Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River

Commission d'enquête sur le déclin des populations de saumon rouge du fleuve Fraser

Public Hearings

Audience publique

Commissioner

L'Honorable juge /
The Honourable Justice
Bruce Cohen

Commissaire

Held at:

Room 801
Federal Courthouse
701 West Georgia Street
Vancouver, B.C.

Monday, May 9, 2011

Tenue à :

Salle 801
Cour fédérale
701, rue West Georgia
Vancouver (C.-B.)

le lundi 9 mai 2011

APPEARANCES / COMPARUTIONS

Wendy Baker, Q.C. Lara Tessaro	Senior Commission Counsel Junior Commission Counsel
Mark East Charles Fugere	Government of Canada ("CAN")
Clifton Prowse, Q.C. Tara Callan	Province of British Columbia ("BCPROV")
No appearance	Pacific Salmon Commission ("PSC")
No appearance	B.C. Public Service Alliance of Canada Union of Environment Workers B.C. ("BCPSAC")
No appearance	Rio Tinto Alcan Inc. ("RTAI")
No appearance	B.C. Salmon Farmers Association ("BCSFA")
No appearance	Seafood Producers Association of B.C. ("SPABC")
No appearance	Aquaculture Coalition: Alexandra Morton; Raincoast Research Society; Pacific Coast Wild Salmon Society ("AQUA")
Tim Leadem, Q.C.	Conservation Coalition: Coastal Alliance for Aquaculture Reform Fraser Riverkeeper Society; Georgia Strait Alliance; Raincoast Conservation Foundation; Watershed Watch Salmon Society; Mr. Otto Langer; David Suzuki Foundation ("CONSERV")
No appearance	Area D Salmon Gillnet Association; Area B Harvest Committee (Seine) ("GILLFSC")

APPEARANCES / COMPARUTIONS, cont'd.

No appearance	Southern Area E Gillnetters Assn. B.C. Fisheries Survival Coalition ("SGAHC")
Christopher Harvey, Q.C.	West Coast Trollers Area G Association; United Fishermen and Allied Workers' Union ("TWCTUFA")
No appearance	B.C. Wildlife Federation; B.C. Federation of Drift Fishers ("WFFDF")
No appearance	Maa-nulth Treaty Society; Tsawwassen First Nation; Musqueam First Nation ("MTM")
No appearance	Western Central Coast Salish First Nations: Cowichan Tribes and Chemainus First Nation Hwlitsum First Nation and Penelakut Tribe Te'mexw Treaty Association ("WCCSFN")
Anja Brown	First Nations Coalition: First Nations Fisheries Council; Aboriginal Caucus of the Fraser River; Aboriginal Fisheries Secretariat; Fraser Valley Aboriginal Fisheries Society; Northern Shuswap Tribal Council; Chehalis Indian Band; Secwepemc Fisheries Commission of the Shuswap Nation Tribal Council; Upper Fraser Fisheries Conservation Alliance; Other Douglas Treaty First Nations who applied together (the Snuneymuxw, Tsartlip and Tsawout); Adams Lake Indian Band; Carrier Sekani Tribal Council; Council of Haida Nation ("FNC")
No appearance	Métis Nation British Columbia ("MNBC")

APPEARANCES / COMPARUTIONS, cont'd.

No appearance	Sto:lo Tribal Council Cheam Indian Band ("STCCIB")
No appearance	Laich-kwil-tach Treaty Society Chief Harold Sewid, Aboriginal Aquaculture Association ("LJHAH")
No appearance	Musgamagw Tsawataineuk Tribal Council ("MTTC")
No appearance	Heiltsuk Tribal Council ("HTC")

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THE REGISTRAR: Order. The hearing is now resumed.
MS. BAKER: Thank you. Good morning, Mr. Commissioner, it's Wendy Baker for the Commission with Lara Tessaro. Today we are dealing with Project 2, with the lead author, Don MacDonald, here to testify. And so we should probably get started with having him sworn in these proceedings, and then we can mark the report and deal with the various documents.

DON MacDONALD, affirmed.

THE REGISTRAR: Would you state your full name, please.
A Donald Douglas MacDonald
MS. BAKER: Thank you.

EXAMINATION IN CHIEF BY MS. BAKER:

MS. BAKER: Don MacDonald is the lead author on Technical Report 2, which is titled the "Potential Effects of Contaminants on Fraser River Sockeye Salmon". If that could be identified and marked as the next report.
THE REGISTRAR: Exhibit 826.

EXHIBIT 826: MacDonald et al, Technical Report 2, Potential Effects of Contaminants on Fraser River Sockeye Salmon, February 2011

MS. BAKER: And just to get the paper out of the way, Mr. MacDonald, there was an errata sheet that you prepared to correct some typographical errors in your report and that's been circulated to all parties. And I'd like that marked, please, as the next exhibit.
THE REGISTRAR: Exhibit 827.

EXHIBIT 827: Errata for Exhibit 826, Technical Report 2

MS. BAKER: Thank you.
Q Now, I'd like to review the *c.v.*s of the authors, starting with you, Mr. MacDonald. Now your *c.v.*

is on the screen in front of you, and this has been again circulated to all parties. I think I will first have it marked as the next exhibit, please. Oh, but first if, Mr. MacDonald, could you confirm this is your *c.v.*?

A Yes, that's my *c.v.*

MS. BAKER: Okay. If that could be marked, please.

THE REGISTRAR: Exhibit 828.

EXHIBIT 828: *Curriculum vitae* of Donald D. MacDonald

MS. BAKER: Thank you.

Q And you were assisted in this report by a number of members of your staff, and their *c.v.*s are also available here and should be marked along with this report, and I'd like to start with Meara Crawford. This is the *c.v.* of Meara Crawford?

A Yes, that's correct.

Q And she assisted you in preparing this report?

A Yes, she did.

MS. BAKER: And I'll have that marked, please.

THE REGISTRAR: Exhibit 829.

EXHIBIT 829: *Curriculum vitae* of Meara Crawford

MS. BAKER:

Q Next is the *c.v.* of Melissa Meneghetti, again this is a person on your staff who assisted you in the preparation of the report?

A Yes. And she was formally on my staff. She has since moved on, but, yes, this is her *c.v.* that was correct and complete at the time that the report was prepared.

MS. BAKER: Thank you. Could I have that marked, please.

THE REGISTRAR: Exhibit 830.

EXHIBIT 830: *Curriculum vitae* of Melissa Meneghetti

MS. BAKER:

Q Next is Heather Prencipe, also a member of your staff who assisted?

A Yes, that's correct.

Q And this is her *c.v.*?

A Yes, it is.
MS. BAKER: Could I have that marked, please.
THE REGISTRAR: Exhibit 831.

EXHIBIT 831: *Curriculum vitae* of Heather Prencipe

MS. BAKER:
Q And then finally Jesse Sinclair, also a member of your staff.
A Yes, that's correct.
Q And assisted you in the preparation of the report?
A Yes, he did.
Q And this is his *c.v.*?
A Yes, it is.
MS. BAKER: Could I have this marked, please.
THE REGISTRAR: Exhibit 832.

EXHIBIT 832: *Curriculum vitae* of Jesse Sinclair

MS. BAKER: Thank you.

EXAMINATION IN CHIEF ON QUALIFICATIONS BY MS. BAKER:

Q Now, I'd like to turn to Exhibit 828, which is your *c.v.*, Mr. MacDonald, and just review with you. You have a Bachelor of Science in Zoology from the University of British Columbia?
A That's correct.
Q And you identify on your *c.v.* your area of specialization, you identify that you are a principal of MacDonald Environmental Sciences Ltd., and that of course is the entity under which this document was prepared?
A That's correct.
Q And your company was established to provide scientific consulting services in the fields of fisheries and aquatic resource management, stream ecology, environmental quality guidelines and policy development, environmental risk and hazard assessment, and information and technology transfer.
A That's correct.
Q And you are a specialist in environmental toxicology and chemistry, ecosystem-based resource management, water quality/water use interactions,

and sediment quality assessments?
A Yes, I am.
Q And if we turn to your professional memberships and professional activities are set out on the first page. Turning to page 3, this begins 33 pages of citations of technical reports and publications which you have authored or contributed to in these areas that we've just identified?
A That's correct.
Q And just highlighting a couple of them. You've done recently in 2011 and you have worked on "Baseline ecological risk assessment of the Calcasieu Estuary" in Louisiana, various publications in relation to that?
A Yes, a labour of love. It's gone on for ten years.
Q Looking at the "predictive ability of effects-based sediment quality guidelines" in that system?
A Correct.
Q And looking at "Baseline Ecological Risk Assessment" of that estuary, including "An Evaluation of the Risks to Benthic Invertebrates Associated with Exposure to Contaminated Sediments"?
A Yes, that's correct.
Q And you've done similar work throughout Canada and the U.S.?
A Yes.
Q Just highlighting a couple of things here. You in 2010 prepared a document or a book entitled "Tools for assessing contaminated sediments in freshwater, estuarine, and marine ecosystems"?
A Yes, it was a book chapter.
Q Okay. You were also in 2009 and 2010, you prepared publications titled "Designing monitoring programs for water quality based on experience in Canada", so that was a two-part publication, one developing theory and framework, and one setting out monitoring tools?
A That's correct.
Q I'm not going to obviously go through all of your lengthy publications, but I do, if I can ask you to turn to page 8, where the technical reports are set out, and just identify that in 2010 you were involved in a "Handbook for Assessing Risks to Fish and Wildlife Associated with the Potential

Use of Water, Treated Wastewater, Stormwater, Sediment, Soil, Biosolids or Other Materials on Units of the National Wildlife Refuge System". and that appears to be a four volume publication that you were involved in 2010?

A That's correct, for the U.S. Fish and Wildlife Service.

Q Thank you. You have also in 2010 you prepared a paper on "Status and Trends of Environmental Quality Conditions in the Transboundary Reach of The Slave River" in Northwest Territories?

A That's correct.

MS. BAKER: I've just highlighted some of the publications of which there are many.

And, Mr. Commissioner, I will be asking that Mr. McDonald be qualified as an expert in environmental toxicology and chemistry, with particular expertise in ecological risk assessment and ecosystem-based management, water quality and water use interactions, design and evaluation of contaminated sediments on ecological receptors, including fish, and the design and implementation of environment quality monitoring programs.

I understand that there are some counsel that would like to speak to the qualifications of Mr. MacDonald, as well. Why don't we start with the Province of B.C.

MS. CALLAN: Callan, C-a-l-l-a-n, initials T.E., appearing on behalf of Her Majesty the Queen in right of the Province of British Columbia.

CROSS-EXAMINATION ON QUALIFICATIONS BY MS. CALLAN:

Q Mr. MacDonald, your degree is an undergraduate degree in zoology from UBC?

A Yes, that's correct.

Q You do not have a Ph.D.; is that correct?

A That's correct.

Q Okay. You do not have a degree in toxicology?

A That's correct.

Q Okay. Other schools in Canada do offer such a program?

A Yes, they do.

Q Okay. In university, did you take any courses in toxicology?

A Not directly, no.

Q Okay. Which ones did you take indirect?

A A number of science-based courses, either on ecology of freshwater organisms, ecology of saltwater organisms, how they interact with the environment, things like that, various chemistry courses, as well, and as part of the work that I was doing outside my degree, that's where I gained most of my experience in toxicology.
Q Okay. You would agree, though, that toxicology is an independent discipline in the biological sciences field?
A Can you explain, please, what you mean by that?
Q Well, there are people that do Ph.D.s in toxicology and are retained as professional toxicologists that...
A I'm not aware of such a designation.
Q Okay. So you haven't published any papers which evaluate the toxicological effects on sockeye salmon by different contaminants at different concentrations?
A Not as directly as I think the way you mean that question.
Q Okay.
A So what I mean by that is I have reviewed the toxicological data on a wide variety of contaminants in the environment and published on those topics, and as part of those investigations there may have been data that we looked at, evaluated and considered in the process that was on the toxicity of those substances to sockeye specifically and/or other salmonid species.
Q Okay. But you didn't do any of the primary research, you did review research only?
A That's correct.
Q And you have not published any papers which establish toxicological effects on any fish species? So my first question was specific to sockeye, now I'm broadening it to all fish.
A Can you please restate that question, please?
Q Okay. You have not published any papers which establish toxicological effects on any fish species?
A No, that's incorrect.
Q Okay. Which papers did you do?
A So you will find, for example, early on in my *c.v.* you'll see papers on the effects of pesticides like dicamba. If you find a series of publications by Caux et al, they'll be probably

1993, or something like that. Anyway, they included evaluations of toxicity of a variety -- there's a series of papers that evaluated toxicity of a variety of different substances on fish and other aquatic organisms.

Q Okay. And again this was review papers, not direct primary research?

A That's correct.

Q Okay. And you'd agree that your papers are largely on water quality standards, as opposed to observed toxicological effects?

A No, that's not correct.

Q Okay. Could you explain.

A Yes. So you will see in my *c.v.* a number of papers that are essentially reviews of the literature, where we look at the toxicity of this substance on that organism, for example, and dilate that data to support the generation of either water quality guidelines, sediment quality guidelines, or tissue residue guidelines.

But you also see in my *c.v.* a number of publications where we have reported the results of things like baseline ecological risk assessments. That's where we will take environmental samples from the field and we will subject various toxicity test organisms to those, to those either test sediments or water, and then use those results to evaluate the toxicity of that material to those species.

MS. CALLAN: Okay. Those are my questions.

MR. LEADEM: For the record, Leadem, initial T., appearing as counsel for the Conservation Coalition.

CROSS-EXAMINATION ON QUALIFICATIONS BY MR. LEADEM:

Q Good morning, Mr. MacDonald.

A Good morning.

Q I want to ask you -- I'm content with your qualifications, but I want to make sure that when I ask you some questions that may arise during the course of my cross-examination of you that's to come later, that you're qualified to give me some answers in certain areas, and I want to explore with you, based upon your expertise and experience, whether you possess the necessary qualifications to ask the questions that I'm

contemplating putting to you. Before I do that, I want to make sure that I go through some of the technical reports that you have worked on. You've done a considerable amount of work for the Province of British Columbia, according to the Technical Reports section of your resume; is that correct?

A Yes, we've done some work for the Province of British Columbia.

Q And, for example, if I ask you to turn to page 19 of the report, about two-thirds of the way down, this is a report that you authored, co-authored in 2004 entitled "Criteria for contaminated sites: Criteria for managing contaminated sediment in British Columbia", and this was a Technical Appendix that you prepared for the Environmental Management Branch, British Columbia Ministry of Water, Land and Air Protection.

A That's correct.

Q And you've done other work for the Province of British Columbia over the years, including "An evaluation of sediment quality conditions in the vicinity of the Macaulay Point and Clover Point outfalls"; is that correct?

A That's correct.

Q And you also did a "Workshop to support the development of guidance on the assessment of contaminated sediments in British Columbia". I'm looking at page 14 of your resume under the heading of "Technical Reports", the second item down.

A That's correct.

Q You've done a considerable amount of work in other jurisdictions, other than British Columbia, Louisiana, Missouri, Pennsylvania, it seems that you've been quite a globetrotter in terms of the work that you've done in other jurisdictions; is that fair to say?

A Well, I like to keep most of my work within North America, but, yes, that's correct.

Q And you've also done work for the Northwest Territories, have you?

A Yes, that's correct.

Q What are you doing, or what have you done for the Northwest Territories?

A A variety of different things. We've designed environmental quality monitoring programs for

places like the Slave River, for the Peel, for the Liard River, as well, as they're sort of three of the main river systems up in the Northwest Territories. We've also assisted them, various participants in the process, in the regulatory process in the Northwest Territories with evaluation of things like applications for mining projects, particularly diamond mining. We've evaluated decommissioning plans for mine sites, gold mine sites in the Northwest Territories.

Q So when you say that you're associated with helping them in the regulatory process, you would have been familiar then with the permitting system of the Northwest Territories and how that functions?

A Yes.

Q And you would have been consulted with respect to conditions upon point sources of pollution and how that ought to be regulated in that province, or that territory?

A Yes.

Q And are you familiar somewhat with the permitting system as it applies in British Columbia, as well?

A Generally, yes.

MR. LEADEM: All right. Those are my questions. Thank you, Mr. Commissioner.

MS. BAKER: Thank you, Mr. Commissioner. In terms of the qualifications that I proposed he be qualified as...

THE COMMISSIONER: Maybe just kindly just read those back to me just a little slower.

MS. BAKER: Sure.

THE COMMISSIONER: I just was trying to make a note of it.

MS. BAKER: Yes.

THE COMMISSIONER: Thank you.

MS. BAKER: An expert in environmental toxicology and chemistry with expertise in ecological risk assessment and ecosystem-based management, water quality and water use interactions, design and evaluation of contaminated sediments on ecological receptors including fish, design and implementation of environmental quality monitoring programs.

THE COMMISSIONER: Is the eco risk assessment and ecosystem-based management, are those linked together, or are those separate?

MS. BAKER: Perhaps Mr. MacDonald can identify how those are described.
A Those are separate.
THE COMMISSIONER: Separately.
A Yes.
THE COMMISSIONER: Yes, thank you very much, Ms. Baker.
MS. BAKER: Thank you. So is he now qualified?
THE COMMISSIONER: Yes, thank you.
MS. BAKER: Thank you.

EXAMINATION IN CHIEF BY MS. BAKER, continuing:

Q Mr. MacDonald, I'd like to just do a bit of an overview of what you did for this report, and I'm just going to run through an overview with you of what I understand the report to contain and you can just confirm whether I've got it right or not.
I understand that this report, the first stage was to define the geographic and temporal scope of the investigation, followed by the creation of an inventory of aquatic contaminants, followed by a preliminary evaluation of contaminants of concern, then actually doing a full evaluation of contaminants of concern you were able to assess, then looking at potential effects of endocrine disrupting chemicals and contaminants of emerging concern. That was the first part?
A Yes.
Q Or the first of many parts?
A Yes, that's correct.
Q You also in doing that work identified uncertainties and data gaps as you did the work?
A Yes, we did.
Q And you provided a set of recommendations for the Commissioner?
A Indeed.
Q Okay. I'd like to begin with the first phase that I described, which was identifying the spatial and temporal scope, which you focused on in your work. And I wonder if you could just identify how you did that, how did you identify the temporal and spatial scope?
A Yes.
Q And just as we do that, I wonder if you might want to just -- the participants might want to have pages 9 and 10, and the Commissioner have pages 9

and 10 open of the report, because that is where you do review it, if that's of some assistance.

