STATE OF MICHIGAN

STATE OFFICE OF ADMINISTRATIVE HEARINGS AND RULES

In the matter of:

The Petitions of the Keweenaw Bay Indian Community, Huron Mountain Club, National Wildlife Federation, and Yellow Dog Watershed Environmental Preserve, Inc., on permits issued to Kennecott Eagle Minerals Company.
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File Nos.:	GW1810162 and MP 01 2007
Part:	31, Groundwater Discharge 632, Nonferrous Metallic Mineral Mining
Agency:	Department of Environmental Quality
Case Type:	Water Bureau and Office of Geological Survey

DRAFT TRANSCRIPT

HEARING - VOLUME NO. XXIX (29)

BEFORE RICHARD A. PATTERSON, ADMINISTRATIVE LAW JUDGE

Constitution Hall, 525 West Allegan, Lansing, Michigan

Wednesday, June 18, 2008, 8:30 a.m.

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Lansing, Michigan

Wednesday, June 18, 2008 - 8:34 a.m.

MR. PREDKO: Your Honor, while Dr. Kapustka is getting settled I did have one exhibit that I neglected to offer yesterday --

JUDGE PATTERSON: Okay.

MR. PREDKO: -- that I'd like to offer before we proceed with cross-examination.

JUDGE PATTERSON: Okay.

MR. PREDKO: I'd like to offer Intervenor 157 which is Dr. Kapustka's issue paper on the ecological effects of metals submitted to the EPA that Dr. Kapustka referenced and relied on, and the figure on page 8 of his demonstrative slides is a figure from that issue paper.

MR. DYKEMA: No objection.

MR. REICHEL: No objection, your Honor.

JUDGE PATTERSON: Thank you. No objection, it will be entered.

(Intervenor's Exhibit 157 received)

MR. PREDKO: I pass the witness again.

MR. DYKEMA: Good morning, Dr. Kapustka.

THE WITNESS: Good morning.

MR. DYKEMA: My name is Peter Dykema. I represent the Huron Mountain Club, and I have just a few questions.

THE WITNESS: Yes.

LAWRENCE A. KAPUSTKA, Ph.D.

having been called by the Intervenor and previously sworn:

CROSS-EXAMINATION

BY MR. DYKEMA:

Q To begin with, I'd like to make sure I understand some of the points you've made in your demonstratives. In the third bullet point on your slide number 2, you say that the projected concentrations are so low that they're not measurable.

A Yes.

Q And if I understood your testimony yesterday, your point is that the concentrations from the mine operation are sort of within the variability of the background level and for that reason can't be picked up.

A That is correct.

Q Could they be monitored by sampling plant or fungal tissues?

A The same issue would arise because the plant and fungal tissues would be responding to both the background and any addition that's there. So without a specific tracer such as a radioisotope, one would not be able to detect any transfer.

Q If the metal emissions in the particulates emitted by the mine operation were substantially greater than are projected in the MDEQ model, what would be the best way to monitor that fact?

A It would be possible to monitor the deposition with filters that one would trap with that before it gets in contact with the soil, basically a dust monitoring package. But once it falls on the soil, there would be too much variability there to ever detect that small increment added into the soil.

Q Again, assume with me for a moment that the particulate emissions from the mine operation are going to be considerably greater than the MDEQ model projects. Is that the only kind of monitoring that you would recommend?

A They would have to be sufficiently higher than the analytical detection limits that are available in any chemistry laboratory. And these numbers here are -- the projected additions over the life of the mine are really at or below the detection limits that one would be able to have confidence in any measurement. And therefore, when you look at that incremental increase over the natural variability of soil, one would not expect to be able to detect that.

Q Okay. But the detection you're talking about is detection in a soil assay?

A Correct.

Q If the emissions of nickel and copper were, for example, ten times greater than the MDEQ projects, would you recommend monitoring by means of dust collection only?

A If they were tenfold higher, one would be able to get some information from a soil sampling program, but there would again be a lot of noise and it would be hard to sort that noise out. So, yes, the dust collector would be the most appropriate way to monitor that addition.

Q We're now looking, Dr. Kapustka, at your demonstrative slide number 5. And just to make sure I understood the train of your testimony yesterday, is it your opinion that at the emissions levels projected by the MDEQ model, we do pass the scoping threshold?

