of the components together.

MR. WILLIAMS: Thank you. At 2-8 of your written evidence, you spent a bit of time talking about Lake Manitoba outflows and Lake Winnipeg levels with and without the drainage channel. Do you recall that, sir?

DR. McMAHON: Yes.

MR. WILLIAMS: And you commented that -- you expressed some interest I will suggest to you in terms of understanding the potential influence of alternative drainage channel configurations or Grand Rapids controlled releases on Lake Winnipeg inflows, lake levels and Jenpeg releases. Do you recall that as well?

DR. McMAHON: Yes.

MR. WILLIAMS: What is the significance of that, sir, and why should my client find that to be of interest and importance?

DR. McMAHON: Well, because if you are looking to determine the impacts of a particular operating regime like LWR, basically the set of physical features and the operational components of Lake Winnipeg Regulation, you basically want to

impose -- you would want to be able to impose that on natural conditions or unimpeded flow conditions. And if you have another project that's regulating inflows -- and this is a plan not just to the drainage channel, but for example the Winnipeg River Hydro stations or Saskatchewan River, anything that's regulated is not -- it is a regulated inflow not a natural inflow, so if you really truly want to look at the impacts of the regulation plan on a natural environment, you have to sort of separate out the regulated from the unregulated conditions.

MR. WILLIAMS: Okay. Thank you. Do you recall using the term equitably allocated a couple of times in your written evidence, sir?

DR. McMAHON: Yes.

MR. WILLIAMS: And at a high level you speak of ensuring that associated cost benefits and environmental impacts are equitably allocated.

DR. McMAHON: Yes.

MR. WILLIAMS: Just in terms of a working definition of equitably, equitably allocated, what definition were you using, sir?

DR. McMAHON: I was hoping you wouldn't ask that question. I mean it is in the

eye of the beholder I suppose. I mean, you could consider the political process to represent, you know, equitable apportionment I guess, or there is probably legal definitions, I know that economists certainly have ideas about equity. But basically in Federal planning in the U.S. there is the notion of, what do you call it, you don't want any purposes subsidizing other purposes.

So all purposes should share equitably in the benefits of multi-purpose development, that's sort of the basic premise of principles and guidelines in the U.S. and they define equity as basically no purpose subsidizing any other purpose. So every purpose pays its own share of cost of development, and then it pays a proportion of the remaining costs, the costs that benefit all purposes like say the dam that serves all of the different purposes, they share that cost in proportion to the benefits remaining after deduction of several costs. So it is this procedure called separable cost remaining benefits method, you know, that is sort of an economic measure of equity. It doesn't balance environmental non-monetized objectives in there, but it does include economic objectives.

MR. WILLIAMS: And, sir, if you don't have this, but in terms of Federal planning in the U.S., do you have a reference that comes immediately to mind where the source for that definition is?

DR. McMAHON: Certainly the principles and guidelines was 1983 principles and guidelines, and then there is called a Planning Guidance Notebook, and it is around the year 2004, or 2000 or so. I could give you the exact regulation number and all of that, but I don't have it in front of me, but if you were to Google Planning Guidance Notebook, it will come up with it and I think you can get that online.

MR. WILLIAMS: And when you reference the statute, you are speaking to the statutory provision that suggests that equal weight should be given to different values or outcomes?

DR. McMAHON: It is not a statute, it is again a guidance regulation promulgated out of different laws. I think the several cost remaining benefits came out of the Water Supply Act of 1958 in the U.S. So it has been around for a long time. There is a thing called the Harvard Water Project when they sort of developed, you

know, principles of public project implementation, and that was kind of the basis for it.

MR. WILLIAMS: Okay. Thank you. And if you are not familiar with this it is fine, but are you familiar within the U.S. literature in particular with any suggestion in the literature that the environmental consequences of development are inequitably shared with a disproportionate weight being borne by vulnerable communities?

DR. McMAHON: Well, it is becoming kind of widely recognized in the U.S. and there has been efforts actually to revise principles and guidelines for that reason. The objective of Federal Water Resource Development is national economic development which is -- it is the changes in national output of goods and services following project implementation. Environmental constraints or environmental quality is only a constraint, it is not an objective. So there has been efforts to try and move it into the objectives, and they have gone into things like multi-criteria decision analysis approaches to sort of integrate economic and non-economic objectives into a planning objective to make it more on a footing, same footing as economic values in planning. I'm not

sure if I answered your original question or not.