A There we are. Yes. So what we did was we obtained information on the distribution of sockeye salmon within the Fraser River Basin. Then we conducted an evaluation of the availability of surface water chemistry, sediment chemistry and other types of data that could be used to evaluate conditions within the Fraser River Basin. We integrated those two types of information to identify a scope of the study area that would encompass the distribution of sockeye salmon within the system and throughout each of their life stages, through incubation and through -- spawning and incubation through rearing, and then through the outmigration and upstream migration, as well, the adults.

And so what we tried to do is make sure that our scope of the study area was inclusive of all of those areas, but was able to be evaluated using the data that were available to us. And so what we ultimately focused on then was identifying a total of 15 areas of interest within the Fraser River Basin that would provide us with the basis for evaluating those conditions, and how those conditions then might be influencing the abundance of sockeye salmon.

Q Right. And those areas of interest begin on page 9 and carry over through page 10?

A That's correct.

Q Okay. And in terms of the temporal scope of the work, how did you identify that?

A Our interest was to be able to understand the factors, contaminant-based factors that could be influencing the decline of sockeye salmon over the last 20 years. And so we wanted to make sure that we captured the last 20 years, plus a period of time before that, so that we would have a basis for comparing information on environmental quality conditions prior to these major declines in sockeye salmon, and after the declines had -- had begun, so that we could compare those results and determine whether there had been any major changes in conditions within the system.

So what we did was we looked at the data that we had, looked at the temporal coverage that we had, and determined that we had sufficient data

that we believed were reliable from 1965 on to present. And so that's what defined the temporal scope of our study.

Q And did you have reliable data for all of the areas of interest for that full scope?

A No, we did not. We had some major challenges in terms of being able to identify sufficient quantities of data to characterize conditions within each of the areas that we wanted to characterize conditions, during the life stages that the animals were actually exposed to those conditions. So we found that we had some major data gaps as we tried to develop that database to support that analysis.

Q I take it in your analysis, you used water quality data from some source?

A That's correct.

Q Where did you get that, what sources did you use for water quality data?

A We looked for water quality data from a variety of different sources, and ultimately what we relied upon was the data that is comprised in the Province of British Columbia's Environmental Monitoring System for the water quality data.

Q And by using that data, were you able to precisely relate water quality data, both spatially and temporally, with where and when the sockeye were spawning and rearing?

A No.

Q Why not?

A We had challenges in terms of linking -- finding data that would specifically relate to, for example, spawning areas. So we frequently had data that characterized main stems of rivers, oftentimes below the rearing lakes that the sockeye were utilizing, but only very infrequently did we have data, for example, that characterized conditions in the headwater systems where the sockeye were spawning, in many cases. And so we had that sort of spatial disconnect between where the animals were actually utilizing habitats and where the environmental quality monitoring data had been collected.

And similarly we had challenges in linking, ensuring that we had appropriate data for the right times of the year when the animals were actually using those habitats. So for spawning

and incubation, for example, the eggs are deposited in the early/late fall, and then the alevins and the fry leave the gravel in the spring. Frequently we have a lot of data for the summer period, but not necessarily a lot of data for that fall, winter and early spring period. And so that spatial, that temporal disconnect between when we wanted to be able to characterize conditions and when we were able to characterize conditions created data gaps for us.

Q All right. So how did you address those challenges?

A Well, what we did was we used the data that we had, to characterize conditions as well as we could. And we made a number of assumptions along the way. So for example, if we didn't have data to characterize a rearing lake, for example, Quesnel Lake, but we had data collected at the outlet of Quesnel Lake, in the Quesnel River, we would apply that information to the river, to the lake itself, with an understanding that this was not the preferred way to characterize conditions within that lake, but it provided, if you believe that the water that was in the river came out of the lake, which we believed that it did, it provided a basis for understanding what the exposure could have been in the lake. It's imperfect, but we had to use the data that we had in that kind of creative way to try to characterize exposures as best we could.

Q And are you satisfied with those methods that you used to address the challenges?

A Yeah, I'm satisfied with the methods. I'm unsatisfied with the underlying data, though.

Q And the underlying data, I take it, at the monitoring sites that are -- these are ones that are administered by the province?

A They may be administered by the province, or they may be federal/provincial sites, in some cases they may have been sites that where the data were collected by others, and then the data were provided to the province for incorporation into the EMS system.

Q And they're not data collection sites that are specific for Fraser River sockeye, right, they have other uses?

A They are almost entirely for other uses. In fact,

I'm not aware of any water quality monitoring program that was designed explicitly for Fraser River sockeye.

Q I'd like to move now to the inventory that you did of aquatic contaminants, and I'm going to make some use of the tables. Mr. Commissioner, hopefully you have those in the report before you. There's a large collection of tables and figures towards the end of the report under the "Appendices". And I'd like to go to, to start on this discussion, I'd like to turn to Tables 3.25 and 3.26, 3.27. So those, I'll grab the page numbers for you. You'll see that the pages in this section for the tables are labelled "T-" a number. So starting at T-78, which is 3.25. And once we all have that I'll just ask you some overview questions. Okay.

So what were you doing in the section where you did the inventory of aquatic contaminants, just as a sort of broad brush, what was the intention?

A Just so we make sure everybody has the right information on the screen. We want to go down to --

Q Yeah, it should be T-78. It's 3.25.

A I'm sorry, now I'm paying attention again.

Q Yeah, T-78.

A -- T-78.

MR. LUNN: Thank you, we'll get there.

MS. BAKER: There we go. Okay.

Q So what was the intention of the -- how did you do it on a broad brush, inventory of aquatic contaminants?

A Yes. So we did this evaluation of, or development of the inventory of aquatic contaminants, using a multistep process. And the first step was to ask the question, what kinds of human activities and anthropogenic activities are ongoing within the Fraser River Basin, and where are those activities occurring. And so we compiled information, geographically-based information, using a geographic information system, data that was available from a variety of different sources, to identify where the various land uses were occurring within the Fraser River Basin.

And as you can see across this table, if you look across the columns of the table, we included

or compiled information on a broad range of activities, including pulp and paper mills, sawmills, plywood mills, et cetera, wood preservation facilities, cement plants, seafood processing facilities, operating and abandoned mines, oil and gas developments, bulk storage and shipping facilities, other types of manufacturing facilities, and that's sort of a term as a catchall for a variety of other types of manufacturing facilities. We looked at contaminated sites and spills that have occurred within the system. Those are two separate things, but they were captured within one title. Municipal wastewater treatment facilities, landfills, salmonid enhancement facilities, lake fertilization projects. So those were the key point sources of contaminants within the system.

But we also recognized that there was a number of non-point sources that potentially could have contributed contaminants into the system, and so we looked at the distribution of activities related to forest management, to agricultural developments. We looked for municipal stormwater runoff areas, and looked at runoff from linear developments.

And then also recognizing that there are atmospheric sources that potentially could be contributing contaminants to the river basin, we looked at both natural and anthropogenic sources.

So this was the first real step was to characterize geographically where each of these types of activities occurred within the river basin.

Q Okay.

A Then we, if we go down to Table 3. --

Q 26?

A -- 26, then we asked the question, for each of these activities, for example, pulp and paper mills, what are the types of contaminants that are typically associated with each of those activities? And then we characterized those, and what you see in this particular table is not a comprehensive list of contaminants. What it identifies is classes of contaminants, so we've called them analytical groups there, or analyte groups. And for each of the types of activities then, like pulp and paper mills, you'll see little

checkmarks which indicate whether or not, for example, nutrients or metals or phenolic compounds, or chlorinated phenolics, are associated with that type of activity.

Q Okay.

A And this information was garnered from the scientific literature. We did a review of the literature on each one of these activities, compiled information from a variety of different sources to support the identification of which contaminants are associated with each one of these activities.

Q All right. And then if we turn to the next page, 3.27.

A And this, what this table does is it integrates the information from the latter two tables, 3.25 and 3.26, to identify which contaminants are likely to be associated with each of the areas of interest within the Fraser River Basin. And if you look at the final column, it identifies the classes of contaminants that are associated with, or have likely been released into the Fraser River Basin as a whole. So this provides, then, the inventory of the classes of contaminants that we believe have been released into the river basin.

Q And then if I can ask you to turn to Table 8.1, which is on T-261. It actually begins on -- sorry, it begins on 253 and goes on for a number of pages.

THE COMMISSIONER: What is the table number, Ms. Baker?

MS. BAKER: It's Table 8.1 and it begins on page T-253.

Q Okay. And this -- how does this inventory of aquatic contaminants interrelate to the tables we've just reviewed?

A So this table is very much like the earlier Table 3.27, with one major exception. And that is instead of identifying contaminant classes only, within each of the classes of contaminants, we also identified the individual contaminants that have been associated, or likely to have been released into each of the areas of interest, into the Fraser River as a whole. And so when viewed in total, then this Table 8.1 then provides our inventory of aquatic contaminants for the Fraser River Basin.

Q And in your view, how complete is the inventory in 8.1?

A This table identifies some 200 or so contaminants that have been released. I don't know what the exact number is. I may have counted them at some point, but I don't remember the number offhand now. This is -- currently that there have been thousands of contaminants that have been released into the system. But what I believe that this inventory does, it identifies the contaminants that are the most likely to be risk drivers within the Fraser River Basin, either for effects on sockeye or other aquatic organisms within the system.

So I believe that this is an inventory that can be used to evaluate potential effects of releases of contaminants into the system, and if used in this way, we are likely to emit important contaminants that could be driving effects.

Q And Table 8.1, it's not just on T-253, it actually carries on for a number of pages and completes on page 266.

A Yes, that's correct.

Q I don't want to spend too much time on the tables, but just to -- that form the backup for some of the summaries we've just reviewed, but I just wanted to understand how some of these tables in section 3 may be useful, and to understand what the data actually refers to. If you turn to Table 3.1, just beginning at 3.1 and going through to 3.12, sets out in some detail the different activities and the permits that are issued under or by various authorities in relation to those different activities.

So if we look at 3.1, for example, which is on page T-9, this would show the different pulp and paper mills in the Fraser River Basin. It shows the discharge, summary discharge information, and under the column "Variable Listed in Effluent Permit" it would show what's actually been permitted under a regulatory regime?

A Yes, that's correct.

Q Okay. So if I ask you to turn to one for mining, as an example, on page T-23, this is Table 3.7, sets out in the same way "Variables listed in Effluent Permit", we see a number of the chemicals listed there.

A Yes.

Q So that goes on for a couple of pages. You'll see

it beginning on the Teck Resources mine at the bottom, and if you can just scroll down to the next page, we can see other mining effluent permits listed there.

A Yes.

Q Okay. If I ask you to turn to page 22 of your report, where you have provided the text summary of different industries and the pollutants associated with those industries, just as a comparison, the mining section which begins on page 20, if we move through that and we turn to page 22, which is the end, you've set out various discharges associated with mining activities. You see those there.

A Yes.

Q Bulleted. Would those discharges that you have on page 22 reflect all of the effluents that are shown on the permits we just reviewed in Table 3.7?

A No, typically the permitted -- the monitoring that is required under the effluent permits is a subset of the variables that are likely to have been released from a mining facility, and that typically is true of other sectors as well.

Q All right. So the list in the text of your report, page 22 for mining, is a broader grouping of contaminants than what we see in the effluent permits?

A Correct. Yes. Based on our review, we believe that there is a broader list of contaminants that have been released, beyond those which are identified within the effluent permits themselves.

Q And in terms of information that you relied on, if we turn to page 15, this is part of your pulp and paper text, what did you use to obtain the information on page 15, which sets out the contaminants associated with pulp and paper?

A We conducted a review of the scientific literature, identified a number of documents that provided us with information on what the characteristics of pulp mill effluents look like, what they are likely to contain. Those references are identified explicitly in these bulleted points, and I think there's probably something on the order of, oh, seven or eight different documents that we've relied upon here, between the Johannessen and Ross 2002 paper, the Suntio et al

1 1988, which is a very thorough characterization of
2 the substances that are contained within bleach,
3 kraft pulp mill effluent. And then you'll see a
4 variety of other references also that were used,
5 the Mah et al '89, and a variety of others that
6 are included in this list.
7 Q Okay. And in your view that's a complete list, or
8 fairly as complete as you can make it?
9 A I believe, we did the review of the literature, we
10 found that these documents provided us with a very
11 good -- what we believed was a good indication of
12 the contaminants that are likely to be found in
13 those pulp mills. There are likely other
14 documents also that could have been used in that
15 evaluation. It's likely, though, that the list
16 that we've identified, based on the use of these
17 documents, would identify all or most of the risk
18 drivers that are associated with releases from
19 pulp mill facilities here in the province.
20 Q All right. And you identified as we were going
21 through one of the earlier tables that you had
22 listed contaminated sites or you had assessed
23 contaminated sites. What information did you use
24 to do that assessment?
25 A Yes, that is correct. There is a contaminated
26 sites registry here in the province, and we
27 attempted to access that information. My
28 understanding was that it was under development,
29 or under redevelopment is probably more correctly
30 stated, at the time that we were doing this work,
31 and so that was not available electronically to
32 us.
33 And so we had some discussions with the folks
34 at the Land Remediation Branch. They were able to
35 provide us with some indication of the number of
36 contaminated sites that occur within the Fraser
37 River Basin, some 3,000 up to 1995, and a current
38 number is something more in the order of something
39 like 5,000 sites within the system. But we were
40 unable to get the information on those, where
41 those sites occur spatially within the system at
42 the time that we were doing this work.
43 And so we reviewed other sources, potential
44 sources of information on contaminated sites. We
45 identified one, a database that was being
46 administered by Treasury Board, and ultimately we
47 relied upon the data within that database to help

us to identify spatially where the contaminated sites were occurring within the system, and what types of contaminated sites occurred within the system.

One thing to note is that the Treasury Board database had information on about 1,000 contaminated sites within the basin, and based on our discussions with the province, there were some 5,000 currently in the system. So, you know, our evaluation may be a representative of where those contaminated sites occur, but it's certainly not comprehensive.

Q So there may be more contaminated sites than what you were able to pinpoint when you did the report.

A Based on the information provided to me by the province, we believe there's another 4,000 beyond the ones that we explicitly identified in our review, yes.

Q Thank you. All right. Once you had identified this broad inventory of contaminants, you had to do some evaluation to try and drill down on what were the contaminants of concern. And that, I take it, is what you did in the Chapter 4, "Preliminary Evaluation of Chemicals of Potential Concern".

A Yes, that's correct.

Q Okay. So what did you -- how did you do this, what screening methodology did you use to go through the contaminants, the broad brush contaminants that you had identified?

A So we used a methodology that is termed a screening level ecological risk assessment. It's an approach that is used consistently at contaminated sites in Canada and the United States. There's a standard guidance on how to conduct this type of assessment that has been put out by USEPA and the Canadian Council of Ministers of Environment have also put out a guidance on how to conduct this screening level risk assessment, as has the Science Advisory Board here in British Columbia, which provides the tools that are used within the contaminated sites assessment system here in British Columbia.

Q All right. And how did this -- is there a way to describe how you did this preliminary evaluation?

A Yeah. The way that I like to describe a screening level risk assessment is the goal is really

threefold: one is to identify those contaminants that pose potential risks to ecological receptors, plants and animals that occur in the environment, to identify the substances that don't pose potential risks, and those that we're uncertain about. So those are, that's really the threefold thrust behind this approach.

And the metaphor that I use to sort of describe this is one of a sieve, and where we're looking at particles of a variety of different sizes, and the larger size particles are the ones that are potential risk drivers, or uncertain risk drivers, and the very small ones are the things that are probably not contributing to risk to ecological receptors.

So in this first analysis we use a sieve that has a very fine mesh, so it's very conservative, and we capture most of the contaminants on top of that, and they go through the next phase of the analysis. And what goes through are the contaminants that really have a very low probability of having caused or substantially contributed to any adverse effects on ecological receptors within the system.

Q Would also, would the contaminants that could fall through your sieve, would they also includes ones where you just don't have enough information to assess whether they're harmful or not, there's just not enough data?

A Well, we retain those as something called uncertain contaminants of concern. And then those automatically go into the next phase of the analysis. So those don't get dropped behind. Those get brought along, because understanding the potential effects of those uncertain contaminants of concern can be very important in the whole assessment process.

Q So for each area of interest did you determine exposure point concentrations for contaminants as part of this process?

A Yes, we did.

Q And what, can you explain what those are, and how they were used?

A Yeah. What we did was we identified -- again, this first level of assessment is intended to be very conservative. And so what we used was a maximum concentration of each of the contaminants

of potential concern to identify the level of those substances to which the organisms could be exposed. So, for example, for each of the areas of interest, we identified the very maximum concentration of cadmium that had been measured in water. And then that gets carried through also to the basin-wide assessment. So that it didn't matter what any of those other lower concentrations were, we only paid attention to the highest concentration to determine whether that was a potential, posing a potential risk to the environment.

Q Okay. And that was done on an area of interest basis?

A Yes, and for the study area as a whole, as well.

Q Okay. And also toxicity screening levels, you also used those in your work?

A Yes, that's correct.

Q And what, can you explain what they are and how they were used?

A Yes. A toxicity screening level, or value is a measure of the toxicity of a particular contaminant. And so for cadmium, for example, you could select any number of toxicity screening values from high levels that are associated with certain types of effects on a very specific species, to concentrations that are expected to be protective of all species in the aquatic environment.

And so what we selected was a very conservative toxicity screening values, typically Canadian Water Quality Guidelines, which are intended to provide a high level of protection to all species of aquatic organisms over extended periods of exposure, and protect all the life stages of those organisms. So they're intended to be very conservative toxicity screening values. That's what we selected in this case for doing this evaluation.

Q All right. And when you were doing that evaluation, did you take into account the different life stages that the fish were at as they moved through these areas of interest, and what contaminants were in the waters at that time?

A Yes. Yeah, we did this analysis looking at four separate life stages of sockeye salmon. So we looked at the period of time within which we

expected to see eggs and alevins incubating within the Fraser River Basin. We called that the incubation period. We looked at and characterized exposures for the rearing period, when the sockeye are largely within these nursery lakes within the system. And also we characterized conditions during downstream migration of sockeye smolts, and upstream migration of adult sockeye as they're headed to the spawning grounds.

Q For surface water contaminants, you have a couple of tables that I wanted to get you to explain. They're found at -- one is found at T-201, so it's Table 4.49.

MR. LUNN: Did you say 4.49?

MS. BAKER: 4.49 is the table, the page is T-201.