A We pass the screening threshold, and we are probably -- in that there is not a formal scoping number to be looking at for comparison purposes in these cases, I'm indicating here some concentration. For birds it might be just sightly above the line that I've shown for scoping, but for the other receptor groups, it would be very close if really not indistinguishable from that hypothetical line that I've drawn for the scoping level.

Q Okay. But at least for birds, and again based on the projections by MDEQ, it's your expert opinion that the emissions are sufficient to require some further -- some scrutiny?

A I would agree with that, yes.

Q Did you review the environmental impact assessment prepared by Kennecott in this case?

A As I mentioned yesterday, I looked at portions of it, and I looked at those portions that were relevant to the scope of my charge which was to look at the terrestrial toxicity questions that were raised.

Q Fair enough. In the portions of the Environmental Impact Assessment that you reviewed, was there any discussion at all of the potential toxic effects of the particulate emissions from the mine?

A I believe those were only brought in after the fact because I think the MDEQ's analysis and initial application had already looked at the amount of emission that was expected and determined that those were safe values to proceed. So I don't recall a specific statement about toxicity in the initial application.

Q So in the portions of the Environmental Impact Assessment that you looked at, there was no discussion of the potential toxic impact of particulate emission?

A I don't recall any.

Q As I understand the EPA protocol that you described for us yesterday and upon which you base your opinions to a certain extent, the core -- the database for that protocol is a synthesis of all available literature on toxic impacts.

A Correct.

Q And did I understand you also to say that most of that literature establishes toxicity levels based on laboratory experiments?

A Correct.

Q Is there any difference -- let me start over again. Do
organisms respond to toxic substances in nature any
differently from the way they respond in a laboratory?

A They can. It depends on a number of other factors, but
the -- and the studies that have been done that look at
those comparisons are remarkably giving similar answers when
certain adjustments for bioavailability and confounding
stressors are taken into account.

Q Tell me what you mean by compounding (sic) stressors.

A Well, there can -- in a field situation, if one is to go out
and look at, for example, a past emission onto a landscape,
there will be multiple potentially toxic substances in that
mixture. And so sorting out which one of those substances
would be responsible for an effect that one is observing is
a little bit more problematical than when one uses a
controlled experiment and knows then precisely what has been
introduced and what the organisms are exposed to.

Q So in this case would it be fair to say that the best
analysis of potential toxic effects of the particulate
emissions would take into account the combined effect of all
the toxic metals that are contained in the particulates?

A That would be true if there were multiple toxic metals above
the individual thresholds. We would not just add up all of
the metals and assume that they have the same mode of action
in the organism or trigger the same toxicological response.

Q Are there instances where exposure to multiple toxins, each of which is below; albeit slightly, a toxicity level, has deleterious effects on organisms?

A There are a few examples of additivity or the synergistic interactions of chemicals. But those have to be dealt with on a case-by-case basis. And in the situation we're looking at here, nickel and copper would not be ones that I would anticipate have any additive response mechanisms.

Q Did you assess your analysis the potential toxicity of any of the components of the particulate emissions other than copper and nickel?

A Not as rigorously as I did here, but I did look at the composition of the metals that are in the ore. And other substances were substantially lower in concentrations than the two primary ones that were examined.

Q But you didn't run any of other metals through the EPA protocol?

A I didn't because they are not going to make -- if I went through that activity, that exercise, they would still give me the same conclusions.

Q Okay. But again, based on the projections in the MDEQ model?

A Correct. Well, let me correct that. Based on the relative projections, if we assume the concentrations that are in the orebody and the foundation rock, because the dust that's coming out is going to be proportional to those sources, one could make some proportional adjustment, if you will, to the projections. And those would all fall below a level of concern.

Q And the clarification you've just given us is necessary because MDEQ didn't model all of the metal components of the dust?

A They modeled the dust -- that's correct. Basically that's correct.

Q And so when you did a -- when you sort of eyeballed the beryllium content of the dust, you reached your conclusion based on the fact that beryllium is "X" percent of nickel, and that gave you a sense of how much beryllium would be deposited?

A Correct. Correct.

Q Is that right?

A That's correct; yes.

Q Going back to the concept of cumulative impacts, is it the case that organisms in nature can be more vulnerable to toxins such as nickel and copper if they are subject to other forms of environmental stress?