MR. WILLIAMS: Well, whether you did or not, it was a better answer than I was looking for, sir, so I will give you full marks for the answer, perhaps not for the question.

DR. McMAHON: Okay.

MR. WILLIAMS: Perhaps we can turn to -- I have got some interesting slides 23 and 24, and perhaps I will ask you to turn to slide 24, first of all. In describing the FERC integrated licensing process, you describe it as a consensus driven, correct?

DR. McMAHON: Yes.

MR. WILLIAMS: And to your understanding what is the importance of having this licensing process being consensus driven, sir?

DR. McMAHON: Well, the most important is just that, because it doesn't have to be imposed on the cooperators or the stakeholders, it is basically agreed to upfront so there is no, you know, contesting it or litigating it, generally speaking, you know.

MR. WILLIAMS: You also spoke in terms of slide 23, and the model depicted there with the

fact that access to this model is open, am I correct, sir?

DR. McMAHON: Yeah, I mean to stakeholders with the resources and expertise to -- I mean, it is not a terribly user friendly thing where anybody can use it, but yeah.

MR. WILLIAMS: And in fact, it is online, is it not, sir?

DR. McMAHON: It is publicly available, yeah. You can down -- well, this particular model since the water control manual has not been completed yet, this is actually an older version of the model, there is another one that's in the works that's not available for public distribution as of yet.

MR. WILLIAMS: In the context of the integrated licensing process, why is it valuable to have open access to these modeling tools?

DR. McMAHON: Well, it is extremely important for one reason, you know, two heads are better than one kind of thing. There is a lot of checking and balancing I guess, or error checking. And we found a lot of cases where, you know, something will be remiss, or there will be a gap or a mistake in the models or data, and the

conclusions that would be drawn would be incorrect otherwise. So having a lot of people looking at it is good. It also gives people confidence in the results. It is open access and it is, you know, sharing of data and models, and it is also kind of a standardized platform. What sometimes happens is if you have a before the ILP, they had other processes where different stakeholders would go off and do their own thing with their own models and data, and what happens is you basically don't have any way to corroborate or to confirm or validate. And there is, you know, people will not necessarily trust anybody else's results. So it is better to have a common platform and common data. And that was a big part of the ability, I mentioned the three state water boards, when we did reach the agreement with Alabama in 2001 we did it because we had the same modeling platform, the same data, we had already accepted it, and there was no question, so it was just a matter of looking at the benefits and consequences of different operating rules and reaching consensus on it.

MR. WILLIAMS: Thank you. I just have a few questions on behalf of Pimicikamak that I

will -- and in terms of your written report, I would ask you to turn to the bottom of page 2-4. And you comment that despite the limitations, that they do not invalidate Manitoba Hydro's overarching conclusions that, and I'm going to direct you to number 2, LWR is not the principal cause of a variety of downstream problems to which it may be attributed.

DR. McMAHON: What page did you say?

MR. WILLIAMS: Page 2-4 in section 2.2 of analysis.

DR. McMAHON: Yes. All right.

MR. WILLIAMS: Sorry. You have got that reference, sir?

DR. McMAHON: Yeah.

MR. WILLIAMS: In the specific context of the downstream problems, which ones were you referring to?

DR. McMAHON: I'm not sure I understand your question now.

MR. WILLIAMS: So you are saying in --

DR. McMAHON: We are at downstream problems, I see, okay. There, you know, for example, erosion and Cross Lake lake levels, I don't remember which other ones I was talking

about there. Just those two, and specifically I remember.

MR. WILLIAMS: Would you agree that there are a number of downstream ecological and downstream problems that can be directly attributed to LWR?

DR. McMAHON: I don't know that I can say that with confidence. The specific impacts of LWR on lake levels and flow, you know, outflows, Lake Winnipeg outflows, from the period '77 through 2013 don't appear to have changed significantly. But whether they have changed enough to cause problems is something that I couldn't really -- I wouldn't feel comfortable addressing.

MR. WILLIAMS: Well, let me just try this a different way. You would agree that one consequence of LWR would be an increase in total outflow capacity?