MR. LUNN: Thank you.

A Yes.

MS. BAKER:

Q Okay. So can you explain what's being described on these tables?

A Yes. And if you move up one page, I believe -- no, that's good. That's good, I'm sorry.

Q So this, just for the record, this table is titled "Summary of hazards posed to sockeye salmon exposed to surface water within the Fraser River Basin".

A Yes. So this table summarizes the results of the hazard evaluation for the entire river basin. And what it reports are something called hazard quotients, and you'll recollect a moment or two ago we spoke about two separate things, one was an exposure point concentration, and the second was a toxicity screening value. A hazard quotient is calculated by dividing that exposure point concentration by the toxicity screening value.

And so where you have a hazard quotient greater than one, you have a concentration of that particular substance that is sufficient to pose a potential risk to aquatic receptors. So we're not actually talking about actual risk yet, but it's potential risk. Keeping in mind that the exposure point concentration was a very conservative estimate of exposure, meaning the highest concentration that was measured for each of these time periods, and the toxicity screening value was a very conservative measure of a concentration that would be protective of aquatic receptors.

And so we've gone through this, the process for each of the contaminants of potential concern for which we had data available, and where you see a toxicity, a hazard quotient greater than one, those then are the substances which were identified as potential -- substances that potentially could pose risk to sockeye salmon within the Fraser River Basin, within one or more of these life history stages.

Q So if we were to look under "Major ions", at "Chloride", for example, dissolved chloride, this assessment would say that it's not a risk until you've hit the adult upstream migration, and at that point it becomes a risk.

A Correct.

Q Okay. And then --

A Potential risk, yes.

Q Potential risk. And then the maximum value across those four life stages is what is carried forward into the column "All Life Stages"?

A That's correct.

Q Okay. In your report at page 53, this is where you, I think, deal with some of the information that's in this table. At the very bottom of the page there's a couple of sentences. I just want to make sure we understand what they mean. It begins, the very last two lines:

> These results suggest that water quality conditions have degraded over the past two decades. However, the results were reversed for the juvenile rearing and smolt outmigration life stages.

What does that refer to?

A So this refers to the results that are presented in Table 4.50.

Q Okay. Which is the next page over to T-203.

A Yes.

Q I think, Mr. Lunn, we can leave this text page and go right to the table, T-203.

A Great. So there are times where you're delighted with the way that you've constructed a table and then there are times that you wish you had put a little bit more information in a table. And this is a place where I wish I had put these percentages explicitly in these tables so it would

be a little easier to be follow. But what that text on the bottom of the page referred to was comparisons between the pre- and post-1990 periods for each of the life stages.

And just to let you know what these numbers mean, first of all, if you go to the final row in the table, where it says "Fraser River Basin", and you'll see a number of numbers that you work across for "Spawning & Incubation, Pre-1990", what this means is that 15 of the 25 substances for which we had data had concentrations that exceeded -- exceeded the toxicity of screening value. And so what that means is that 60 percent, 15 of 25, 60 percent of those contaminants had exceedances.

If you go to the next column, you'll see the Post-1990 data and you'll see 18 of 25 (sic) of the contaminants had exceedances of those conservative toxicity screening values. That corresponds to a rate of about 67 percent.

Q I think you said 18 out of 25. You meant 18 out of 27?

A Yes, that's correct. Thank you.

Q Just so we know that we're looking at the right place.

A I apologize for that, and appreciate you correcting that.

And then as you work across, and you can calculate percentages, as well. And long story short is what we saw for spawning and incubation was a higher percentage of the contaminants exceeded the benchmark post-1990, and that was also true for upstream migration, where we had a higher percentage of the contaminants that exceeded the toxicity screening values in the post-1990 timeframe.

Contrary to that, for the juvenile rearing we had slightly percentages in the pre-1990 period for the percentage of the substances that exceeded the benchmarks, and the same is true also for the smolt outmigration life phase, where there was a slightly higher percentage of the contaminants that exceeded the benchmarks during that time.

And so what we did not see was a consistently higher percentage across all of the life stages for that post-1990 period, which is what one might expect if these contaminants were the primary drivers of effects on all of these life stages.

What it does tell you is that you do have for the incubation phase and for the adult upstream migration phase, some higher percentages of incidence of exceedance of the benchmarks. And so those are places where you might say there could be some correlation between changes in abundance of sockeye and changes in conditions within the system over those pre-1990 to post-1990 time periods.

Q And this information we've just reviewed, Tables 4.49 and 4.50, are all in relation to surface water; is that right?

A That's correct.

Q Okay. And then the next piece you looked at was sediments, and that is also set out conveniently in a table, Table 4.53, which is pages 208 and 209.

A Yes, that's correct.

Q All right. So if you can explain this table.

A So this table is very similar to the last table, that you will see that there are a couple of differences that are notable. One is you see only four areas of interest represented in this table, compared to for the water quality there were tables for each of the areas of interest, just prior to the one that we talked about, the summary table. And you'll see that these data were not separated into two time periods, pre- and post-1990. And the reason for that, for both of those changes between -- we would have liked to have done the assessment in the very same way that we did it for surface water, but the available data did not support that.

And so what we see here is a summary that applies to all of the data that were available to us when we conducted this assessment. And what it identifies again is those hazard quotients for individual contaminants for the Fraser River as a whole, and identifies a series of metals that occurred at concentrations in excess of the toxicity screening values and hence had hazard quotients greater than one.

And if you flip through, through this table, to the next page, as well, you'll see there were certain other contaminants that emerged as posing potential risks to aquatic receptors within the Fraser River Basin that included one of the

phthalates that we were able to evaluate, Bis (2-ethylhexyl) phthalate, and some polycyclic aromatic hydrocarbons, and there was three of those that occurred at concentrations in excess of the toxicity screening values in one or more locations within the system.

Q And what are those chemicals, what are the significance of those chemicals that you just reviewed?

A Could you ask that question in another way, please?

Q Sure. Why don't you tell me how you'd like to answer that question.

A So what that says to me is that there are a number of substances that occur in sediments at concentrations sufficient to pose potential risks to aquatic organisms within the Fraser River Basin. And by and large those risks are focused in the Lower Fraser River Basin. It's very, very important, though, not to draw broad conclusions about this, because again the data are very limited, and as a result of that, there are many, many, many locations throughout the Fraser River for which we don't have any sediment chemistry data. And so while we've been able to identify the Lower Fraser River as one of the key areas where we have some exceedances of these benchmarks, one should not conclude that that's the only place where these types of exceedances occur.

Q All right.

A It's simply based on our review of the existing data.

Q And what is a - I'm not going to pronounce it right, so I'm going to spell it - p-h-t-h-a-l-a-t-e, what is that chemical?

A Was that the first one under PAHs?

Q Yes. Under "Plastics-Related Chemicals".

A Oh, Bis (2-ethylhexyl) phthalate?

Q Yes.

A That's a --

Q Rolled off the tongue nicely.

A Yes. We call it BEHP, just to avoid having to say the word out loud. That's a substance that's used as a plasticizer in the plastics-related industry. You also find it in things like motor oil, outboard motor oil seems to contain substantial

quantities of that. And so it's a substance that we find in many places that we look across North America.

Q All right. And many of these columns have "ND", which I understand stands for "no data", particularly once you get outside of the Lower Fraser. What data were you able to actually use when you did this assessment?

A We used data from several sources for the sediment chemistry data, and they included the EMS database that we talked about previously that is administered by the Province of British Columbia. Also we were able to access some data that were available from GVRD in one of their annual reports, I believe that report was dated 2006. And I believe those were the two main sources. There may have been one or two other minor sources, but those were the main sources.

Q All right. And in your view was that data sufficient to address the broad reaches of the Fraser River?

A No.

Q And what impact does that have on the work that you were doing?

A Well, the challenge is that we have virtually no data for spawning areas within the Fraser River system. We had no data for the rearing areas within the Fraser River Basin. The data for the Lower Fraser provided us with some indication of where we may have some exposure within those migration routes, may have some relevance to the early rearing that occurs for at least one of the stocks down in the Lower Fraser. But again, those data were not necessarily co-located with those locations where the sockeye salmon, the relatively smaller number of sockeye salmon actually rear within the Lower Fraser. So it's difficult to use these data explicitly to evaluate what the exposure of sockeye salmon was to sediment-associated contaminants, and hence the risk.

As sort of an add-on to that, I'd also like to mention, you know, we don't expect to see a lot of contaminated sediments within the areas that sockeye are actively spawning and rearing, for the most part. So they're spawning in largely the headwater systems or main stem areas, further up the Fraser, those are typically spatially isolated

from a lot of the point source releases of contaminants into the system. And the kinds of places where you expect to see contaminated sediments deposited, those are typically the slow-moving areas where you have soft-bottom sediments. Those are not typically the areas that a lot of salmon would be using for spawning purposes anyway. That is not necessarily true for rearing, but it is for -- for all stocks, but it is for incubation.

And so if there was exposure during incubation it would be to a relatively small percentage of the contaminated sediments that might be incorporated within that matrix that they use for spawning within the streambed.

Q Okay, thank you. And one last question on this topic and then we'll take the morning break, I think, is if you can go to your report at the text of your report, page 55. This is the end of your sediment analysis in the text body of your report.

A I'm sorry, could you repeat the page again?

Q 55, it's on the screen now in front of you. You've set out three substances with bullets.

A Yes.

Q What is the significance of these three that you've set out?

A So those are the three groups of substances that had hazard quotients greater than one. So those are the substances that pose potential risks for aquatic organisms within the Fraser River Basin, utilizing those areas where those contaminated sediments occur, and within each of those groups there are a number of substances that are explicitly identified.

The flip side of this, of that statement, though, is that there are a variety of other substances for which there was insufficient information to conduct an evaluation. And so we're left with a higher level of uncertainty in a sediment-type assessment than we would be otherwise, if we had data for a large number of places and a large number of contaminants that we thought had been discharged into the system.

MS. BAKER: Thank you. Mr. Commissioner, it's 11:14, so this would be a good time to break, and then we'll move to the next chapter of his report.

THE COMMISSIONER: If I just might, just before we

break, Ms. Baker. I wonder if we could just -- he talked earlier about availability of data from the Crown, and I wonder if he could just outline for us where he went to get this data specifically within the framework of the legislative provisions that exist within the province, or even federally, if that is an appropriate source of data. But if you could just tell me, because you mentioned Treasury Board, and I wasn't quite following why there would be data there, and not somewhere else.

A It was also surprising to me to see that the Treasury Board was administering a database of contaminated sites. So that data that we accessed from that source was specifically about where certain contaminated sites were within the system, and what types of sites those were.

So beyond that, we tried to access data from a variety of different sources, provincial sources, meaning the EMS system, that's their data warehouse, from federal sources, Department of Fisheries and Oceans, Environment Canada, from the GVRD, as well as other sources that we may have identified during our reviews of the scientific literature. And keeping in mind that with the short timeframe, we needed to be able to access data that were electronically available, rather than data that were sequestered in written reports somewhere, where we would have to then retype all that data into the database and then evaluate it, et cetera. So the data then that we relied on, then, was largely from that EMS system administered by the province.

THE COMMISSIONER: Thank you.

A You're welcome.

THE COMMISSIONER: Yes, we'll take the break then, Ms. Baker.

THE REGISTRAR: The hearing will now recess for 15 minutes.

(PROCEEDINGS ADJOURNED FOR MORNING RECESS)
(PROCEEDINGS RECONVENED)

THE REGISTRAR: Order. The hearing is now resumed.

MS. BAKER: Thank you.

EXAMINATION IN CHIEF BY MS. BAKER, continuing:

Q Before the break, we were looking at page 55 in your report which set out the three classes of contaminants of concern in sediment. And I had meant to take you to page 53 where you've done the same with surface water. Now, let me just do that now quickly before we move to the next chapter. So page 53. It's on the screen. Here again, in the same way for surface water, you have set out the classes of contaminants of particular concern; is that right?

A Yes, that's correct.

Q Put your mike on.

A Yes, that's correct. And in this portion of the test we identify five separate classes of contaminants including conventional variables, such things as pH, the TSS, which stands for Total Suspended Solids, concentration and turbidity. Both of those latter two are indicators of the amount of suspended material in the water column. Nutrients, including nitrate, nitrite and phosphorous, several major ions. There is a list of metals and then phenols was identified as the fifth group of contaminants that were present at concentrations sufficient o pose potential risk to aquatic organisms in the Fraser River basin.

Q Thank you. Now, I'd like to move to the next part of your report you deal with in chapter 5 of your report and where you have gone through an evaluation of the contaminants of concern. So if you can just explain what was the intention with this part of your work, as opposed to the previous section you just reviewed?

A Yes. And so in the chapter 4, we had tried to identify those substances that pose potential risk to aquatic organisms within the Fraser River basin. In this evaluation, we're trying to focus our evaluation to identify those substances that pose potential risks to sockeye salmon specifically in the Fraser River basin.

Q Okay. So everything else is falling out of the new sieve that you've got?

A Yeah. So to use our analogy of the sieve again, in this evaluation, what we do is we use less conservative assumptions for both exposures. We talked about exposure being exposure point

concentrations and we talked about effects and in the first analysis we talked about toxicity screening values. So in this evaluation, what we do is we increase the size of the pores in that sieve so that we let drop out those things that are unlikely to be risk-drivers for sockeye salmon. And the way that we do that is we apply these two separate types of assumptions that decrease the level of risk and the level of conservativism in the analysis.

So first, on the effects side, rather than looking at conservative toxicity screening values that apply to any aquatic organisms that may be occurring within the Fraser River basin, we use toxicity thresholds in this case that are specific to sockeye salmon, or if we can't find sockeye salmon toxicity thresholds, we use toxicity thresholds for salmonid fishes. So animals that are very closely related to the animals that we're most concerned about. And instead of calling these benchmarks "toxicity screening values", we call them "toxicity reference values", in this case to distinguish them from the tools that we used in chapter 4.

And then the second thing that we do is you'll recollect we used exposure point concentrations to identify what kinds of concentrations of each of the contaminants of potential concern the sockeye could be exposed to and the measure there was the maximum concentration that was measured in each of those areas of interest.

In this evaluation in chapter 5, we've used a less conservative assumption. We've used a 95th percentile concentration rather than the maximum. And so by incorporating those two changes into this evaluation, it allows us to retain on the top of that screen those substances that we believe to be the primary risk drivers relative to potential effects on sockeye salmon in the Fraser and the uncertain contaminants of concern, the things that we can't evaluate because of either limitations on data or limitations on the availability of toxicity thresholds.

MS. BAKER: All right. And if I can ask you, Mr. Lunn, to put up Table 5.18. This is T-238 and this is a similar-looking document to what we looked at

previous to the break. But if I can ask you just to review that with us. So T-238. Yeah, 518.

Q This again shows the different life stages and the different contaminants of concern. And it shows it being measured with a 95 percentile exposure point concentration?

A Yes, that's correct.

Q Okay. So what is this? And we go on to 5.19, which is the next page, and 5.20, which is the following page. What do these show?

A Yes. So in this analysis that we did for chapter 5, which is a more detailed analysis of potential risks to sockeye salmon posed by contaminants in the Fraser River basin, we've used there lines of evidence or types of data, if you like, for evaluating potential risks to sockeye. We've used surface water chemistry data. Those results are presented in Table 5.18. We've used sediment chemistry data. Those results are reported, I believe, in 5.19. And we've used fish tissue chemistry data. And those results were reported in 5.20.

So if we go back to 5.18 for a moment, what this shows is that even when we implement these less conservative assumptions about both exposure and effects, we still see a number of contaminants that come through as posing potential risks. In this case, specifically to sockeye salmon or salmonid fishes. And they include suspended sediments. It includes then also five separate metals and phenols in water. And as you can see, looking across the tables, those contaminants, at least a subset of them, are relevant for spawning and incubation period for the rearing period for smolt outmigration and during adult upstream migration. So we have potential risk posed by one or more contaminants of concern through each of the four life history stages that we've looked at in this evaluation.

Q Okay. And then 5.19?

A So in 5.19, once again we've applied these less conservative assumptions in the evaluation. We've used the same data. The underlying data are exactly the same. The difference is that we've calculated the exposure point concentration in this case again as the 95th percentile concentration of each of these contaminants and

we've applied a toxicity threshold that is less conservative than what we've used previously. And instead of using a threshold effects-like concentration, as we did in chapter 4, what we've used is a probable effects concentration or a similar type of benchmark, similar meaning the same narrative intent, same level of protection for aquatic organisms.

And what we see when we do this evaluation is that a couple of the metals, iron and nickel, come through this assessment as posing potential risk to sockeye salmon that may be exposed to these contaminated sediments. And again, we talked about it a little bit before the break and that is, this evaluation of risk posed by contaminated sediments is strongly limited by the limitations that we have on the data that went into this process and limitations associated with our understanding of how much sockeye salmon actually interact with contaminated sediments within the system. So those two uncertainties leave us in a place where we have a relatively higher level of uncertainty in the sediment assessment than we might have in perhaps some of the other assessments.

Q And 5.20, this table was actually one of the tables that was modified and it shows up in your errata sheets; is that right?

A That's correct, yes.

MS. BAKER: Okay. So Mr. Lunn, that's actually Exhibit 827. And the table has been reprinted within the errata at the very end. There it is.

Q Okay. So what were you looking at here? This is a fish tissue sampling assessment. And that wasn't done for the earlier assessments in chapter 4, right?

A That's correct.

Q So what was being done here?

A What we've done here is we've collated information available on the contaminants, bioaccumulative contaminants in fish tissues, specifically salmonid tissues. We've used sockeye and Thompson River chinook tissues in this assessment. We looked at the data before we did that analysis and convinced ourselves that the data were similar enough between the species that it would not be unreasonable to combine the data to have a more

robust dataset. And for those who are following along but didn't have the errata, what we had in the original table was units for the metals that were milligrams per gram and the correct units were micrograms per gram. So the analyses were conducted using the correct units but the table itself showed the incorrect units when we printed it the first time.

And so what this shows is that for roe particularly, we have some exceedances of the toxicity reference values for selenium. We have hazard quotients that exceed one, both at the Fraser River mouth and at the spawning grounds.

And then for the sum of 2,3,7,8 tetrachlorodibenzo-p-dioxin, toxic equivalent, that's the some symbol TEQs in that final line of that column, showed hazard quotients of greater than one for both at the Fraser River mouth and at the spawning grounds based on the data that we had available to us.

Q It identifies in the heading for this table that you have looked at contaminants of concern in Weaver and Adams sockeye and Thompson chinook salmon populations. Why did you only use those populations?