A That theory is in the literature. It does not often apply. It frankly is one that has as many detractants to that theory as there are proponents to it.

Q I take it you personally are a skeptic on that issue, or are you?

A I'm not just a skeptic. I look at the individual data which comes in. And if I'm presented with clear information that would say that there is a response that's triggered by a prior condition, then, of course, I would take that into account.

Q Is the vulnerability of an organism to toxins such as copper and nickel variable according to the maturity of the organism?

A It is to some extent. I don't have the precise percentages to say when it is most sensitive and, you know, how much more sensitive it is.

Q Generally speaking, are juvenile organisms more vulnerable to toxins such as copper and nickel than mature organisms?

A In a general sense, that's correct.

Q Is it possible to generalize with respect to the literature foundation for the EPA protocol that you've relied upon as to whether that literature involved laboratory studies of juvenile or mature organisms?

A The majority of the test would have been conducted on very young organisms. For example, the plant tests are largely derived from seedlings that have just germinated so they're in the earliest stages that they could be. The avian studies, the bird studies, are generally performed on young chicks, young ducklings, young of the species. Certain test protocols might have different ages organisms. Some of the earthworm studies, as an example, will start -- if it's an acute study which means an exposure for a very short period of time, those studies, the protocols ask for using sexually mature earthworms; however, many of the studies that were relied on in setting the Eco-SSL involved the reproductive studies. And in those cases, the end points that are measured are the production of cocoons and the survival of the hatchlings of those cocoons. So the reproductive end points are, in fact, moving in that direction. I can summarize by saying the majority of the tests that qualify for making these very protective determinations for the Eco-SSL's are taking into account those -- not only the bioavailability that I mentioned yesterday but the sensitive stages of the life cycle.

Q You used the expression "acute study."

A Correct.

Q Do I understand that to mean a study that measures the susceptibility of an organism to toxins over a short period of time?

A That is correct.

Q Are most of the studies upon which the EPA protocol is based, are most of them acute studies?

A Most of them are chronic studies which means they were over a substantial length of time relative to the life history of that species.

Q Well, in studies of the impact of toxins on trees, are most of those studies chronic and they measure the susceptibility of the organism over the entire life span of the organism?

A No. Most of the plant tests are done on herbaceous plants. The data that is available on trees are on relative short periods relative to the whole life span of the tree species. However, these are balanced against some observations in field work as well, and they're deemed to be fully protective of trees as well.

Q Can you give us some sense of how many species of birds have documented toxicity studies in the EPA protocol?

A The majority of data would come from, I'm guessing, five species, four species. There are a few studies, depending on the substance, where there would be an additional suite of species examined.

Q So the species-specific studies of birds, it's your sense, are five or six species of birds?

A The majority of data would come from that, yes.

Q Which, if you know, are the best studied birds?

A Well, there are a number of studies on bob white quail, mallard duck, poultry -- domestic poultry are used quite frequently, so there are a number of studies involving chickens and turkeys. There are a few with pheasant. There are a few studies that are done with the Japanese quail.

Many of these were -- the protocols were established because of the need to use a standardized test species in pesticide registration. It could be used worldwide. But there have been a number of other studies with birds such as the starling, and very specialized studies with house finches and the like.

Q Any other birds that you know of that have been studied in the literature that underlies the EPA protocol?

A Well, it would depend on the specific substance that's being examined. There are some -- different species have been used in looking at selenium, and these would include stilts and avocets. There are a few studies of other waterfowl species as well.

Q Again with reference to the body of scientific literature on which the EPA protocol is based, how many bird species have been studied for their vulnerability to nickel or copper?

A I don't have that number readily available. It's something that could be easily pulled out of the database if it were hooked up to the computer and do a search. I just don't know the number.

Q Would it be fair to assume, though, based on your answers to my prior questions that it's probably less than a dozen?

A Yes.

Q So there are in the Upper Peninsula of Michigan literally hundreds of bird species that are not the subject of toxicity studies regarding nickel and copper in the literature that underlies the EPA protocol?

A It would be many hundreds. There may be -- I don't know the exactly number of what's out here, but --

Q A couple hundred.

A I think, yeah, 200 would probably be the maximum of the birds that are in the area.

Q How many species of pine tree have been the subject of nickel or copper toxicity studies in the literature compendium that underlies the EPA protocol?