DR. McMAHON: Total outflow capacity you mean through the ice management efforts?

MR. WILLIAMS: And through the deepening of the channels, the 50 per cent increase in total outflow capacity, sir?

DR. McMAHON: Probably so, yeah, I

would say so.

MR. WILLIAMS: You would also agree that there have been seasonal flow alterations directly related to the operation of the hydrological regime as controlled by LWR?

DR. McMAHON: Well, any time you have anything other than run-of-river regulation, which is basically inflow equals outflow, and whenever inflow doesn't equal outflow, yeah, there is going to be some changes in the timing, and whether or not it persists over seasonal levels it would be hard to say. I mean there are no -- not knowing what the operating rules are precisely, but knowing that the top and the bottom of the power pool is constant through the year, I don't see any reason that there would be a seasonal shift. If you had -- and that's what we were talking about earlier, if you had a seasonally varying pool that you induced a draw down or refill, then you would be altering natural seasonal flows because you would be augmenting in a certain season or cutting back in a certain season. But in this case I don't actually see there is a seasonal shift. I haven't looked at it closely enough to see if I can look at it -- I did do some monthly flow

duration curves and pool elevation duration curves, and with Lake Winnipeg itself I didn't see much changes. With Cross Lake I think it was too inconclusive because the weir changed everything and it kind of messed up the direct comparisons.

MR. WILLIAMS: Okay. Then let's just for the sake of the next couple of questions restrict it to we are agreed that there was a material change in total outflow capacity as a consequence of Lake Winnipeg Regulation?

DR. McMAHON: Again, that wasn't the focus of what I was looking at. I was looking at the operational models. I'm assuming that in order for me to say that with certainty I would have to look at the rating curves essentially before and after Winnipeg, and compare those and look at some other data, and to be honest with you I haven't really looked at it that closely, so I don't want to say anything that I can't really stand behind.

MR. WILLIAMS: So that's something that you haven't looked at in any detail, sir?

DR. McMAHON: Say again?

MR. WILLIAMS: You haven't looked at the changes in total outflow capacity in any

detail?

DR. McMAHON: No, that's not been the focus of what I have been looking at.

MR. WILLIAMS: And so that would be a limitation that we would put on any conclusions that you might make with regard to the influence of Lake Winnipeg Regulation on downstream problems?

DR. McMAHON: I have read some things about the effectiveness of the ice management that has helped increase winter flow capacity, but beyond that I can't really say.

MR. WILLIAMS: And just -- so just to finish the point, sir, so that would be a limitation on any conclusions?

DR. McMAHON: Yes.

MR. WILLIAMS: Thank you.

THE CHAIRMAN: Thank you, Mr. Williams. Ms. Whelan Enns.

MS. WHELAN ENNS: Would you tell us if you've assessed or responded to similar requests of any other large reservoirs on hydro systems in Canada?

DR. McMAHON: Sorry, could you repeat that?

MS. WHELAN ENNS: Have you had a similar request for assessment or review like the CEC has asked of you regarding Lake Winnipeg Regulation? Are there other reservoirs in hydro systems in Canada that you have --

DR. McMAHON: No, I have not.

MS. WHELAN ENNS: Thank you. In your presentation and your comments about operating rules, I would appreciate knowing whether you are assuming and identifying that operating rules for each generation station need to be included in the operating and connected to the operating rules for Lake Winnipeg Regulation?

DR. McMAHON: I would recommend that, yeah, because for a system operational model to work it has to have rules for all of the projects in the system, and not only have their own individual targets and objectives, what we call outside rules, but also system-wide, things that all projects in the system work together to meet. That would be primarily power generation, but also the way storage is balanced in the system, that sort of thing.

MS. WHELAN ENNS: Then you are including operational rules for each reservoir in

your assumption?

DR. McMAHON: Yes, to the extent that they are controllable. I mean if you have uncontrolled products, then basically they respond to hydrologic inputs only and the operational model will show what is coming in and going out of those components of the system, but you don't have any regulation decisions to make on it.

MS. WHELAN ENNS: Thank you. Would the kind of set of operational rules for Lake Winnipeg Regulation potentially have an effect, positive, negative, either way, on the rivers and tributaries and channels that flow into the lake and the lake systems connected to Lake Winnipeg?