A That was the data that we were able to locate to support this analysis.

Q In your view, is there adequate fish tissue sampling being done?

A Not in my opinion, no. No, if there is a lot more data on concentrations of bioaccumulative contaminants in sockeye salmon populations in the Fraser, we weren't able to access it. And if what we had was the sum total of what was available, then I would say that is inadequate to characterize exposure and potential effects of bioaccumulative contaminants on sockeye salmon.

Q Is fish tissue sampling being done in a routine basis in any other areas of the province?

A Yes. Under a variety of different programs, there are fish tissue chemistry data being collected, for example, under pulp and paper liquid effluent rates. Each of the companies are required to collect fish for fish tissue chemical analysis. They're not sockeye salmon. They may be sculpins or there may be chum or there may be some other foreign fish species. But typically they're not

salmon specifically. So while that kind of data is being conducted for other purposes, it doesn't provide information that is explicitly relevant for doing this kind of evaluation for sockeye or for other salmon.

Q All right. But it certainly could be done for sockeye salmon or salmonid species in the Fraser River if that kind of a monitoring program was put into place?

A Yeah, there's no technical barriers to collecting this kind of information.

Q Okay. And what does fish tissue sampling tell us that we can't understand by looking at water quality sampling or sediment sampling?

A What's interesting about the fish tissue chemistry data is that it gives you a very clear idea of what the animals have accumulated in their tissues of bioaccumulative contaminants that they accumulate in their tissue over time. And so rather than when you look at concentrations of contaminants in water gives you an idea of what the potential exposure was. When you look at the concentrations of contaminants in sediments, it provides an indication of what potential exposure was.

When you actually measure the concentrations of mercury or dioxins or PCBs in the tissues of fish from the Fraser River, you know that they have been exposed to those contaminants, you know at what kind of levels they've been exposed and it provides a basis for comparison with toxicity thresholds that are explicitly developed for fish tissues. And so as a result of that it provides a basis for estimating effects as well. So for certain classes of contaminants, it's some of the most useful information that you can collect.

Q And is that information of any greater significance for migratory fish like sockeye salmon, as opposed to a more local fish?

A It's relevant for both. We certainly want to understand what's happening with resident fish species. That's very useful information they may be getting among the higher levels of exposure to these contaminants but it's also relevant to fish that are migratory as well because they can be exposed to these contaminants and pick up their body burden as they migrate downstream through the

Fraser River mainstem, as they spend some time in the Fraser River estuary, as they're feeding out in the open ocean as well when they're developing for the period of a couple of years during their open ocean residence and they can pick up additional exposure on their way upstream.

And so it's understanding what the levels are and what they are at various points of their life history provides a basis for understanding what those pathways are, what the sources are, what the pathways are, how they're picking it up, where they're picking it up and where the concerns are relative to these classes of contaminants.

Q Okay. On the contaminants that you were able to assess, which are set out in relation to this chapter and set out on the Tables 5.18, 19 and 20, what were your conclusions with respect to the impact on Fraser River sockeye?

A What we concluded was that there are certain contaminants that accumulate in the tissues of Fraser River sockeye at levels that are sufficient to pose potential risks or to cause adverse effects on those animals.

Q Okay. Now, are there any uncertainties that should be identified in the toxicity assessment that you did?

A Yes. So we went through the process of identifying sockeye salmon specific toxicity reference values to support this analysis. And for certain substances, we were able to identify toxicity thresholds that were explicitly relevant to sockeye salmon. In other cases, we identified toxicity thresholds that were relevant to salmonid fishes. As you take a step away from sockeye salmon and you look at salmonids as a whole, that increases your level of uncertainty a little bit.

In some cases, we were unable to identify salmonid specific toxicity thresholds and ended up using fish specific toxicity thresholds. PCBs would have been an example of one of those. And then for a vast majority of the substances that were on an inventory, we couldn't identify toxicity thresholds at all that related to sockeye, salmonids or fish. And so it left us with a large number of substances that carried through as uncertain, contaminants of concern, as we moved through the tail end of the chapter 5

analysis.
Q Okay. And what about the exposure assessment? Were there uncertainties that we should highlight in that?
A Yeah, we talked a little bit about the limitations on the available surface water chemistry data, the sediment chemistry data, the fish tissue chemistry data. All of these limitations affected our ability to estimate exposure point concentrations within individual areas of interest and for individual life stages within those areas of interest. And so the absence, in many cases, of data or limitations on those data creates a relatively high level of uncertainty in the results of this analysis.

So to put that another way, you'll see a number of substances that are identified as those that occur at contaminants sufficient to adversely affect sockeye salmon. It would be incorrect to assume that there are no others that are present within the system at concentrations sufficient to adversely affect one or more life stages of sockeye salmon because the data are so limited for so many contaminants and limited on a spatial and temporal basis as well for those areas where sockeye salmon actually utilize habitats within the Fraser River basin.
Q All right. Well, that sort of leads nicely into the next question I wanted to ask you. You'll remember earlier this morning we reviewed Table 8.1 which set out all the classes of contaminants and the various constituent chemicals under those contaminants and it was a very long list, going on for ten pages or so. The analysis that you did in chapters 4 and 5, which is sort of putting the contaminants through this sieve, were you able to identify with certainty all of those chemicals that show up on Table 8.1?
A No. No, the vast majority of those substances are listed in Table 8.1. We were not able to evaluate using this systematic screening or detailed type of assessment that we've described in chapters 4 and 5.
Q Okay. And that's for the reasons that you've identified some of the data gaps that you've already reviewed?
A Correct.

Q Okay. All right. So nevertheless, the analysis that you did in chapters 4 and 5 and leading up to these Tables 5.18, 5.19 and 5.20, are the contaminants that were identified in that process important contaminants for us to be aware of vis-à-vis sockeye salmon?
A I'm sorry. Could you restate that question?
Q Although Chapter 5, you were able to evaluate a more limited subset of all the potential contaminants, are those still important contaminants for us to consider with respect to Fraser River sockeye even though it's a smaller group?
A Yeah, it's a shorter list of substances. It's typically the conventionals, the metals and a few hangers-on beyond that. Those are very important contaminants. One thing I didn't mention, by the way, on data limitations that came up because I thought about metals just now, is virtually all of the monitoring data, and I won't say all, but virtually all of the monitoring data that we collect on metals right now is on total metal concentrations. And that's typically because our Canadian Water Quality Guidelines are based on total metal concentrations.

But there are other measures of metal concentrations in water or in sediments that provide a better indicator of what is biologically available. And I'm speaking specifically here in terms of dissolve concentrations of metals in water. If we wanted to do a very thorough assessment of the potential effects of metals on sockeye salmon in the Fraser River basin, that's another data limitation that we would need to address, is we would need to move from collecting these concentrations of total metals to something that is a better indicator of what is biologically available to those salmon as they're engaging in the various life history stages.
Q And right now we don't have that easily available?
A We have very, very little dissolve metal data available to us. We had some but very little and certainly not enough to do a proper characterization of what exposure was like.
Q Okay. Once you had done the evaluation of the potential contaminants of concern and then the evaluation of the ones that are set out in chapter

5, did you do some analysis to determine whether there was a relationship between productivity and water quality once you had done the analysis?

A Yes, we did. So we were left sort of with this level of dissatisfaction, having worked through this process, given all the limitations that we talked about on the data and our ability to interpret it. So what we thought we'd do is a different type of analysis that looked at really two things. One is the overall indication of water quality conditions, which we captured using a water quality index, which is a standard way of incorporating information on many contaminants. You know, we talked about, for example, the percent of contaminants that exceeded the thresholds in chapter 4. There's other indicators that you may be interested in as well, things like not just how many contaminants but how frequently individual contaminants exceed a benchmark and by what magnitude those exceedances occur.

And so the Canadian Council of Ministers of Environment have developed something called the Water Quality Index that incorporates information on all of those indicators of water quality conditions into a single metric called a Water Quality Index. And so we took all the data we had, calculated Water Quality Index values for each of the life stages and each of the areas of interest within the Fraser and then plotted those against measures of productivity of each of those life stages called Ricker residuals, which I understand this has been discussed previously in this setting.

Q So if I can ask you to turn to Figure 5.2?

MS. BAKER: And that's in this section with the footer F, not T, so it's a new section of the report, F-65? There.

Q All right. This is a table that shows what is described as an expected relationship between salmon productivity, Ricker residuals and water quality index. So can you explain what this shows?

A Yes. So we talked about the water quality index. It's an index that goes from zero to a hundred. A hundred is indicative of very good water quality; zero is indicative of poor water quality. Ricker residuals, that's on the Y axis running up like

this, and a high Ricker residual indicates that you've got relatively good productivity and a low Ricker residual indicates poor productivity. And so what you would expect to see when you plot these two variables, one against another, is if water quality, as measured, using the variables that go into the water quality index, is a primary factor influencing the productivity of sockeye salmon in the Fraser River basin, you would expect to see this type of relationship that goes from basically the origin of this graph on up to the right and to the top.

Q Okay. And then you did that analysis looking at different stocks in the system; is that right?

A Yes, that's correct.

Q So those pages follow 5.2, would be Figures 5.3 and following. I think the 5.3 is for the Fraser basin as a whole, if I'm right, and then 5.5 goes through individual stocks?

A Yes, that's correct.

Q Okay. So each figure shows a different life stage; is that right?

A Yes, so if we went to, for example, 5.3, a couple pages back, you'll see an indication of water quality index versus Ricker residuals for four different life stages here. The first graph is for the spawning areas. And the second graph is for the rearing areas. The third is for outmigration of the smolts. And the fourth graph is for upstream migration of the adults. And what this shows is when we pull together this overall figure, 5.3, and if we go maybe back up to the top, what we see is that when we look at all of the data for all of the stocks, for the whole basin, all time periods, we see a very weak but insignificant relationship between water quality index and the Ricker residuals.

So that suggests that there's very little relationship between the water quality index and productivity of sockeye salmon across the Fraser River basin when one is looking at exposure that occurs in the spawning areas. As you sort of work your way down this plot and we look at the second plot, we see sort of a weak negative relationship. Again, that doesn't lead us to believe that water quality index is a good predictor of productivity of sockeye salmon in those areas that are being

used for rearing by sockeye in the Fraser River basin. And similarly, when you look at the basin-wide data, there is again no relationship between the water quality index and the productivity of the sockeye salmon when all of the data are pulled together, temporally into one place. So now what we've tried to do is in Figure 5.4, we've split that data into pre-1990 data. Those are those solid circles that you see there. And the relationship is plotted as a solid line for the pre-1990 data. And you'll also see hollow circles. So that's the post-1990 data. And you'll see the relationship between the water quality index and the productivity is indicated by a dotted line in that case.

And so what we see in both of these cases when we break the data out temporally, what we would expect to see is we've seen the declines sort of between 1990 and present over the last 20 years, what we expected to see if water quality was, as indicated by this water quality index, is a primary factor influencing the productivity of Fraser River salmon, we would expect to see for one or more of these life stages that relationship that we saw in Figure 5.2 where we had an increase in productivity with increasing water quality index. We didn't see that here. And so when you aggregate all the data across the whole basin, you don't see that kind of relationship for the variables that go into the water quality index. Keeping in mind the calculation of this water quality index is limited by exactly the kind of limitations that we had in chapter 4 and 5. We had data for conventionals, metals, phenols, very little else beyond that.

Q All right. So there could be contaminants that you weren't able to assess that could have an impact that just would not show up at all on these plots?

A You would not see them using this tool.

Q All right. And then the next tables or figures that follow actually try and do this analysis for individual stocks, some of the stocks. And if you'd turn to 5.5, you'll see this is for the Pitt. And what we see is very little data on this particular stock?

A Correct.

Q And if you turn over to 5.6, this is Harrison. Again, very little data. So I take it one of the limitations that you had here was that the stocks you were looking at even you didn't have sufficient data on all of them?
A Correct.
Q Okay. And if we look at one that you do have a bit of data on, Weaver, which is 5.7, this shows a bit more of a relationship. Can you explain what you see, not in the early phases but in the outmigration and upstream migration phases? You have a bit more data?
A Yes. So if, for example, you look at the outmigration route data for the Weaver stock, pre-1990 data, there appears to be a relationship that would be expected, an expected relationship between water quality index and productivity, if water quality was a factor influencing the outcome, influencing the abundance of salmon in that system and that relationship is less strong for the post-1990 period.

And what I would caution us, as we look at this, is that although the relationships in both cases explain some percentage of the data, the variability in the data like up to 50 percent of the variability of the data for the pre-1990 period, that relationship is not statistically significant.

And so most of the data are between the water quality index of, say, 30 and roughly 50 so we don't really have a broad range of water quality conditions within which to evaluate there. And so sometimes you see these kinds of relationships that are somewhat spurious as a result of having limitations on the data. They're not covering as wide a range of conditions as we would like or there's just simply not enough data to develop those relationships fully.
Q All right. I'd like to move now to chapter 6 where you talk about endocrine disrupting chemicals and contaminants of emerging concern. And I just want to pick up on what you were just talking about here when we were looking at these figures, which is that there's a whole wide range of chemicals, which you were not able to evaluate based on the data available. And if we turn to page 73, this begins a listing of a series of

chemicals or contaminants that you were not able to evaluate. They begin on page 73 of your report.
A Yes.
Q And then they follow through all of page 74 and over onto page 75. That's a pretty long list.
A Yeah, and keeping in mind that these are typically classes of contaminants here and what is in brackets are typically some examples of the kinds of contaminants. This is not going to be a comprehensive list of all the things that we couldn't evaluate but it gives you a pretty good idea that there is a very long list of substances that we couldn't evaluate using either the screening level ecological risk assessment type approach or the detailed ecological risk assessment type approach, which is what we tried to apply in chapters 4 and 5, respectively.
Q Endocrine disrupting chemicals have a specific discussion in your paper. And I just wondered if you could explain for the Commissioner what those chemicals are?
A Yeah. So they are a group of contaminants that influence either the production or the release or the metabolism or the binding or the elimination of hormones in an organism. And hormones are the chemical messengers that we use within the body to do such things as maintain homeostasis, to regulate reproduction, regulate the immune system, those kinds of things. So the endocrine system is extremely important in terms of the function that it plays for organisms and these chemicals, the endocrine disruptors are those substances that either mimic or in some other way adversely affect the functioning of those hormones in the body.
Q And when we look at Fraser River sockeye specifically, what are the concerns of these types of chemicals vis-à-vis sockeye?
A So the kinds of effects that we've seen in fish previously are things like altered reproduction in fish that have been exposed to these endocrine disruptors. We see things, particularly adverse effects on the immune system. We see changes in thyroid function. Thyroid regulates metabolism in fish. So we've seen those kinds of effects. And there's a lot of different sort of twists on reproductive effects, be they changes in the

organisms' ability to produce eggs. Or, in some cases, you see changes in the gender, in the apparent gender of the fish so that the male fish exhibit characteristics of female fish. They have things like vitellogenin in their tissues, elevated levels of that, which is an indicator of what you would expect to see in female fish when they're getting ready to produce eggs. And you see gonads that look very much female-like. And so this kind of gender-bending is something that is typically associated with these endocrine disruptors.

Q And they are bioaccumulating as well?

A At least some of the contaminants that are known to be endocrine disruptors also bioaccumulate. And that may be part of the way that they are exerting their action.

Q All right. And what is the significance of a bioaccumulating chemical?

A Maybe if you ask me that question in a slightly different way?

Q Please answer it.

A So a bioaccumulating contaminant is one that is present in the environment at often times very low levels in water or in sediment. And what happens is that through the process of either uptake directly from water or ingestion of prey items that accumulate these substances in their tissues, these bioaccumulating contaminants become present in predators like salmon at elevated levels in their tissues.

And they frequently become elevated depending on where you're looking, you know, what areas of North America you're looking at or elsewhere in the world, they can become elevated to levels that adversely affect their use by humans or by aquatic dependent wildlife, things like osprey that tend to eat salmon or other fish species, can be adversely affected by exposure to bioaccumulative contaminants in fish tissues.

But also they can accumulate to levels that are sufficient to adversely affect those fish themselves. So those are sort of the three types of bioaccumulation that were types of effects that we're concerned about when we think about bioaccumulative contaminants.

Q All right. And what are the pathways by which

these chemicals may enter sockeye? You mentioned those two, water and prey. Are there other pathways that we should be aware of?

A Yeah. So water and prey are probably the two most important pathways. We can't categorically rule out direct exposure to sediment. I think it's a minor pathway because of where the salmon are incubating and where they're typically rearing in the nursery lakes and they're utilizing primarily planktonic organisms as their prey species. So I think that's a minor pathway. So very likely direct exposure to water and ingestion of contaminated food represent the two primary exposure pathways for most bioaccumulative contaminants.

Q And has there been sufficient research directed to understanding fates and pathways of these chemicals?

A There has been some research done that helps us to understand sources and releases and importantly how these contaminants are transported within aquatic systems once they're released and then how they're transformed, what their fate is, you know, how they -- how they either become associated with the water column or how they become associated with sediments or how they become associated with biological tissues that can then be consumed and get this biomagnifications effect up the food web.

So that kind of information exists for a subset of these contaminants that are on this long list that starts on page 73. And it exists for a subset of the organisms that we care about in the receiving water environment. I would say for most of these contaminants, though, the information needed to fully understand what the exposure pathways are and what the fate are for salmonids specifically are not well-studied. And if they are, I haven't seen that information.

Q What are the point sources of these kinds of contaminants that are the biggest concern vis-à-vis Fraser River sockeye on the Fraser system?

A So I've identified two types of lists here. One goes under the umbrella and endocrine disruptors and the other is contaminants of emerging concern. And this list starting at page 73 covers both of those groups of contaminants. Let's start with the endocrine disruptors first. The key sources

of those in the Fraser are going to be things like the wastewater treatment plants, municipal wastewater treatment plants, industrial wastewater outfalls as well. Pulp and paper mills are known to contain a variety of different endocrine disrupting compounds. But also other industrial sources represent potential discharges to the environment of these kinds of things. Wood preservation facilities. Landfills are contaminated sites.

So some of these endocrine disruptors are legacy contaminants that we've had around for a long period of time, things like PCBs, dioxins, et cetera. So contaminated sites and landfills become potential sources as well. And then atmospheric sources. For some of these substances, their fate in the environment is such that they can be released into the environment in the more southern latitudes in the United States for example and over periods of evaporation and condensation through summer and winter periods, these contaminants can move northward as well and things like PCBs and toxaphene and various organochlorine pesticides fall within those groups where atmospheric sources are also potentially important.