A I don't -- I haven't looked at it for that purpose. There may be some.

Q But you're not sure that there are any?

A I'm not certain that there are any.

Q The same question for reptiles and amphibians, how many studies of the susceptibility of reptiles and amphibians to nickel and copper are in the literature compendium that underlies the EPA protocol?

A I would hazard a guess there would be very few if there are any.

Q Same question for mammals.

A Mammals would be in that range of five to ten species as well that are commonly used.

Q What are the common lab animals for testing the susceptibility of mammals to copper and nickel?

A Well, there are a number of rodent studies, mice, including the deer mice -- that are a species of deer mice. There are voles. There are occasionally some larger rodents and some rabbits and that sort of thing. A lot of good data comes from species of domesticated animals that are derived from veterinary work that's been done over the years.

Q Dogs and cats?

A Dogs, cats, sheep, horses, cattle.

Q So is it fair to say that there are in the Upper Peninsula of Michigan dozens of species of mammals that are not the subject of nickel or copper toxicity studies in the literature compendium that underlies the EPA protocol?

A That is correct.

Q Same question on invertebrates. Can you give us some sense of how many studies are in the EPA literature compendium that have tested the susceptibility of invertebrates to the toxicity of nickel and copper -- or copper?

A I would say that the predominant database is derived from six or seven different groups of invertebrates that live in soils.

Q Would you agree with me that there are probably thousands of species of invertebrates in the Upper Peninsula of Michigan?

A Yes.

Q Would it surprise you to -- if I were suggest to you that on the property of the Huron Mountain Club some 6,000 species of beetles have been identified?

A There are many, many species of insects everywhere, so I would want to see the list, but it wouldn't be a big shock if that's correct.

Q Are you familiar with Dr. Haldane's line about beetles?

A No, I am not.

Q When asked whether his lifetime of biological research had given him any particular insight into the mind of God, my understanding is his response was that, "Yes. God has an inordinate fondness for beetles."

MR. DYKEMA: I apologize, your Honor. I realize that was not a question.

Q Am I right that the vulnerability of invertebrates to metal toxins such as copper and nickel varies enormously?

A There are some very resistant species. That is correct. Most of the tests are designed to look at the most sensitive species that are available.

Q But one can only know the sensitivity of a species by testing it.

A That's not entirely true. One can extrapolate from known information about the responses of different companion or related species.

Q So if you have data on the susceptibility of a member of a particular invertebrate family, you can posit a reasonably sound hypothesis that other members of that family will exhibit similar susceptibility.

A It may not even be with family. It may be with behavioral traits, life history traits, the mechanisms of exposure that the organisms exhibit.

Q When referring yesterday to the background levels of toxins such as copper and nickel, I think I heard you say that the background is what God put there. Is the background level the natural level?

A Yes.

Q And do I understand the EPA protocol to require that further inquiry for further testing is called for if a particular contributor of toxins is going to elevate the total level of environmental toxins above the background level?

A No, that's not correct.

Q Is it that's one of the requirements is that it be elevated above background?

A Yes.

Q We're looking now, Dr. Kapustka, at your demonstrative slide 16 in which you have helped us to understand fate and transport mechanisms. In the box that represents soil, you have an arrow indicating that some amount of atmospherically deposited metals will be taken out of the system by percolation or leaching?

A Correct.

Q And will the materials that percolate or leach wind up in the groundwater?

A They may if they are in contact with groundwater.

Q Does "percolation" mean carried off by water?

A Yes. If you think of the old coffeepot percolators where the water flows through the matrix of the grounds, the water flowing through soil, if the channels are large enough, for example, an abandoned burrow or a root that has decomposed and now there's a cavity, when the water flows through there, that would be percolation.

Q The EPA protocol that you explained for us yesterday establishes thresholds, as I understand it, for birds, mammals, plants and invertebrates.

A Correct.

Q It does not establish thresholds for fungi?

A It does not.

Q And if I understood your testimony yesterday, your view is that if the atmospheric deposition of nickel and copper caused by this mine were substantially greater than the MDEQ has projected, you personally would have some concern on potential impacts on mycorrhizal fungi.

A I don't believe I would phrase it as a concern. I would be interested in looking at that to see if it is a concern.

Q That if the atmospheric deposition of nickel and copper were substantially greater than the MDEQ model projects, that, in your view, would warrant further investigation?