DR. McMAHON: Only the regulated inflows. The Winnipeg River and the Saskatchewan, I think the natural rivers would only be affected to the extent backwater from the lake or something would affect their, you know, outflow capacity. But I'm not sure if other than that it wouldn't be something that you would need to consider. That would be determined, if there is any sort of man-made alterations to the flow regime, that would come out in the derivation of the naturalized flows that go into a model like this.

And then once you have the naturalized flows, you would put in those other physical alterations to the system and it would, whatever kind of regulation effects they would have, it would come out.

MS. WHELAN ENNS: Thank you. When you've made reference to the whole hydro system in your presentation today and the need for operational rules, have you been literally including all of the reservoirs and all of the dams? They are not all within the scope of the CEC's review, hence the question.

DR. McMAHON: Yeah, they would be included in the model, even though they are not controllable. For example, the model that I showed has both Federal projects and private power projects in it. They are, you know, the control is not related, but they are --

MS. WHELAN ENNS: Thank you. The references to the kinds of models you are explaining and describing today caused me to wonder whether or not then the transmission generation and reservoir elements in a system have been modelled together with operational rules by some -- using some of the tools and the FERC

example that you gave us?

DR. McMAHON: Are you talking about the cases that I worked on or this particular application?

MS. WHELAN ENNS: The cases you've worked on and the examples that you gave us, including the FERC tools and that model, again it is a similar kind of question, and that is, when that approach is used does it apply to whole system including existing components? So would it apply to transmission systems, the generation and the reservoir and water flows?

DR. McMAHON: For operational planning purposes, now I'm talking about just looking at developing the rules, formulating the rules and evaluating those with respect to stakeholder interest, generally you only consider the -- you consider the power output of the projects, the energy capacity delivered by the projects under these rules, but you don't normally get into the dispatching of it, which is -- that's something that occurs more of on a real time basis. So the operational planning simply develops the broad framework for reservoir operations, and on a day-to-day basis or weekly basis, whatever, the

release decisions are made in consideration of the operating rules plus the market conditions for generating power, the load and the sale of power, imports, exports, all of that, they are not going to be exactly the same as what the operational models would show because they are only showing on kind of an on average condition, so to speak.

MS. WHELAN ENNS: Thank you. In the example again from FERC that we have seen in your slides and had a fair bit of discussion about today, can you tell us how in a then Federal private review and licensing process in the U.S., how the capacity and funding for stakeholders, cooperators and so on to participate is maintained independent of the proponent?

DR. McMAHON: Well, one thing is easy, in the U.S. we don't fund stakeholders, so there is none of that. And in that case it is pretty simple. I'm not saying that's the right thing to do, but that's the way it is. The other thing is the licensing process only applies to non-federal projects, private projects. Federal projects have a whole different -- they don't get licences, they develop water control plans, and that's done with the same kind of -- it has public participation

processes, but it is a lot less open and transparent than I would say the licensing process for private projects is. It also takes a lot longer and I would not recommend it for anybody.

But what -- the reason I wouldn't say I would necessarily recommend this for Canada is because our notion of Federal projects and private projects are, you know, there is a clear distinction, you know. I understand that Manitoba Hydro is more of a sort of a quasi public corporation, and so there is different -- I guess there is different nuances or different considerations that might apply there.

MS. WHELAN ENNS: Thank you. I would appreciate it if you would tell us again both public and private processes that you've been telling us about in the U.S., were there any of the ones that you were involved in having included U.S. tribes?

DR. McMAHON: U.S. what?

MS. WHELAN ENNS: Tribes.

DR. McMAHON: They all do in theory. I have just been involved in one in Georgia and South Carolina, and there are Native Americans involved, but to what extent they are accommodated

in the -- they are accommodated through, you know, they may raise issues in these issue analysis groups, for example, preservation of cultural resources or Indian burial grounds, that sort of thing. But as far as actual uses of water and changes on the conditions of a licence, I'm not sure that I have seen anything that really necessitates a particular licence provision. A lot of times there will be -- the applicant will invest in, you know, development of cultural resources or preservation of cultural resources, something not really directly related to the operation of the project, it is just more of a process to, you know, build goodwill or consensus or something, I'm not sure. I haven't worked on any out west, for example, that might have involved, you know, tribal lands or reservations or any of that kind of stuff.