Q And atmospheric sources, you've mentioned the U.S. but they could be other places in the world as well that contribute?

A Absolutely, yes. Other places, for example, where PCBs were not banned until many years subsequent to when they were banned in North America.

Q Where on the Fraser system is the majority of the volume of effluent from municipal sewage treatment released?

A That'd be the lower Fraser River and estuary.

Q Does that concentration then of that high volume of effluent have any particular impact on Fraser River salmon in general or particular stocks? Like is there some spatial relationship between the volume of release of municipal sewage treatment?

A That's an excellent question.

Q Are you able to answer it with the data you have available to you?

A I cannot answer that explicitly with the data I have available to me. What I do know is that

there may be some differential exposure among stocks but in terms of actually characterizing what that exposure is for any individual stocks or even for the Fraser River salmon as a complex, I don't believe we're in a position to be able to do that for most of the substances that are on our list here of endocrine disruptors.

Q Okay. And where are the majority of the pulp effluents released?

A They're released in a variety of locations within the basin so we have some discharges in the vicinity of Prince George and Kamloops but also discharges in the lower Fraser River. Some in mid Fraser River around Williams Lake as well. So those are the main areas. So it's primarily in the migration routes of salmon is where the pulp mill effluents are primarily...

Q And is the spatial relationship between those releases and salmon in different life cycles or particular stocks of the Fraser River sockeye? I take it you have the same answer that you had for municipal sewage effluent?

A That's correct. We know that there is going to be some exposure. We know that all the stocks migrate through the estuary and through the lower Fraser and then some of them get differential exposure as they move upstream but that's largely theoretical rather than being able to characterize exactly what those exposures are for individual stocks right now.

Q We've talked a lot now about the endocrine disrupting chemicals but in this chapter you also talk about contaminants of emerging concern. And so first of all, are those two separate concepts or would endocrine disrupting chemicals also be considered a chemical of emerging concern?

A They can, yes. So there can be overlap between those two lists for sure.

Q And how do you define or describe contaminants of emerging concern in your report?

A Well, that's always a good question about how to define that. There's a variety of different definitions that are out there. I believe I have a definition on one of these pages.

Q Maybe 105 at the bottom?

A Thank you for knowing that. Yeah, 106. I was unable to find a Canadian-based definition and so

I ended up taking this particular definition from one that had been produced by the Commonwealth of Massachusetts. And so this is going to be largely consistent with other definitions that have been used either in the Economic Union or other states in the United States. But essentially it included these substances are ones that represented a perceived threat to human health, public safety or the environment.

There are no health standards or guidelines available for them. There's typically insufficient or very limited toxicological data available for evaluating the effects of these substances and their pathways or sources are relatively new. There's been some development in analytical chemistry that allows us to understand better what their levels might be in the environment than was possible previously. If we lower detection limits in the lab that sometimes identifies emerging problems that we were unable to identify previously when detection limits were much higher than what the levels were in the environment.

Q So the idea of it being emerging doesn't necessarily mean it's a chemical that we've just had introduced into the environment in the last year; they could be chemicals we've known about for a long time but we don't have sufficient information, as you've identified to assess them?

A Correct.

Q Okay. And with that bigger basket of not just endocrine disruptors but all of these contaminants of emerging concerns, what are the sources of contaminants in the Fraser watershed?

A They have a lot of common sources. So the municipal wastewater treatment plans, the industrial discharges, but in addition to that for some of the emerging contaminants we include on that list things like feedlots for antibiotics that are used in agriculture. That becomes a potential source. Atmospheric sources, we talked about those as well. Wood preservation facilities. Some of the things that have been identified as emerging contaminants also are present in things like antifouling paints.

It's not that contaminants like tributyltin or DDTs are emerging contaminants but that in the

case of DDTs we may not have known that they were used in fowling paint in other parts of the world. And those DDTs then find their way into sediments here in North America as a result of shipping traffic that has come from other parts of the world. And likewise, TBT or tributyltin, is one of those components of antifouling paints that we're starting to understand its effects better. But just starting to understand its effects better such that we're able to identify what harmful levels are in the environment. And so that's why some of these other things are on the list of contaminants of emerging concern.

Q On the list of chemicals, the emerging concerns that you've set out on pages 106 to 107, the drugs descriptor there, "drugs including prescription drugs and non-prescriptions drugs and sex and steroidal hormones", are those primarily found in municipal waste sewage treatment effluent?

A Yes, that's correct.

Q You looked at pesticides in this analysis, I take it?

A Yes, I did.

Q Okay. What data was available to you to locate pesticide use to particular geographic areas in the province?

A We relied upon a pesticide sales and use survey that was completed in 2001 by Encon Environmental and that was summarized in a variety of other places. I think we cited a publication by the name of Verrin *et al*, 2003, as our primary source of that information.

Q But the sales and survey data, I take it, simply describes that, sales that were made of pesticides. It doesn't locate the pesticide use to any geographic area in the province; is that right?

A That's my understanding, yes.

Q And the other piece of data that you described, Verrin or something *et al*?

A They're related. Same information.

Q So that also wouldn't help us determine where in the province pesticides were being applied?

A Correct.

Q Or the volume or concentrations?

A Without taking multiple pieces of information and bringing them together, for example, the pesticide

sales information would provide a broad perspective on creosote sales within the province and one could then look at the locations of wood preservation facilities and infer where you might see releases of creosote. In terms of getting numbers for individual facilities, no, you don't get that.

Q It's not available, is it?

A It's not available. Let me put it another way. If it's available, I was unable to find it.

Q Okay. And even on the example that you gave, the creosote example, you wouldn't know what concentrations or what time of year or what life stages of salmon were passing through areas that could have that kind of contaminant being released; is that right?

A That's correct.

Q Okay. And certainly, for agricultural pesticides, none of that would be tracked in a way that would help us know exactly where they were applied or in what concentrations?

A Yes, that's correct, with the *caveat* that there have been limited number of very specific area pesticide use surveys done in various portions of the province. For the Okanagan, for example, we did one back in 1994 or something like that.

Q Your company privately, not privately, but your company did that as a project?

A Correct, yes.

Q There's not a government database that holds that information?

A I'm not aware of a source that would provide that kind of information, no.

MS. BAKER: All right. Mr. Commissioner, I do have more questions for this witness so we may want to break now.

THE COMMISSIONER: All right. Thank you.

THE REGISTRAR: The hearing will now adjourn until 2:00 p.m.

(PROCEEDINGS ADJOURNED FOR NOON RECESS)
(PROCEEDINGS RECONVENED)

THE REGISTRAR: The hearing is now resumed.

MS. BAKER: Thank you.

EXAMINATION IN CHIEF BY MS. BAKER, continuing:

Q Now, Mr. MacDonald, just before the break, we were talking about pesticides and the ability for you to understand where pesticides were applied geographically in the province through the data that's currently available and you indicated that there was no way right now to understand where the geographic location of pesticide application or the concentration or timing of pesticide application. Would that information be important to have to properly assess pesticide impacts in the province and on the Fraser watershed?

A Yes.

Q Why?

A Well, let me answer that with an example. Typically, what has been done historically with pesticides is that legacy pesticides like the DDTs and the chlordanes and the endrins and the aldrins, those are the ones that are incorporated into monitoring programs either of sediments or fish tissues. What's been missing has been information on in-use pesticides. And just to sort of illustrate the importance of in-use pesticides, I'm involved right now in a study with the USGS, the U.S. Geological Survey. And the study involves collecting sediments in small streams around major urban centres throughout the United States, so Dallas, Seattle, a variety of other places throughout the U.S.

And the study was designed to look at a broad suite of contaminants, metals, pHs, PCBs, a variety of legacy pesticides but it also included a number of in-use pesticides, things like pyrethroid pesticides, which are things that are now broadly used but are not broadly measured. And what's interesting about this study is we looked at toxicity to a suite of sediment dwelling organisms, midge, little non-biting flies, amphipods which are little crustaceans and freshwater mussels, which are bivalves. And when we look at the exposure information and the effects data together, the metric that provided the best basis for understanding toxicity was pyrethroid levels in the sediments, bifrenthin specifically.

And so it's clear that across certain places

that we're looking at right now, these in-use pesticides are important. And some of these ones that we've never paid attention to before are so important that they are actually driving toxicity to some of the organisms that are out there being exposed to it. So that's why it makes it so important to have this kind of information for the Fraser River basin as well.

Q Now, another industry that you've mentioned in your report is pulp and paper. We've talked about that a bit already today. Do you have sufficient surface water and sediment chemistry data to assess contaminants associated with pulp and paper?

A No.

Q And is the kind of data that you would require difficult to collect?

A I would have liked to have had that information to support this assessment, yes.

Q All right. Is that kind of data being collected right now in the pulp and paper industry that you're aware of?

A No, the suite of contaminants that are typically being measured either in effluent or in the receiving water system is a fairly narrow range of contaminants and doesn't really reflect all of the kinds of contaminants or even a large subset of the kinds of contaminants that we identified as being associated with those types of effluents.

Q And is there any technical obstacles to the collection of the kinds of data on the contaminants you're talking about that aren't being collected now?

A No.

Q No?

A Not that I'm aware of.

Q Same question for wood preservation facilities. Is there sufficient surface water and sediment chemistry data to assess contaminants associated with wood preservation facilities?

A I don't believe so. We were unable to locate it.

Q And again, is there any technical obstacle to the collection of data from those facilities?

A No.

Q What data is available to understand concentration of surfactants and fire retardants in the Fraser watershed?

A As far as I know there's very little data available right now. Surfactants is a general term for this group of contaminants that are like alkylphenols that are used as emulsifiers or they're used to change the surface tension of liquids essentially so they allow you to mix two types of liquids more efficiently or they're used as dispersants in certain types of spill situations.

And then the fire retardants you're talking about are things like the PBDEs, the polybrominated diphenyl ethers that have characteristics very much like PCBs, the legacy contaminants. And what we know about certain things like they use these classes of contaminants that the concentrations have been increasing rapidly in receiving water systems around the world. But there is evidence also from B.C. that suggests that things like the PBDE concentrations have increased dramatically over the last ten years. And the quick answer is there's very little information, though, with which to evaluate the concentrations or potential effects of those contaminants in the Fraser River basin.

Q And is it possible to collect that data?

A Yes.

Q Okay. And what data right now is available to understand concentrations of some of the hormone drugs that we've talked about already today, hormone levels of pharmaceuticals, personal care products, disinfectants and their by products and nanoparticles? What do we know about that right now?

A I was unable to locate data on any of those classes of contaminants for the Fraser River basin. I know that there's a pilot study ongoing in Victoria by the CRD but I was unable to locate that type of information for the Fraser River basin.

Q Okay. And what are nanoparticles?

A Nanoparticles are basically very small particles that have specific properties and they're less than a hundred nanometres in size so that makes them very small. And they are used in a variety of applications, some of them in biotechnology so they can be used to deliver, for example, antibiotics or chemotherapeutics to specific sites

in a body but they're also used in a number of industrial applications as well.

Q All right. And could that data be collected?

A Oh, yes.

Q So we've reviewed now a lot of contaminants that you were not able to assess. How significant to Fraser River sockeye are those contaminants that you were not able to assess?

A Well, because we were unable to assess them it's hard to say how important they were. What I can tell us that things like the volume of discharges from wastewater treatment plants have increased in the last 20 years. Human populations have increased at the Fraser River basin. It's not surprising then that we've had increases in the volumes of those discharges and many of the contaminants we've been talking about are associated with discharges from wastewater treatment plants or from other types of industrial activities. So I think it's important from the standpoint that we think the concentrations are increasing yet we haven't had the data to evaluate them. So quick answer is I don't know what the answer is but I'm concerned enough that I think it should be on our list of things that we should be looking at very carefully.

Q All right. You've referred to periodically in your report total suspended sediments or solids. Are those monitored right now by any branch of government?

A Yes, it's total suspended solids, which is an indication of the level of suspended settlements in receiving water systems. Typically included in most of the major monitoring programs that are being conducted either at the federal sites or the provincial sites around the province and they're typically measured also in effluent. What's missing for me is measuring TSS concentrations, total suspended solids concentrations, in the vicinity of where the sockeye are actually spawning. So the concern is that you might have, for example, as a result of increased forest management activities associated with, for example, pine beetle, salvage logging, those kinds of things.

You may have large areas of the landscape that are deforested. As we get precipitation in

those areas, we'd have erosion. That erosion leads to the release of these fine sediments into the receiving water system and that can either be carried along in the flow in which case they get into the gills of fish and can cause toxicity, or they can be deposited in the stream substrate where the eggs are. And when that happens, it creates a layer on the bottom and that can suffocate the eggs if they're not getting the flow and the oxygen to them. So even very conventional contaminants that are typically measured in these kinds of programs are very important, particularly if we measure them in the right places where the fish are likely to be exposed to. And that's right where they're spawning and incubating.

Q And you might have already answered this question when we were talking about some of the earlier tables but are contaminated sediments monitored right now in the province?

A Yes, they are.

Q In what locations?

A There are a number of monitoring locations throughout the province. In our report, we've identified a number of locations in particularly the lower Fraser River area of interest plus a few places in other locations. And they're being monitored, I believe, by various interests. And so we were able to access data that were readily available from the EMS system that we talked about earlier. I believe that the data on the concentrations of contaminants in sediments are also being included as part of the pulp mill monitoring programs, for example, the municipal wastewater monitoring programs.

But the challenge that I see in having this kind of data generated in multiple, somewhat disparate monitoring programs, is that it's hard to bring it together and develop sort of a comprehensive picture of what sediment contamination looks like across the Fraser River basin. Some of the data is readily available like the EMS data. Much of the data is not readily available and that represents a problem.

Q All right. And you had talked earlier about contaminated sediment and whether it was an issue for spawning sockeye. So I think I'll move on but I'll ask you if contaminated sediment is an issue

for sockeye rearing habitats.
A Yeah. Most sockeye salmon are using nursery lakes and so they're up in the water column and they're feeding on plankton. And so they're not getting very much exposure to those contaminated sediments apart from what might be bioaccumulating in the food web that way. But certain stocks, and Harrison is one of them, utilize habitats within the lower Fraser River and estuary during their relatively brief compared to other sockeye stocks. They're rearing in these backwater areas in the lower Fraser. Those are the places where they're feeding on amphipods and other invertebrates that are associated with these finer sediments, the soft-bottom sediments. And that's where they can potentially get exposure to the contaminants that are associated with those sediments.
Q All right. And are there effluent discharges into any of the rearing lakes in the province?
A As far as I know, that occurs in only a few situations. And by that, we mean either major industrial or municipal discharges. And so there would be only a few examples of those in the province.
Q Do you know which ones they would be?
A I believe that Endako Mines has a discharge into Fraser Lake. And there are some discharges upstream of Kamloops Lake as well and to what extent the sockeye are using that water body, I'm not entirely sure, but if they are, there would be some interaction with those discharges as well, both pulp mill and municipal wastewater.
Q All right. Now, did you look at the interactive effects of temperature, disease and contaminants?
A I did not.
Q And has any work been done by others in that area?
A I'm not aware of a specific work that has looked at all three of those elements. There's been a variety of studies that have been done on the interactive effects of temperature and the pathogens in salmon. There's been studies that look at contaminants in pathogens in salmon. As well, some of the studies that have been done by the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration. But if there's studies that have been done where we look at the interactive effects of

contaminants, temperature and pathogens, I'm not aware of those.

Q And are those interactions significant in any way? Should there be work done on that area?

A I believe so. I've looked at a series of studies that have been done by others around North America and what it shows is that there are strong interactions between contaminant uptake in juvenile salmon, specifically chinook salmon is what has been looked at in the past, and their ability to acclimate to saltwater and their disease resistance.

So when you look at those two factors together and you see that contaminant exposure impacts potentially immunocompetence and you know that there is also an interactive effect between temperature and pathogens, as was indicated in some of Scott Hinch's work, which I believe we've already heard from, that it's logical to look at the three of those factors together and determine if the potential effects are even greater than what we might expect looking at either of those two individually.

Q When you completed your analysis of the contaminants of emerging concern and the endocrine disrupting chemicals, did you form an opinion on whether the presence of those contaminants was explanatory of the declines in Fraser River sockeye over the last 20 years or in 2009 in particular?

A I did.

Q Describe the assessment that you did and how you arrived at your conclusion.

A So what I did was I looked at sources and releases of these kinds of contaminants. I looked at potential effects of these contaminants on sockeye salmon, salmon in general, fish in general, integrated that information using something we call an eco-epidemiological approach. And I apologize for those who have to type that in the machine in advance. And what that approach does is it looks at five different characteristics of causality, things that you would expect to see if there was a causative relationship between the concentrations of contaminants in the watershed and the declines of sockeye salmon that we've seen. These are over the last 20 years or, more

specifically, in 2009 where we had the very little returns relative to expectations.

Q Okay. And what was your conclusion?

A My conclusion was that it's unlikely that contaminants was the primary factor causing either the decline in sockeye salmon in 2009 or the declines that we've seen over the last 20 years. But I also concluded that there was a strong possibility that contaminant exposures was a contributing factor in those declines over the last 20 years.

Q When looking at the impacts of pollution on Fraser River sockeye in relation to the 2009 decline, in particular, would it be appropriate to restrict your analysis as to whether there had been a Fraser basin-wide environmental incident that could have impacted the fish in that year?

A In my opinion, that would not have been the way to do it.

Q Why not?

A It is premised on the assumption that there would need to be a very large, for example, spill or some other effect that would be very obvious and well recorded in the literature for there to have been an effective contaminants on sockeye. Well, that assumption, I believe, is true. I think we have all the necessary and sufficient conditions to have contaminants represent a significant contributor to adverse affects without this sort of large almost apocalyptic effect that you just described.

Q In your report on pages 140 and 141, you set out a number of recommendations. They breakdown generally into some recommendations on monitoring, recommendations about coordination of information-gathering and then some recommendations on research. The monitoring recommendations are very clearly set out and I don't want to go through them one-by-one with you but I'll just ask you if there's anything you'd like to highlight today in the monitoring recommendations?

A Yes, there is, if that's okay. We identified what data were available and most of these monitoring recommendations lay out what we would need to do to provide or to generate the kind of information that was missing to support this type of evaluation so it lays the where and the when and

the what to look at, I think, reasonably clearly. What might be easy to skip over in these recommendation is something that is imbedded in one of them that calls for the design of accumulative effects monitoring program.