A It could.

Q You testified yesterday that mycorrhizal fungi have performed different functions with respect to metals among different classes of plants. Did I understand that correctly?

A That is correct.

Q And if I understand what you were saying, it is that in some cases mycorrhizal fungi are facilitators of metal uptake by their post plants.

A Correct.

Q But in some cases they are inhibitors and that the fungi actually accumulate metals and prevent the uptake by their host plants.

A That is correct.

Q And I think you said that one can generalize for some whole classes or categories of plants that their fungi tend to be either facilitators or inhibitors.

A Correct.

Q But in some classes of plants, it's a mix.

A That is correct.

Q Now, in most cases where the mycorrhizal fungi are inhibitors and hoard the toxic metals that they're exposed to, does that raise a concern for the well-being of the fungi itself?

A It does not appear to be the case because they have evolved to be extremely tolerant of the metals and found -- these types of mycorrhizal fungi are found in highly mineralized areas. That's where this phenomenon has been initially discovered.

Q Is that true of all mycorrhizal fungi?

A No, it is not.

Q So your point is that in some cases it has been demonstrated that mycorrhizal fungi are highly tolerant of toxic metals?

A Correct.

Q But that has not been demonstrated as a generalization for all mycorrhizal fungi?

A That's correct.

Q So would you agree with me that it is not unlikely there are species or classes of mycorrhizal fungi that are not highly intolerant to toxic metals?

A I would.

Q Am I right that there are many species of plant that have a symbiotic relationship with their mycorrhizal fungi?

A Yes.

Q And am I right that there are many species of plant that will suffer or die if their mycorrhizal fungi die?

A There are a very few species that have a one-to-one relationship between the mycorrhizal and the host. The majority of plants, particularly the grasses and herbaceous plants, but also to some extent, the deciduous trees and the coniferous trees, they will tend to have multiple mycorrhizal species colonizing their roots at the same time, and the fungi indeed are observed to be in somewhat of a competitive interaction to where -- it depends on which fungus is closest to the root at the time that root is growing in that area. That will determine which of those fungi will become the symbiont. So it is not a -- there is not an absolute requirement of one-to-one relationship with very few exceptions.

Q	If I understand what you just said, the vulnerability of plant species -- let me start over again. The extent to which plant species will suffer or die from the loss of the mycorrhizal fungi varies quite a lot?

A	It does.

Q	Are you aware of any studies that have attempted to assess the impact of heavy metal contamination in an old growth hemlock hardwood forest?

A	I don't recall any at this point.

Q	The EPA protocol that you've explained for us yesterday does not provide a basis for assessing potential impacts to fungi; correct?

A	Correct.

Q	You testified yesterday about some of the materials you reviewed in preparing your opinions and in preparing to testify. Did you review the testimony of Dr. Kerry Woods?

A Is he from CRA?

Q No.

A "No"?

Q He's with the Huron Mountain Wildlife Foundation?

A I may have. I don't recall the -- I haven't linked up the names to everything yet.

Q Do you recall any testimony regarding the number of rare and unusual species of fungi that have been identified in the Huron Mountains?

A Okay. I glanced through that, yes. I don't have the number.

Q Are liverworts and bryophytes fungi?

A No, they're not.

Q Are there any studies in the EPA literature compendium that underlies the EPA protocol that assess the vulnerability of bryophytes and liverworts to heavy metal contamination?

A No, not directly.

Q We're now looking at slide 19 in your demonstrative, Dr. Kapustka. And I got confused when you were answering questions about what the background concentrations are in Michigan. Can you clarify that?

A The background for copper is -- I believe it was 15.5. It shows up on another demonstrative slide that I used.

Q Okay. Let's go to the next slide, number 20. Does this help you?

A Yes. 15.5, and for nickel, it was 19.4.

Q Okay. And do you know where in Michigan those background concentrations were measured?

A In the reports of the Michigan DEQ, that was described as the area in the Upper Peninsula near the -- that was relevant to the project area. I don't have the specific location.

Q Okay. But your understanding is that's local?

A Yes.

Q And were these measurements taken by the state government in the context of this proceeding, or was this in the available literature?

A I believe it was in the literature.

Q And your understanding of the literature is that it's local to some extent?

A Yes.

Q Do you have any sense of how variable the background levels are in the Upper Peninsula of Michigan?