MS. WHELAN ENNS: And therein lies probably a fairly significant difference between Canada and the U.S. I want to thank you for your presentation today, and that's the questions.

DR. McMAHON: Thank you.

THE CHAIRMAN: Thank you, Ms. Whelan Enns. Ms. Riel?

MS. RIEL: No.

THE CHAIRMAN: Mr. Yee? Ms. Suek?

MS. SUEK: Yes, I do. I would like to just ask some questions about trying to make it simple for my understanding here. I think the modeling that you are suggesting is kind of more future oriented than what seems to be being done now, and takes more diverse factors into account in terms of making decisions. Is that basically what it is?

DR. McMAHON: I would say that's a good reflection, yeah.

MS. SUEK: Okay. So in terms of the factors, can you factor in -- like we heard a lot about, you know, water is released during spawning periods and it ought not to be released during spawning of fish, or, you know, that there is more ecological factors that could be considered in terms of how the water is regulated. Can those things be included as factors in this kind of a model?

DR. McMAHON: Oh, absolutely, this model that I showed you, they dominate those kind of considerations really. The other thing, remember that this is a very hydro dominant system

here. We are exactly the opposite. You have 95 per cent, we have maybe a couple of per cent of our energy and it is peaking, so hydro is very minor. It started out to be the major force behind these projects, but it has since become much less of a factor. That's what I did my doctoral research on. This model that I showed you, I would say there is hundreds of rules in here, and there is a lot of state variables that sort of externally impose conditions that might trigger changes in rules, those are all centred around environmental flow requirements for the most part. Hydro is in there, but it is just subordinate to everything else.

MS. SUEK: And I was also interested in your consensus model of decision-making that you have used in other places. Here we have, we have a lot of competing interests. I mean when we did the community consultations we heard people around the lake want the lake lower, and people downstream don't want the water, and somebody has to take the water, you know, water is going some place.

So, you know, to get people together to understand the problems and the issues and the

dynamics, and you can't have it both ways, you have to have it one way or the other, I mean that kind -- and people were quite misinformed about how it all worked. So this kind of consensus building development seems like it would be very helpful here. Do you think that?

DR. McMAHON: The good thing about this process is by sort of pushing these people into these issues groups and then sharing all of the models and data is that any one user can see the impacts of his demand on the other users. So if somebody wants to keep the lake higher, or reverse it, those that want to keep the lake lower, or those that want to flood more or less downstream, they can see what results of any marginal improvement to their particular use, what kind of harm that sort of shows the other users. And so they can sort of appreciate the impacts of their -- in other words, everybody is not just sitting back in a vacuum and saying I want a higher lake and I don't want to hear anything else. So it does help in that way and people can tend to -- I am going to say it is no panacea, because in some cases they are so hotly contested, and if some of the issues become more ideological

than principled or technical, it is pretty hard to, you know, change that.

MS. SUEK: Yes, but it is a good start.

DR. McMAHON: It is better, certainly better than any other approach I know of.

MS. SUEK: Great. Thanks.

THE CHAIRMAN: Neil?

MR. HARDEN: No.

THE CHAIRMAN: I have a couple of questions about this FERC process, which I find a little intriguing. First of all, what are cooperators?

DR. McMAHON: They are what you would call stakeholders. They become cooperators because in effect they have -- they not only have their own vested interest in their own particular holding in the basin or, you know, but also they have a stake in the outcome of the study. So that in a sense their property values or their benefits, their economic livelihood in effect becomes dependent upon the outcome, the successful resolution of the study. Because the idea, you know, a big thing driving this is the wish to avoid litigation, because litigation never turns

out to anybody's interests, almost never. So there is a powerful stake behind this. I have done some work in China, and they go through all of this stakeholder stuff too, believe it or not, but they have a big stick at the end that if you can't meet a consensus, the state council is going to come in and tell you what to do.

THE CHAIRMAN: Litigation usually works out well for lawyers.

DR. McMAHON: Except in China, it works out well for the state council.

THE CHAIRMAN: True. Who identifies the stakeholders?