Sometimes when we look at these kinds of problems that emerge in the environment, we're looking for that one thing that explains all the effects that occur where, in fact, it's more the concept of the thousand cuts that is creating the problem. And so the design of a cumulative effects monitoring program allows us to, one, look at all of the activities that are ongoing within the Fraser River basin, identify the types of changes in the characteristics of the ecosystem that are associated with each of those types of activities and collectively with those activities to develop some predictions about what the cumulative effects of all of these activities might be, and then allows one to then do some very structured or focused monitoring that allows us to, one, determine what the characteristics are, the physical and chemical characteristics of the receiving water system so that we could evaluate exposure and effects but also importantly it allows us to evaluate the responses of the organisms that we're most concerned about, in this case, sockeye salmon.

So we want to be able to make some hypotheses about what cumulative effects might be and then be able to design a sampling and monitoring program that actually is targeted on what those effects might be so that we're measuring the right things in the right places to be able to draw conclusions about what are the things that are actually affecting the declines of sockeye salmon that we've seen over the last 20 years and be able to hopefully understand whether creating these fairly atypical returns like we've had in 2009 that are difficult to explain right now with the data that we have available to us.

Q And you also suggest at your Table 8.1, which is the table we went to this morning, setting out all the different classes of contaminants and then the individual contaminants within each class is something that could be used. Can you explain how that would be used?

A Yeah, what we've tried to do in our evaluation is to look at land uses in such a way that it enables us to, on an area-of-interest-by-area-of-interest basis, identify the classes of contaminants that are most likely to be released into receiving water bodies within that area of interest. And so by looking, for example, at the Pitt River system and going down this list, it would help us, using this Table 8.1 as a guide, it would allows us to focus monitoring activities on those things that really are being released into the Pitt River so that we're not spending a lot of resources, collecting information that is unlikely to be useful as we're trying to explain interactions between the characteristics of the environment and the responses of the sockeye that are utilizing those habitats.

Q Thank you. On page 141, the top recommendation that you make is -- top in the sense of being the first bullet on the page:

> Coordination among government agencies and regulated interests should be improved to ensure the requisite data are being collected and are compiled into a single database or multiple databases that are compatible.

Can you explain what were the concerns, where that concern came from that allowed this recommendation and just explain a bit more about what you're thinking of?

A Yeah, so as we've been trying to collect and collate this information to support this analysis, what has become apparent, certainly was apparent in the past but it's certainly no different now, is that there are a number of organizations throughout the province collecting different types of data for different types of purposes and that data is frequently held in various locations that are not all readily available.

And it would be very helpful to be able to coordinate and it would be cost effective as well to coordinate the collection and collation of that type of information into a single database or at least databases that are readily available and that can talk to one another very easily so it doesn't require a lot of data translation steps.

Having this kind of coordination would allow everybody to have better access to data that can be used in a variety of different ways.

For this type of evaluation like we're doing here but also for the other types of evaluations that we know monitoring data is required for. If it's in one place or it's readily available, it can be used for multiple purposes.

Q And this would be agencies that would include the federal government and the province?

A And First Nations.

Q First Nations and municipalities and --

A Absolutely.

Q -- any other agencies that you can think of?

A Yeah, it's basically all the regulated interests as well. Whoever's out there collecting data that's required to collect data as part of their permitting process, all of this should come to one central repository that is compiled comprehensively.

Q Today you've talked about the EMS database. Is that not sufficient?

A We love the EMS database. We think it's a great tool. And what would make it a better tool is if we were able to compile data from other sources in there. And if it became a comprehensive repository for this kind of information, then its value would be even greater than what it is today.

Q Okay. And then my last questions relate to research. What, in your view, are the key data gaps which need to be addressed?

A So there's a number of things that are sort of high on my list. One is evaluating the toxicity of these endocrine disruptors and these contaminants of emerging concern to salmon. We've got some data for other ecosystem receptors but very little data on salmon *per se* for a lot of the chemicals that are on that list. We talked moments ago about interactive effects of contaminants and disease agents and water temperatures. For me, this seems to me to be a very, very important area of investigation because this effect of contaminants and water temperature and disease agent is potentially very important for the fish as they're out-migrating out of the Fraser River and transitioning to their life in the saltwater system.

But it's also potentially very important as they're returning adults, particularly in light of some of the changes that we're seeing in water temperatures in August and early September in the Fraser. So that's critically important. I talked a little bit about the cumulative effects monitoring program that I think is very important to move forward with in the near future. And then one of the last recommendations I had was to do a survey of disease agents upstream and downstream of fish processing facilities in the Fraser to see if there's any potential for that being a contributing factor to this sort of interaction between the water temperatures and the disease incidents that Scott Hinch has described in his work.

MS. BAKER: Thank you, Mr. Commissioner. Those are my questions. The next questioner will be Canada with Mr. East.

MR. EAST: Mr. Commissioner, Mark East for the Government of Canada.

CROSS-EXAMINATION BY MR. EAST:

Q Mr. MacDonald, I suppose if we were going to write an abstract for your paper, your report, and following upon some of the groundwork laid by Ms. Baker, I suppose you would say that your report had been able to demonstrate that we haven't had that kind of catastrophic event that happened in 2009 that you see perhaps more recently in the press about Goldstream River, for example, with chum salmon or the notorious incident with respect to Cheakamus River a couple of years ago. You didn't find any evidence of that kind of catastrophic event that would have demonstrated a high and obvious fish kill in 2009?

A I was not aware of any event like that that occurred, that's correct.

Q Okay. And so when we're looking at the issue of contaminants, I think, gleaning from your report I would suggest there's perhaps three themes and I'll put these to you as questions. And I think they've all been covered to some extent already. First of all, to comprehensively answer the questions relating to the role that contaminants have played in the decline of Fraser River sockeye

salmon, more data is required, more specific tools are required in the form of standards and guidelines and more research and analysis needs to be done on the issues of contaminants affecting Fraser River sockeye salmon. Would you agree that that's a major theme of your report?

A Yes, I would.

Q And as you've dedicated an entire chapter to it, chapter 6, this is particularly the case for the class of endocrine disrupting chemicals and also overlapping with these contaminants of emerging concern. That's another major theme, the need to do more work in these areas. That would be a second theme in your report?

A That's correct.

Q And finally, and I think this is something I want to explore a bit more with you, and you've just discussed this now so maybe I'll just provide some examples to you in the time that I have.

MR. EAST: And sorry, Mr. Commissioner, I think that I will certainly be done prior to four o'clock today.

Q When considering the role the contaminants may have played in the decline of sockeye salmon, it's important to look beyond the effects of the toxicity of contaminants to lead to issues of lethality, fish kills, reproduction and growth. But look at the factors that may tend to weaken the salmon to make them more vulnerable to other environmental or human cause factors in the environment. Would you agree with that?

A Not exactly in the way that you characterized it but I would agree. So I'll characterize it in my own way. So I wouldn't look at sublethal effects in exclusion of the potential for lethal effects. And I'm thinking about things like suspended solids and deposited sediment in spawning beds. Those are factors that can cause a very clear toxicity to salmon and they're very important in determining their egg-to-fry survival rates and things like that. But in addition, and here's where I will agree, looking at the sublethal effects of these contaminants on salmon I think is critically important.

It's clear that there are whole classes of contaminants that we've never looked at sufficiently in the past. And many of these act

through mechanisms like changes in reproduction, changes in immunocompetence that you cannot evaluate using sort of the classical toxicity test mechanisms that we've used throughout the '60s, '70s, '80s and '90s to look at the effects of these contaminants. So that's a longwinded way of saying, yes, I agree.

Q No, and that's a crucial point and I'm probably going to jump around or return to these three themes. And maybe what I'll do now is jump ahead in my own notes to present a paper that I think you're familiar with and you refer to it in your report and that's by Johannessen and Ross and that's Tab 4 of Canada's list of documents. I think maybe this is a good example perhaps of what we're just talking about here. Now, this paper, you've referred to it a number of times so you're familiar with it?

A Yes, indeed.

Q And just for the record, it's a 2002 report by Drs. Johannessen and Ross. It's called "Late-Run Sockeye at Risk: An Overview of Environmental Contaminants in Fraser River Salmon Habitat". And perhaps for the record I'll just maybe go to the abstract, which is page Roman numeral 8. And the purpose I want to bring this to your attention again, Mr. MacDonald, is just to use this as an example to demonstrate the potential importance of examining sublethal effects of these contaminants. First of all, in the abstract, I just want to put this into context and this is what the paper was looking at, if you look starting on the top line.

> Fraser River sockeye salmon utilize some of the most populated and industrialized regions of British Columbia during sensitive life stages --

And this is another theme that I might want to come back to.

> -- (e.g. spawning, egg hatching, larval development and migrations between fresh and saltwater).

Now, just stopping there. Sockeye salmon and salmonids, in particular, would you agree that

they are a particularly sensitive species because of the nature of their life cycle in comparison to perhaps other aquatic species, for example, resident species?

A Yeah, I'll answer this question by saying when we develop environmental quality guidelines for individual contaminants, what we find is that salmonids are generally the most sensitive species to the contaminants that we're looking at. You added something about by virtue of their life cycle but they are inherently more sensitive to most contaminants than are other aquatic organisms. And that's important to keep in mind as well. But then also you added, by virtue of their life history, and that's also true because they utilize so many different habitats throughout their life history and each one of those habitats has a potential to be adversely affected by discharges of contaminants or other anthropogenic factors that influence their survival during those critical time periods. So yes.

Q So one such example would be for anadromous fish that critical and very vulnerable period in their lives when they convert from fresh to saltwater or back from salt to freshwater. That would be an example of one of those kind of very vulnerable life stages?

A Yes.

Q And this is perhaps more general than just sockeye salmon but I think it's a truism for many species that the early developmental stages in the life cycle of any species but particularly for salmon are times where particular care and attention needs to be paid to sensitivities during those very early developmental stages?

A Yes, that's correct.

Q Continuing on with the abstract.

> During the period from 1994 to 2001, pre-spawning mortality of adults associated with the change in migration timing increased from 10 percent to over 90 percent among Late-Run stocks of the Fraser River sockeye.

And I think this is something that we've certainly been discussing in the context of this inquiry. I'll skip over the next line that talks about the

value of this lost harvest. Go to the next line:

> A contaminated-associated impact represents one of several possible contributing factors touted in the sudden appearance of this mysterious phenomenon.

So the purpose of this article, as I understand it, is examine that perhaps contaminants in the ecosystem are one of the reasons why these Late-Run stocks would experience such high pre-spawn mortality. Is that your understanding?

A Yes.

Q And perhaps I can just go to the page 1 introduction.

MR. EAST: This is page 13 on the ringtail.

MR. LUNN: Thank you.

MR. EAST:

Q And here again it talks about, and this is called "The Problem". And this is the phenomenon where sockeye in certain Late-Run stocks traditionally would mill about back and forth in the Georgia Strait and the Fraser River estuary for six weeks before moving up into the Fraser River. And then the next line:

> This milling period began to decrease significantly in 1995, and, concurrent with the early entry, the sockeye exhibited unusually high pre-spawning mortality.

And it talks about in the next line:

> The trend increased to the point where the milling period in 2000 and 2001 had decreased to a few days and the pre-spawning mortality had increased to more than 90 percent.

Do you understand that this is still a concern with respect to certain Late-Run sockeye stocks?

A That's my understanding.

Q And then the next paragraph:

> There is evidence that the actual mortality is caused by an infection of myxosporean parasite in kidneys of affected sockeye individuals. However, it is believed that

the infection would not progress to a lethal level prior to spawning if the sockeye were not heading upstream earlier in the season.

So in other words, this is a naturally-causing parasite that normally would not have had this impact on the salmon if they had not entered this stream so early on. Am I understanding that correctly?

A I believe that's what the words say here, yes.

Q So this is an example, and maybe going to the next page where he talks about the focus of the report:

> We hypothesize that if a contaminant is to have caused this change in behaviour it must have increased in use sometime in the last ten years.

And this is the temporal correlation and that's kind of a similar approach that you've taken in your report to try to correlate time periods of water quality plus with the evidence of decline. And here, and I think this is crucial. This is what I really wanted to focus on. Under "Known Contaminant Effects of Fish":

> The object of this study is not to identify contaminants that might be killing sockeye salmon.

We're not looking at evidence of direct lethality to the salmon.

> The goal is to identify contaminants that could alter the normal return migration timing pattern through sublethal effects. The following are recognised sublethal effects of some contaminants which could result in the observed behaviour change.

So here's an example, and I'll get into it in a second, where the report is not looking at what actually necessarily killed the salmon or affected their reproduction and growth but which alter their behaviour in order to make them more susceptible to other factors. This is kind of an example of what we just talked about; is that

right?
A Yes, that's correct.
Q Okay. So I just want to give some examples and perhaps discuss some of them with you. Neurotoxicity in the next paragraph. And if you look at it, where it says:

> Genetically-programmed behaviour, such as migration timing, is triggered by external stimulate which involves the brain and nervous system. For this reason, a neurotoxic effect is perhaps the most likely scenario for a possible contaminant-related basis for the observed change in sockeye behaviour.

Would you agree with that statement? Was that something that you would consider to be a likely sublethal effect of contaminants?
A I think that's a reasonable hypothesis.
Q It's a reasonable hypothesis. And over on the next page, 1.3.2. And this is something that I was just curious as to whether you're aware of this work.

> Chemical imprinting has been shown to attract fish toward a spawning stream, suggesting that olfaction --

- the sense of smell as I understand it -

> -- is connected to migratory behaviour.

Are you familiar with some of the work that exists to study the connection between the ability to smell and the ability to find the natal streams of sockeye salmon?
A Yes, certainly.
Q And I think 1.3.3, endocrine disruption, you've discussed to some extent, "effects such as feminization, masculinisation", those kind of issues are things that we've already talked about. 1.3.4 is something I want to just ask you about, osmoregulatory disruption. And we've discussed earlier about the sensitive life stage from moving to freshwater to saltwater and saltwater to freshwater. Is that what's meant by

osmoregulatory disruption?
A Yes. It's a disruption in their ability to move efficiently and successfully between freshwater and saltwater, vice-versa.
Q So a contaminant may not have a direct lethal effect but if it somehow inhibits the ability of fish to make that transition, it would leave them susceptible to other forms of predation or disease or parasites?
A Yes, if they're unable to make this transition effectively or efficiently, they are potentially more highly stressed at that time when they're trying to make these transitions and that makes them more susceptible to other types of, for example, disease organisms or, like you say, potentially to predation as well.
Q And there was quite a celebrated study and I think I saw it in your bibliography by a gentleman named Fairchild of Atlantic salmon back in 1999. And it's my understanding, perhaps I'll ask you to explain what you know about that study. I understand that this was an example of trying to determine why certain Atlantic salmon were not returning to their spawning grounds. This is, I believe, in New Brunswick. And it was determined that there was some impact on pesticides on osmoregulatory disruption. I'm probably not getting that quite right. Do you have some familiarity with that study?
A It's been a little while since I looked at it specifically but yes, what it showed was exposure to, in that case, I believe the pesticide was atrazine, which is a herbicide. I may have that --
Q I think it was metrazine it was called and it was like one of the surfactants that you talked about earlier on, that it was applied with a pesticide to deal with spruce budworm, I believe it was.
A Right. So the bottom line was that the animals that were exposed to these chemicals had impaired ability to transition from freshwater to saltwater. And so that is consistent with this concept of osmoregulatory disruption.
Q Right. And so here in the context of Fraser River sockeye salmon, Dr. Ross and Dr. Johannessen are suggesting, this is in the second line, that:

> Osmoregulation is particularly complex for salmon because they are anadromous, therefore their process of osmoregulation must change dramatically as smolts and again as returning adults.

So again, that's a particularly vulnerable life stage for them. And at the bottom of the paragraph:

> It is possible that a contaminant (or a combination of contaminants) could disrupt the osmoregulatory changeover such that the salmon would need to get into freshwater as soon as possible rather than waiting for the usual migration trigger.

Would you agree that that's a reasonable hypothesis?

A Yes, indeed, that's reasonable.

Q And this doesn't exclude other contributory causes, I suppose, such as changes in temperature and other kind of climate or human-caused changes that may also impact this behaviour as well. It could be one of a number of effects that caused this result?

A Yes, it could be additive, for example, or synergistic in nature.

Q Okay. And just quickly on the rest of this report, he talks about immunosuppression as something you've talked about that these chemicals could reduce the ability of salmonids to fight off disease or parasites. And finally, in the next page, 1.3.6, and this is something that I wanted to discuss with you because I think it's relevant to the issues of contaminants in natal streams. Under "Development Effects", and we talked about this just now:

> Early life stages of aquatic organisms can be more susceptible to some of the effects described above such as neurotoxicity and endocrine disruption.

Do you agree with that, that's essentially what we had discussed a few minutes ago?

A Yeah, that's what we often find is that the early

life stages are the most sensitive to these types of effects.

Q I just want to follow up with something you said earlier and it's at page 53 of your report.

MR. LUNN: Sorry. One moment, please.

MR. EAST: It's okay.

Q And this is something you spoke to earlier. In the last paragraph:

> In the Fraser River Basin, both spawning and incubation habitats and adult upstream migration habitats had a higher percentage of measured chemicals of potential concern exceeding toxicity screening values during post-1990 period, compared to the pre-1990 period (Table 4.50).

And then you concluded:

> These results suggest that water quality conditions have degraded over the past two decades. However, the results were reversed for the juvenile rearing and smolt outmigration life stages.

Now, that's with respect to the chemicals that you had filtered down to in your chapter. I believe this is chapter 5. These are your chemicals of potential concern. This analysis did not include the endocrine-causing chemicals and the contaminants of emerging concern that you considered in the next chapter; is that right?

A That's correct.

Q And in fact, you say that. Just to be fair, on the next page, page 54 at the top, you're very clear that:

> Many other substances have the potential to partition into water and may pose potential hazards to Fraser River sockeye salmon stocks...

And you go through many of them. And you talk about how there's insufficient data.

> However, insufficient data were available to characterize exposures to these contaminants

and/or toxicity screening values were not located for these substances. As such, it was not possible to evaluate the hazards posed to sockeye salmon in the Fraser River associated with exposure to these contaminants.

So just to be clear, when you're talking about the exposure of particularly vulnerable eggs in the incubation stage in the sediments or fry in their rearing habitats, your comments on page 53 were not related to these endocrine disrupting comments, contaminants and these contaminants of emerging concern. They may still have an impact in these natal areas?

A That's correct.

Q Okay. I'm going to step back a bit. You went into great detail and I appreciate it for discussing the data gaps and you've been very clear about that. There's a few things I just wanted to follow up on. I just had some clarification questions. You mentioned, in response to a question by Ms. Baker and I just want to confirm this, that you felt it necessary to study data back to, I believe, 1965?

A Yes, that's correct.

Q And I guess that's intuitive in the sense that if you were going to study the decline of sockeye salmon starting around 1990, you would want to go back historically to look at data that occurred prior to the commencement of the decline. And that's what you've done?

A That's correct.

Q Okay. Now, I wouldn't mind going to Table 3.7. And there's just something that struck me when I was looking at this table.

MR. EAST: And I'm not sure of the exact number. I think Table 3.3 is T-13 and maybe we can start there, Table 3.3.

MR. LUNN: One moment, please.

MS. BAKER: T-25.

MR. EAST: T-25?

MR. LUNN: Thank you.

MR. EAST:

Q Now, what struck me in looking at this, and this is just an example, and you'll see this in a number of the tables under this heading. There's

a lot of "N/A" here.
A I'm sorry.
Q I'm sorry.
A Just to be clear, were we going to look at Table 3.3?
Q Why don't we go to 3.3 first?
A Okay.
Q It's the same point really for all of them in this section. And really, what I just wanted to ask you about, earlier you talked about and you clarified to Ms. Baker that when there was an effluent permit, that in your report you identified a number of contaminants and went beyond what was allowed for or described in the effluent permit. But what also struck me is that for many of these companies, these industries, and this is 3.3 and if you go to 3.4 and 3.5, I think it's the same thing, there's an awful lot of "N/A"s here. And here "N/A" means "not available"?
A Data not available. That's correct.
Q Can you explain why? When you say data not available, is it the data does not exist or that you just were not able to, in the time that you had or the circumstances you were under to be able to identify and find it?
A Certainly, the latter and possibly the former. So we definitely had major time constraints that prevented us, for example, from doing -- we access readily-available information for compiling this kind of information. And if we were able to get it relatively quickly doing searches for this type of information then it exists in these tables. If we were unable to get it, it's not in this table. One of the reasons potentially for not being able to get it is that it doesn't exist. The other reason is that it's not readily available. So I know that's sort of a fine distinction but it's hard when you don't have something to determine if it's one or the other.
Q So I guess then if you were to take this conceptual framework and if you had the luxury of more time and, I guess, more funding, you would want to be able to dig around and determine (a), I suppose, does this information exist? And secondly, is it available in a format that you can use? And you weren't able to do that in this

report.
A That's correct. So if I was to prioritize the data that we would want to collect, clearly, the types of information that we were most interested in was exposure information. So what are concentrations of contaminants in the receiving water system and what are the effects of these chemicals? So what are the toxicity thresholds that we could use to evaluate individual chemicals? Now, for the purposes of developing the inventory of aquatic contaminants, the kind of information limitations that you've identified here, we believe are reasonably important but don't necessarily change the overall outcome of our report, for example. If we had more time, we absolutely would have wanted to compile all of the information on effluent permits and all the variables that are associated with those permits. But more than that, we want to be able to know what's explicitly in those effluents.

The kind of information that's on this table gets you partway to understanding what's in the effluent but only partway. Typically, these effluents from sawmills or pulp and paper mills or from mines, they include very complicated effluents and include many, many, in some cases, from pulp and paper mill effluents, hundreds and hundreds of substances associated with those. This permit information provides very little help in terms of identifying what those are. And that's why we've relied also on reviews of the scientific literature to provide us with ancillary information that allows us to understand more generally what do we see in pulp mills from general studies not necessarily tied to individual facilities.
Q Okay. Thank you for that. Maybe on a similar theme but moving over to questions that I have about the methodology in the determination of toxicity thresholds, perhaps we can go to page 59 of the report. And I believe it's right above the heading "Toxicity Thresholds for Water". And I'll return to the theme that we just talked about a few minutes go. And where it starts with:

> For the purpose of conducting a detailed analysis of the contaminants of concern, a

toxicity threshold is defined as the concentration of a contaminant in water, sediment, or fish tissues above which adverse effects on survival, growth, or reproduction are likely to be observed in sockeye salmon exposed for extended periods of time to environmental media that contain the substance, either alone or in complex mixtures of contaminants.

In your experience in this report, were you able to obtain toxicity reference values that accounted for all of these different requirements to come up with a toxicity threshold?

A Not fully, no. Typically not. In some cases, I would say yes. Things like, for example, cadmium, which is very well studied, the toxicity thresholds incorporate a lot of information on a variety of different endpoints on salmonids. And so in those kinds of cases, we had sufficient information to be able to convince ourselves that the toxicity thresholds that we selected would be protective against these types of effects.

But for many of the other types of contaminants, either there were no toxicity thresholds available, things like the EDCs and the contaminants of emerging concern, but also for certain contaminants that are more classical or legacy-type contaminants, even they didn't necessarily provide all of the information that you need to understand the concentrations that are associated with sublethal effects like growth and reproduction.

Typically, there's lots of data on survival effects. Typically, more, but less so for growth. And then when you start getting into other types of effects that require longer-term studies to evaluate, then the amount of data drops off very substantially. And so there is only a subset of the contaminants that provide the kind of toxicity thresholds that would be protective against all three of those types of effects.

Q Now, I wouldn't mind discussing a little bit about the tools that you have to assess and to develop these toxicity thresholds.

MR. EAST: And maybe to use as an illustration, go to Table 4.53. I'm sorry. I should have written

down what the page number was. It was one of the ones that you had up earlier.
MR. LUNN: Yes, I have it here.
MR. EAST:
Q And this is where, as I understand it, you bolded those exposure thresholds that are greater than 1.0. What were the source of the water quality guidelines? I understand you used the CCME Guidelines and other similar type guidelines?
A Right.
Q Could you explain a little bit about how those are developed? What are they for? What is their purpose and what is their focus?
A Okay. So just as a point of clarify, so in the chapter 4 analysis, we used generic guidelines like the Canadian Council of Minister of the Environment, Canadian Water Quality Guidelines as a basis for identifying our toxicity screening values or similar values developed by other jurisdictions. And would you like to talk about those first?
Q Yeah, and I recognize that in chapter 5, you develop more salmon-specific guidelines.
A Correct.
Q And I'll get to that in a second. But I wanted just to talk a little bit about the ones you use in chapter 4. And I'm just curious as to the circumstances under which those guidelines are created. My sense is that they're laboratory-based assessments based on laboratory experiments and not necessarily based on real world situations.
A Yeah, typically what happens is the work group on the guidelines development will identify a substance that needs to be evaluated, i.e., guidelines need to be generated for them. Then a mechanism for getting that work done is identified. It may be a consultant that is asked to do a review of the toxicological literature on, for example, cadmium, to determine what its effects are. The available data is then compiled in a large database or in a series of spreadsheets depending on how they do this work.
And the vast majority of that, you're correct, is from laboratory toxicity studies where individual contaminants have been added at various concentrations and then organisms are added to

those beakers, if you like, with the various concentrations and then the effects of those exposures for whatever period of time are evaluated and used to calculate a lethal concentration to 50 percent of the population that was exposed or an effective concentration, if they employed as a growth or reproduction to some proportion of that population, 20 percent or 50 percent. So those kinds of laboratory toxicity studies probably represent 90 to 99 to, in some cases, a hundred percent of the data that goes into generating those guidelines. In some cases, also, there are data from work that's done in the real world.

So for example, in Canada, we have the experimental lakes area that's out in the Prairies. That's where there are whole lake manipulations done as well where a certain amount of cadmium is added to Lake 1 and more cadmium is added to Lake 2, et cetera, and then those effects are evaluated across each of those exposure scenarios under real world conditions. But that's very much atypical of the type of data that goes into the guidelines development. Most of it is, as you've indicated, laboratory toxicity data from these very tightly-designed laboratory studies.

Q And these studies typically address one chemical at a time or one contaminant at a time, one chemical compound at a time in the studies?

A So as you look back into the scientific literature, that was the most common approach years ago. Now, we're starting to see more studies that are done like that with mixtures, either mixtures of like chemicals, for example, like mixtures of several types of pyrethroid pesticides, for example, or mixtures of polycyclic aromatic hydrocarbons. So you see these kinds of mixture type experiments happening more and more in the literature as we've identified the need to understand the effects of mixtures of contaminants more out in the real world. These kinds of data now are being generated under the laboratory conditions at least and, to a certain extent, in the real world as well.

Q And also, often I think, as I understand it, the aquatic organisms used for the testing aren't necessarily salmonids. These are guidelines that

are developed for other types of species. Is that rainbow trout, for example, or fathead minnows?
A Yeah, typically the data that goes into the guidelines development is whatever is available. And so for example, when there's sockeye salmon data available, those will be used, or pink salmon data are available, those will be used in the guidelines development for sure. But most commonly, you see fathead minnows and rainbow trout and various types of cladoceras, water fleas, invertebrates, that are used in these types of tests, daphnia magnas or daphnia dubia, those are probably the four main species that are used to generate more than 50 percent of the data that go into these types of evaluations.
Q So I would suggest then some caution, and I think you reflected this perhaps in your chapter 5, some caution must be taken in applying some of these guidelines to a particularly sensitive species such as sockeye salmon?
A I don't know that I would characterize it quite the way that you've stated it. And again, there are a wide variety of different types of water quality guidelines generated. In Canada, the Canadian Council of Ministers of the Environment are responsible for generating those guidelines. And they have in place a protocol for generating those numbers that are intended to be very protective. So notwithstanding the data that go into them, which is always a limitation, they're designed to protect the most sensitive life stage of the most sensitive species of aquatic organisms over an indefinite period of exposure.
And the way that they get that is that they look at the data that are available, identify the most sensitive toxicity threshold from the available literature and then typically there is a safety factor applied to take a number that might be here and then drop that down by a factor of ten or so to account for interspecies differences in sensitivity that you might see if, for example, salmonids are much more sensitive than the species that were used in generating the toxicity threshold. But usually there's a requirement for having salmonid-specific data in the database that are used to generate those guidelines. And so I consider the Canadian Water Quality Guidelines, of

all the guidelines that are available in the world, they are probably the most protective.

Q Fair enough. I guess where this is leading to is that ideally it would be useful for researchers in this area to have guidelines that were established, first of all, specifically for salmonid species and as much as possible rooted in real life, real world, *in situ* situations so that the data you have you know you have some confidence that's relevant to sockeye salmon. Would that be something you'd want to see in the ideal world?

A Well, the more specific you can have the toxicity thresholds, the higher level of confidence that you have in the results of your assessment that is conducted. So that type of information that allows us to identify very specifically toxicity thresholds that are specific to salmon is something that we'd be very interested in. I just want to caution, though, that developing that kind of information in real life scenarios is really challenging from the standpoint of in controlled studies you can certainly develop epidemiological type information and use that to generate toxicity thresholds.

But to design these types of controlled studies that get you real life toxicity thresholds that are reflective under real-life exposure scenarios, they're challenged. We've done them in certain cases by re-circulating stream systems and then to do our exposures and then comparing those to results of exposures that were done under typical laboratory conditions and comparing those. So you can get there for sure. But these are challenging studies. But we definitely would love to have more of that kind of information, yes.

Q Okay. I think I'll change focus a little bit in the time I have left and talk a little bit more about some of the sources, potential sources, of the endocrine disrupting contaminants you've discussed and these contaminants of emerging concern, recognizing they're not necessarily the same but there's a significant overlap in those two categories and this is your chapter 6. I want to talk a little bit about and just ask you a question about pulp mill effluent.

MR. EAST: And perhaps I can have Tab 4 again,

Johannessen and Ross, and it's ringtail page 27.
Q So in this paper, Drs. Johannessen and Ross discuss potential sources of these kind of contaminants that could perhaps explain the apparent change of behaviour in Late-Run sockeye salmon. And so ringtail page 27 and 28 is page 15 on the actual page. Actually, well, first thing before I get to the pulp mills perhaps I want to talk a little bit about wastewater. And you've identified, and I think this is consistent with what I've seen in the literature, that the two main point sources of these kind of contaminants appear to be municipal wastewater treatment plants and pulp mill effluents, as well as the various sources from highly-urbanized areas, industrial areas; is that right?
A That's correct.
Q I'm curious. There's a couple things that struck me about the wastewater treatment and one question I'm not clear on. And I imagine we'll get a lot more evidence in the hearings to come about wastewater treatment plants and the benefits of primary, secondary, up to tertiary treatment. Do you know if secondary treatment is effective in screening out these chemicals of emerging concern, especially the endocrine disrupting chemicals? Is that an effective method to screen out these contaminants?
A That is a very broad question.
Q Or some of the contaminants? Perhaps you can maybe just give me...
A We recently completed a project for the U.S. Fish and Wildlife Service where we essentially developed tools for them for screening biosolids. And as part of that investigation, I looked at several studies that provided some information that would lead you to believe that at least some proportion of some of these chemicals that we identify as EDCs and emerging contaminants are primarily or in large measure associated with the solid fraction. And so a treatment process that removes solids from the wastewater treatment effluent would have the net effect of removing some of the loading of these contaminants to the receiving water systems. So I'm not sure that I fully answered your question with that answer but that's how far I feel I can go in that.

Q Well, no, that's fine. And maybe what I'll do is I'll tell you what Drs. Johannessen and Ross said about it and see if you agree. And it's at the bottom of this page where they talk about secondary and tertiary treatments and the various grades of treatment of contaminants. And here it says:

> Secondary treatment involves assisting in biological breakdown of organic matter.

And I understand that that's a process whereby some of these chemicals of concern, especially the ones that bind with particles, will attach themselves to the particles in the sludge and then be removed and not put back into the water.

> Tertiary treatment can involve chemical treatment and a variety of filtration techniques to remove even more contaminants. While there is no doubt that waste water treatment is an important step in the reduction of human pollution in the environment, there are three *caveats* that come with increasing treatment levels.

And I think this is what I wanted to ask you about.

> First, the greater the treatment, the greater the quantity of sludge produced that must then be treated before it can be disposed of. This sludge is known to contain a variety of contaminants, including PCBs and other toxic and persistent compounds.

And I guess included in that would be some of the pharmaceuticals and some of these other type of drugs that had been flushed into the system and into the wastewater treatment. I mean these are the kind of things that are building up in the sludge.

A Well, just to be cautious, I fully agree with this first statement that things like PCBs, those contaminants that have a high affinity for organic carbon that tend to partition into the solid phase, those are absolutely going to go with the

biosolids. Keeping in mind that many of the pharmaceuticals that you're describing are also highly water-soluble. And so the effectiveness of the treatment in terms of reducing those may be different. It's likely to be different than what you would see for these contaminants that are most strongly associated with a particulate fraction.

Q Okay. Well, that's a useful distinction. What struck me is in the next line is that at least for those particles like PCBs and other persistent compounds that would remain in the sludge, in here it says that:

> In some cases, the sludge is often used as soil treatments (e.g. fertilizer) in forestry and agriculture, where these contaminants can later migrate into local surface waters.

And it talks about a product called Nutrifor that was recycled and marketed as a fertilizer, especially as a forestry fertilizer. Are you aware of that?

A I don't know that specific product, that the application of biosolids to upland areas for those kinds of applications is something I am familiar with, yes.

Q Okay. So that's one example of possible non-point source contaminant that could leach from these upland areas into sensitive natal streams, rearing habitats, that could impact sockeye salmon?

A Yes, absolutely.

THE COMMISSIONER: Mr. East, would this be a good place to take a break?

MR. EAST: Yes.

THE REGISTRAR: The hearing will now recess for ten minutes.

(PROCEEDINGS ADJOURNED FOR AFTERNOON RECESS)
(PROCEEDINGS RECONVENED)

THE REGISTRAR: The hearing is now resumed.

MR. EAST: For the record, Mark East continuing his cross-examination.

THE REGISTRAR: Microphone, please.

CROSS-EXAMINATION BY MR. EAST, continuing:

Q Where we left things, Mr. MacDonald, was we were talking about waste water treatment plants. And in Johannessen and Ross, again Tab 4 --

MR. EAST: Before I go on further, perhaps I should mark this Tab 4, Canada's Tab 4 as an exhibit.

THE REGISTRAR: That'll be Exhibit 833.

MR. EAST: Thank you.

EXHIBIT 833: Johannessen and Ross, Late-Run Sockeye at Risk - An Overview of Environmental Contaminants in Fraser River Salmon Habitat, 2002

MR. EAST:

Q So on ringtail page 27, the bottom, there's three caveats that were put forward by Johannessen and Ross. One we talked about is the sludge, and the sludge that has been converted into fertilizer and redistributed into the upland areas, thereby potentially at least redistributing some of these persistent chemicals back into the environment.

The second caveat - and maybe you can describe this for us a bit - is:

> ...that the breakdown of some [of these] contaminants leads to chemicals that are more toxic and more persistent. For example a number of pesticides, and the commonly detected surfactants alkylphenol ethoxylates, break down to products that have more of a negative impact than the parent compound...

Is that a phenomenon that you've looked at very much in your studies?

A I wouldn't say I've looked at it very much in my studies, but I have looked at degradation products of certain contaminants over the years. Yes, some of them can be more toxic than the parent compounds, some can be less, so you can go in both directions. But this statement is correct in the way that it's -- in my opinion, this is correct in the way that it's presented here in this section of the report.

Q And so why this is significant is because a parent compound may have been evaluated and approved

without perhaps really a full understanding of how these compounds may break down when they hit -- when they reach the real world environment.

A Yes, that's correct.

Q And the third caveat in this paragraph, the last sentence, and I think this is what we talked about with respect to pharmaceuticals, at least some of them, is:

> ...that highly water soluble contaminants may not be affected by anything less than tertiary treatment.

Do you agree with that?

A Yeah, I would even go so far as to say until we know how effective that tertiary treatment is, even for those water soluble contaminants, we may not even have the right tools available to us now to remove those with the types of tertiary treatment processes that are currently available.

Q So, again, this is another area that obviously requires further analysis, data and research.

A That's right, particularly for things like the pharmaceuticals which are the fate -- long-term fate is relatively poorly understood.

Q Thank you. And the same paper, going to page 35 in ringtail -- sorry, page 34. I just have a quick question about pulp mills. We've heard some discussion about them.

My understanding is that with respect to pulp mills, certainly historically, they have been of great concern with respect to the nature of the contaminants that have flowed from them into the Fraser River. My understanding, however, is that because of some improvements in regulation, at least for some of the contaminants produced by these facilities, the concerns are greatly reduced. Would you agree with that?