DR. McMAHON: That's the key, the applicant has to devise, effectively identify the issues and determine who should be in that group, should be in that group collaborating. And it is a very -- to me that's the most critical part of the whole thing. You can have stakeholders that really do nothing but obstruct and really make it difficult to reach an agreement because they are not really there to reach an agreement. You want to make sure that you get the right people involved and that they have decision authority, that they actually have the authority, that they

are representative of a particular interest group, you know.

THE CHAIRMAN: But you could have a stakeholder who for very legitimate reasons opposes the project?

DR. McMAHON: Yes, but you would have to elicit the reason why they would be opposed to it, and then identifies as a fishermen, or property owners or navigation interests or something. But almost all of the -- most of what they call purposes of Federal reservoirs, whether it is environmental or water supply or hydro power or navigation, they have a sort of a trade group or some sort of interest group that represents them, so they work out their own kind of lines of authority and delegation of, you know, negotiation.

THE CHAIRMAN: Where in this process would an environmental assessment occur? Would that be in the issue analysis and the attempt to come to a consensus or is that the regulatory?

DR. McMAHON: No, that comes at the end after the final licence.

THE CHAIRMAN: The regulatory agency review?

DR. McMAHON: Yes.

THE CHAIRMAN: Okay. Thank you. That's all of the questions that I have. Thank you very much, Dr. McMahon, thank you for preparing your paper and coming this afternoon to present it and also for being present for the last week or so.

DR. McMAHON: Thanks for inviting me to Winnipeg.

THE CHAIRMAN: It was very nice, although maybe not this week, but last week or the week before, I certainly would have preferred the 80 in Atlanta than what we had here.

That just about brings us to a close for today. Tomorrow is a late day. We will reconvene here at 1:00 o'clock. The afternoon session will go until 5:00, the evening session will be from 7:00 until 9:00, and that will be for public presentations. Now the afternoon session tomorrow, since we've concluded the cross-examination of Dr. McMahon, will only be cross-examination of the Manitoba Hydro panel. Now there are two interest groups, the Keewatinook Fishers and Peguis First Nation, as well as the panel remaining to cross-examine the Hydro

officials.

So it is possible, depending on how lengthy the answers are, that tomorrow afternoon could be a little less than four hours, but we will see. So, documents to register.

MS. JOHNSON: We certainly do. Dr. Goldsborough's paper on the Ecology of Wetlands is CEC 15. His presentation is 16. Dr. McMahon's paper is number 17. His presentation is 18. And two other pieces of information received today, CAC number 2 is the modeling paper excerpts, and number 3 is the Lake Ontario St. Lawrence plan.

(EXHIBIT 15: Dr. Goldsborough's paper)

(EXHIBIT 16: Dr. Goldsborough's presentation)

(EXHIBIT 17: Dr. McMahon's paper)

(EXHIBIT 18: Dr. McMahon's presentation)

(EXHIBIT CAC 2: Modeling paper excerpts)

(EXHIBIT CAC 3: Lake Ontario St. Lawrence plan)

THE CHAIRMAN: Thank you. Any other questions, Ms. Mayor?

MS. MAYOR: We were just -- perhaps

I'm mistaken, but I thought that Peguis had already asked questions of Hydro? Is that not correct?

THE CHAIRMAN: Okay. We will pull that back. I don't have my notes with me, they are in my bag behind me. I know that there are two participant groups remaining to cross-examine Hydro, as well as the panel, and we will confirm that -- in fact, we can confirm it in a few minutes and let you know off the record.

MS. MAYOR: And just for clarification, for the sake of Mr. Bedford and I, litigation in no way benefits in-house counsel.

THE CHAIRMAN: Yes, that I understand too. Good point. Okay. We are adjourned until 1:00 o'clock tomorrow.

(Adjourned at 4:00 o'clock)

OFFICIAL EXAMINER'S CERTIFICATE

Cecelia Reid and Debra Kot, duly appointed Official Examiners in the Province of Manitoba, do hereby certify the foregoing pages are a true and correct transcript of my Stenotype notes as taken by us at the time and place hereinbefore stated to the best of our skill and ability.

Cecelia Reid

Official Examiner, Q.B.

Debra Kot

Official Examiner Q.B.