Perhaps maybe I can take you to what Dr. Ross and Dr. Johannessen say on page -- the paragraph that starts, "All the B.C. pulpmills...".

A Sorry, I didn't mean to be slow in answering you. Yes, for certain things like the dibenzopidioxins and dibenzofurans, the regulations have dramatically reduced the concentrations of those contaminants in the pulp mill effluents. That is correct, yes.

Q But to give a complete picture, as Dr. Ross and Dr. Johannessen point out here, and this is after the page or the bullets showing the improvements:

> Despite these significant improvements there are still concerns about contaminants in pulp mill effluent. The general toxicity test of the effluent is for acute toxicity only, and does not test for sublethal effects or [on] chronic exposures.

And that's consistent with what we've talked about earlier, you'd agree?

A Yes. That's correct. Just keeping in mind, at some of the mills are some sublethal toxicity tests that are also done, but that's only at a subset of the mills, I understand.

Q I understand one of the issues they're looking at now, and I think we're talking about endocrine-disrupting chemicals and in fact natural plant hormones. These pulp mills introduce plant material, wood products material, natural materials into the ecosystem that are highly estrogenic. These aren't manmade, but they're just in greater volumes than you would see in nature. That's one of the major concerns as identified as far as pulp mills now.

A Yes, that's identified in this paper that you've shown us here today that's also been identified in other sources as well.

Q Thank you. I'd like to talk a little bit about pesticides. You referred earlier today to an article that's in your bibliography, and it's -- it's at Tab 2 of Canada's list of documents. This is a paper by Verrin, "Pesticide Use in British Columbia and the Yukon, An Assessment of Types, Applications and Risks to Aquatic Biota." So you're familiar with this article?

A Yes, I've used this article.

Q As a matter of fact, this is the one that referred to the Enkon data from 2001.

A That's correct.

Q Perhaps we can go to page 35.

> Numerous pesticide --

And this is in the bold text.

Numerous pesticide classes are currently on the market in British Columbia and the Yukon. Organochlorines were commonly used in North America until many were banned in the 1980s.

Are those the kind of pesticides that you hear about, the ones referred to in that seminal work *Silent Spring*, DDT, some of those earlier pesticides? Is that what organochlorines are?

A That's correct, yes.

Q And those are very persistent and biocumulative.

A That's correct.

Q And so they still exist in the environment even today.

A Almost everywhere we go we are able to detect those contaminants, yes, in sediments.

Q And continuing on:

However, the legacy of past activities continues as organochlorine pesticides are generally persistent. Currently, organophosphates are the most widely used of the pesticide classes. Despite their relatively rapid breakdown in the environment, much remains unknown about the impact of sporadic pulses in the sensitive ecosystems, the nature of their breakdown, and their fate. In BC and the Yukon, salmonids may be particularly vulnerable during certain lifestages, given their dependence on habitat that spans freshwater to marine and may run through forestry, agriculture and/or urban waterways.

So this is consistent with what we talked about so far today. Would you agree?

A Yes, I agree.

Q Over on the next page, I just want to ask you a question about inert ingredients, so-called inert ingredients. My understanding is that when you look at a pesticide, it's not always the pesticide itself that's the active contaminant of concern for sockeye salmon, but there's other additives - I guess they're surfactants - that could be the problem. Here in Verrin, it says in the top line:

The active ingredient in pesticide

formulations is what is intentionally used to control or kill target organisms. However, other ingredients are also added to the active ingredient such as surfactants, dyes, catalysts, and intensifiers to augment the effects of the active ingredient or facilitate their dispersion. These ingredients are often termed "inert" and can account for up to 99% of a product's ingredients.

When a product is approved, are you -- or reviewed for approval, are they typically reviewing for approval the additives as well?

A I have not been involved directly in approval, in the process for having new products approved for use.

Q Okay.

A So I can't comment on that specifically.

Q We'll leave that question for another day. But in the Fairchild example, the study of the Atlantic salmon test, it was actually not the pesticide that was killing -- or indirectly killing the fish, affecting the fish, but it was actually the surfactant that was used with the pesticide.

A Correct, yes.

Q And here it says - and I think it's important - second paragraph. Again, if you don't know the answer if this is true or not, just let us know.

Pesticide manufacturers are required to label products with the quantity of active ingredient present in their products but not the inert ingredients used in the product formulation. Inert ingredients are not readily disclosed and are withheld as they are considered a trade secret.

Is this your understanding now?

A That's something that I don't know.

Q Okay. Well, we'll leave that for another time, another day. I also wanted to go to page 43. I think, again, this is consistent, I think, with what you've said. This is the bold here.

Despite the widescale use of pesticides in forestry, agriculture and domestic

applications in BC/Yukon, information on the quantity of different pesticides used in different areas in the Pacific Region is not readily available.

Would you agree with that, based on your experience?

A Yes, I would agree that it's generally correct.

Q And, further down:

A centralized reporting system and information warehouse for sales and use numbers for the Region merits serious consideration. This data gap makes it difficult to readily and accurately assess the actual quantities of pesticides used in BC/Yukon.

I think that's consistent with some of the evidence you gave earlier today.

A Yes, that's correct.

Q Maybe just leaving this report, after I just look at a couple -- the next page, perhaps, next couple of pages, 44. It talks about pesticide use in the Pacific Region. I believe your evidence was that we have some data on pesticide use but we don't have specific data as to how it's used, how much is used and where it's used; is that right?

A That's correct.

Q And here I'm just referring to under the heading, "British Columbia". It talks about:

According to the Enkon 2001 report --

Which is what you discussed. It talks about over eight million kilograms:

...of pesticide active ingredients (excluding domestic label use, but including veterinary use for flea control) in 1999. This represents a 19% increase from 1991 figures.

So you'd agree that according to the Enkon report and this article, pesticide use has been increasing in this time period. Would you agree?

A Yes, over that period that they covered, which is '91 to '99, that's correct.

Q And if you go to page 46, I think this is represented in chart form, and I think it gives more particulars about the statement. This is Table 5.

Just going to the far right column -- if you look on the left column you have certain types of uses of pesticides, wood preservative being one, and then the far right column, "Percentage Change in Sales from '91 to '99", a 77 percentage increase in sales in these products in the time period. And the third line, "Reportable Pesticide Sales", a 19 percent increase.

Then in the bottom, "Use by Agricultural Services", a 105 percent increase in the time period. Is that consistent with your understanding?

A So I've relied upon this information. I have not done an independent evaluation of this information, but I believe this to be true and correct.

Q Okay. One of the things you mention, we don't really know where these pesticides have been used. I guess it's fair to say that certain assumptions can be made, I suppose, based on the nature of the agriculture and specific regions, and the nature of the needs of certain industries.

So, for example, we know, I guess intuitively, that in the Lower Mainland/Greater Vancouver/Lower Fraser Valley area, there's rather intensive agriculture use, and so it's reasonable to assume that a lot of the pesticides are used here in the lower Fraser River. Would you agree?

A Yes, and of course the Thompson-Okanagan area, large fruit-growing area as well, which is potentially an area of large agricultural use as well of certain pesticides.

Q And in fact, actually, now that I see it, Dr. Ross and Dr. Johannessen actually say this in the paragraph where it says -- talks about herbicides above in the Peace Region, but:

> ...in contrast, the Lower Mainland and Southern Interior (Thompson-Okanagan) regions exhibited large use of all three pesticide classes (herbicides, insecticides and fungicides) and have a wide variety of agricultural and urban activities that result

in a steady use of pesticides.

So that's, again, some evidence from the Verrin report that there is, certainly in this area, lower Fraser River, and in the upland area of Thompson-Okanagan a heavy use of pesticides.

A Correct, yes.

Q I think the last thing I just wanted to bring to your attention, I think it's page 66 and in fact, again, reiterating this point, and this is the last bolded section. According to the authors of this report -- it's right at the bottom of the page.

> Available evidence suggests that the Fraser River Valley represents a critical area of concern for several reasons: i) high urban density --

And just stepping back a bit, when we talk about pesticides, we also have to consider, I suppose, residential pesticides, lawn care, herbicides that could go into urban run-off. And that's an issue that has been identified as an issue of concern, has it not?

A Yeah, when I described earlier today the problem that we've identified with bifenthrin and other pyrethroid pesticides, that's exactly the problem that we're discussing at this point, the urban use of those substances.

Q And then:

> ii) intensive agricultural practices...

And there, I think in your report you talk about the possibility of pesticides washing into the lower Fraser River and some of the tributary streams, especially in the lower Fraser River.

Would you agree that for those fish species, salmonid species that rear in these habitats, they could be particularly vulnerable to agricultural pesticides?

A Yes.

Q And I'm thinking of the Harrison Rapids, for example.

> iii) heavy use of pesticides in the forestry

sector, particularly in the Thompson region...

And, of course, this is, I ask you, relevant because some of these pesticides may leach into some of, as we said, the natal areas of the streams, the rearing habitats for sockeye salmon.

A Yeah, this may be one of our greatest concerns, actually.

Q Okay.

iv) critical salmon habitat found throughout the Fraser River watershed with signs of a decreasing population trend in late-run sockeye salmon stocks.

That is obviously one of the reasons why we're here, and one of the main focuses of both this article, but also of the Johannessen and Ross article.

I want to talk a little bit in the time I have left about forestry pesticides. We've referred to this. My understanding is the Enkon report didn't really address forestry pesticides, but they're addressed in this article by Verrin; is that right?

A You hopefully will refresh my memory on that.

Q My understanding was that one of the aspects of the Enkon 2001 report is that it didn't necessarily look at forestry pesticides, so that was something that was brought into the analysis by this article, by Verrin.

A Right.

Q Maybe I'll go back to Johannessen and Ross, because one of the theses advanced in the Johannessen and Ross article was that they identified a potential forestry pesticide. I believe it's called triclopyr as a potential cause, or at least a suspect for why late-run sockeye salmon were moving early into the Fraser River. Are you aware of that analysis?

A Yes. I believe they produced a little graph that showed the relationship between triclopyr use, or sales at least, and increased pre-spawn mortality in sockeye salmon.

Q And maybe we'll go to that now, because I think it's an interesting example of -- well, why don't

we go there and I'll ask you a question about it. It's page ringtail 67 on Tab 4 of Canada's documents. This is the Johannessen and Ross. This is the diagram to which you were referring?

A Yes, that's correct.

Q Now, triclopyr, as I understand it, is a herbicide used to assist the reforestation by keeping down broadleaf plants and may compete with planted species.

A Yeah, to allow the emergence of those conifer species, among all the other stuff that's growing on the forest floor.

Q And of interest to hear, Dr. Johannessen and Ross make a correlation, I suppose, between the use of this triclopyr and pre-spawn mortality in sockeye salmon, indicating that it's interesting, I suppose, that the phenomenon of mortality seems to correlate, at least, with the use of this triclopyr.

Now, to be fair, and we'll go over to the next page, the second paragraph. They say:

> There are a few reasons to doubt the involvement of triclopyr in the sockeye behaviour change. The apparent correlation in Figure 14 may be coincidental, particularly as this data is for all of B.C., not just for the Fraser River watershed.

And then they talk about, in the last sentence of this paragraph:

> It is difficult to tie the B.C. wide use of a ground applied chemical to behavioural change in an aquatic organism. Data on the effects of sockeye exposure to triclopyr is clearly needed.

Are you aware if this work has been done since this report came out in 2002?

A What work specifically were you --

Q Sorry, work on the potential cause and effect of triclopyr and the impacts on late-run sockeye salmon.

A I did not locate that information if it's available.

Q I'm interested in this diagram, back to page 67

again, this is an example, I guess, of a reasoning using a correlation of data in the sense that a problem has been identified, in this case, pre-spawn mortality in late-run sockeye salmon and identifying a potential cause that correlates with it, and also a recognition on the part of the authors that that's all this is, is just a correlation; is that right? It's a correlation. There's no cause and effect being demonstrated here.

A That's correct.

Q In fact it's been acknowledged that further data is needed.

Would you say that, really, at large, with respect to your report, that some of the conclusions that you've reached with respect to contaminants and their impacts on Fraser River sockeye salmon similarly are based on correlations, correlations of evidence.

A Yes.

Q And again, for us to be able to have even more confidence in those conclusions, we would need to examine the data that underlies some of those hypotheses. Would you agree that that's what we need to do?

A I would argue that there's a step before that.

Q Okay.

A And that is that we need to collect the correct type of data so that we can evaluate those hypotheses, and then we can look at the data very carefully. But, you know, keeping in mind that one of the things that I think I tried to be as clear as I can about is that there are very serious data limitations associated with the work that we've done here in terms of trying to link exposure to contaminants to effects on sockeye salmon. So I don't disagree that there is a need to examine data in more detail, but I would argue strongly that before we do that, there is a need to make sure that we have the right data in front of us to be able to do those kinds of analyses.

Q Okay. Thank you for that. I only have a few minutes left, so I'm just going to focus on a couple of questions relating to other potential non point-source contaminants that may affect sockeye salmon. I'm particularly interested in the phenomenon as to how, I guess, atmospheric

sources of contaminants and marine sources of contaminants may have impacts upon sockeye salmon particularly in these kind of sensitive natal streams.

My understanding is that one of the phenomena that we're seeing with respect to these discussions of climate change and global warming is that some of these legacy chemicals that were located in mountainous areas in the snow pack, or in the glaciers, are increasingly being flushed now down into the upland areas. Have you heard or read anything about that phenomenon?

A Not specifically, but logically that's what you would expect, given that a lot of this material was tied up in this -- in the snow pack. As we reduce it, the snow pack, or reduce the mass of the glaciers, we would expect that those materials that were bound up in that material would end up ultimately in the aquatic ecosystem.

Q And I think, actually, Dr. Ross and Dr. Johannessen mentioned this and I'll just maybe -- ringtail page 81 -- and just note that this is discussed, and I guess there has been some research done. This is "Legacy POPs". These are some of the PCBs, DDT, dioxins, furans, what are these persistent biocumulative chemicals that are now banned but still exist in the environment.

If you look down the second-to-last paragraph, there's a reference to a study here that shows that:

> The results of these processes are demonstrated by the high concentrations of certain POPs found far from any possible source in the Arctic and B.C. mountain lakes and snow.

This is a phenomenon where these may be essentially flushed out into the natal streams and rearing areas, potentially, as these snow packs melt. This is an example of what we just talked about, would you agree?

A Yeah, the statement refers to high concentrations as a subjective term, of course, but it's not at all surprising to have these types of contaminants show up in either Arctic systems or mountain lakes. That's consistent with what we would

expect, yes.
Q And the final thing I wanted to discuss about this endocrine-causing or endocrine-disrupting contaminants, and particularly those contaminants that are persistent and biocumulative, where these chemicals exist in sockeye salmon, my understanding is that they bind to the fats, lipophilic I think is the term. So they bind to the fats of the sockeye salmon. As the salmon migrate up to their natal streams, there's a process where the fat reserves are burnt off so that it has the tendency for the contaminants to actually biomagnify, or perhaps the term I've seen is remobilize within the fish. Are you aware of that, because there's discussions about that phenomenon.
A Yes.
Q So at a time when assuming -- I mean, that may be a potential cause of pre-spawning mortality if, at some point, the contaminants become -- or remobilize to the point where they actually prevent the fish from, for some reason, spawning. Is that a possibility?
A Yes, and also, as some investigators have speculated, also an increase in egg mortality as well, so you can lose the adult or you can lose the eggs as a result of accumulation of particularly things like dioxins, furans, coplanar PCBs, PCBs that look like dioxins and furans and behave very much like them, you can expect to see those types of effects, yes.
Q And that's a key point is that the nature of these chemicals are such that they may be passed on from the spawning adult to the eggs, and thereby affect, potentially, these eggs and the fry at a very early developmental stage.
A That's right. So they're sequestered in the fat of the adult. As the gonads develop, the eggs, which also have a very high fat content, these contaminants are transferred from the maternal body burden into the eggs, so yes, you do have that kind of transfer.
Q And perhaps to just leave this topic and the questions on this point, this is another example, I suppose, where, when assessing - and getting back to where we started - when assessing the range of impacts that these contaminants can have,

we can assess these impacts without reference to all the other multiple stressors that are taking place that are impacting upon these salmon, and we talked about climate change and changing water temperatures, changing water flows, and other natural or anthropogenic or human-caused impacts.

Again, this is another example of why contaminants are important in that they need to be looked at in the context of these other stressors on sockeye salmon. Would you agree?

A Yeah, and that's why we've recommended this development of cumulative effects monitoring program that would get at these multiple interactive effects of things like the water temperatures and pathogens and contaminants, and the other factors that are potentially adversely affecting the survival and reproduction of the sockeye salmon.

MR. EAST: Great. Well, thank you very much, and those are my questions, Mr. Commissioner.

THE COMMISSIONER: There was another tab, was it Tab 2 of your Canada --

MR. EAST: Thank you, I will --

MS. BAKER: The Verrin report, yeah.

MR. EAST: -- mark Tab 2. Thank you. This is the Verrin article, Tab 2 in Canada's list of documents. "Pesticide Use in British Columbia/Yukon, An Assessment of Types, Applications and Risks to Aquatic Biota."

THE REGISTRAR: That's marked as Exhibit 834.

EXHIBIT 834: Pesticide Use in British Columbia/Yukon, An Assessment of Types, Applications and Risks to Aquatic Biota

THE COMMISSIONER: Thank you, Mr. East.

MS. BAKER: Thank you, Mr. Commissioner, that's all we have for today. Tomorrow we'll expect questions from the Province, Mr. Leadem, and from the First Nations Coalition.

THE COMMISSIONER: Thank you very much. We're adjourned, then, till ten o'clock tomorrow morning.

(PROCEEDINGS ADJOURNED TO MAY 10, 2011 AT 10:00 A.M.)

I HEREBY CERTIFY the foregoing to be a true and accurate transcript of the evidence recorded on a sound recording apparatus, transcribed to the best of my skill and ability, and in accordance with applicable standards.

Pat Neumann

I HEREBY CERTIFY the foregoing to be a true and accurate transcript of the evidence recorded on a sound recording apparatus, transcribed to the best of my skill and ability, and in accordance with applicable standards.

Karen Acaster

I HEREBY CERTIFY the foregoing to be a true and accurate transcript of the evidence recorded on a sound recording apparatus, transcribed to the best of my skill and ability, and in accordance with applicable standards.

Diane Rochfort