A I don't have firm sense of that, no. I would hazard to say that it's not as -- on the lowest end of the range, and it's not on the highest end of the range of North America.

Q Well, would it be safe to assume that over the course of your distinguished career, you've seen a fair amount of literature on background levels of toxic metals and soils?

A Yes.

Q Just help me to understand, if 15.5 is an average measurement of background levels of copper in the soils in the Upper Peninsula of Michigan, what kind of variability would you expect to find if there were extensive data available?

A Extensive data, I think the range could possibly reasonably be expected to be from 10 to 20 milligrams per kilogram of copper.

Q And would you expect the variability for nickel would be on the same order of magnitude?

A Possibly, yes.

Q Well, you say "possibly." Anything's possible. What kind of variability would you expect for --

A I would expect similar variability.

Q Okay. When you were testifying about slide 20 yesterday, I think I heard you mention a study by someone named Sweet?

A Yes.

Q What's that?

A That is the study that was of the regional deposition in the Great Lakes area. It was a summary of wetfall and dryfall concentrations that were measured over, I believe, a one- or two-year period. And it was reported as a -- both the air concentration and then as a deposition rate. It's in the Journal of Water, Air and Soil Pollution, I believe. I can get that reference if need be.

Q Oh, I think that will be enough. And that nickel and copper, I think you testified, generally gets into the atmosphere from industrial activities.

A Industrial activities is one contributor, but just the natural retrainment of dust from areas that can be quite some distance away contribute to that.

Q Am I right that a substantial amount of the mercury in the United States comes from China?

A That seems to be the evidence, yes.

Q Did you have occasion in preparing your opinions in this case to examine the background levels of mercury in the area?

A I saw the information that was available. Mercury is more of an issue for the aquatic system, and so in looking at what was in the dust or potentially in the dust and what would be contributed by the Eagle Mine, there wasn't any indication of mercury being an issue for the terrestrial system.

Q Returning briefly to mycorrhizal fungi -- and forgive me if I've asked you this question before, but if the deposition rate from this mine were ten times what MDEQ projects, would that, in your view, warrant further investigation as to potential harmful impacts of the mine with respect to mycorrhizal fungi?

A If mycorrhizal fungi were determined to be a significant factor, there might be a need to investigate further. That's correct.

Q I'd like to ask you a couple questions about the materials you reviewed in preparing your opinions and your testimony here.

A Okay.

Q I believe you said yesterday that you reviewed the testimony of Dr. Ejnik?

A Yes, I did.

Q And Dr. Flaspohler?

A Yes.

Q And I don't know if he's a doctor or not, but a gentleman named Depa?

A Yes.

Q Did you review any other testimony? Well, let me be clear. I think you mentioned today that you may have quickly looked over Kerry Woods' testimony?

A Yes.

Q Did you review any other testimony in preparing your testimony today?

A Was it Steve Kish?

Q Kish. Okay.

A Yes.

Q Anyone else?

A I believe those are the ones that I focused on.

Q Did you review the testimony of a gentleman named Sube Vel?

A Not that I recall.

Q Did you review a deposition modeling report prepared by Conestoga-Rovers Associates?

A I looked at it. I didn't review the entire report in detail.

Q Okay. But in preparing and formulating your opinions in this case, you relied upon the deposition modeling done by Mr. Kish for the DEQ?

A That is correct.

Q In reviewing Mr. Kish's testimony, did you take note of the fact that Mr. Kish acknowledged that the DEQ model only tried to measure particulate emissions from 2 of 30 sources at the mine site?

A Yes, I did note that.

Q And did you take note of the fact that Mr. Kish acknowledged that as a result, his model only captured 70 percent of the metal emissions?

A I don't know if that's how it was characterized. The percentage doesn't necessarily walk all the way across the different sources. When asked to take into account -- if you look at massive particulates, that may be correct, but because there are different compositional characteristics of the different sources, one can't just assume that that translates as a 70 percent capture of all of the metals.

Q Now, looking at the Bureau of Land Management protocol in the bottom half of your slide 23, I was a little confused yesterday. My understanding was that the way BLM does it is they determine the lowest documented toxicity level --

A Correct.

Q -- and then divide that by 2, 4, 6 or 8 by way of extrapolation.

A Correct.

Q So looking at birds, for example, the bottom of their range is 7 milligrams per kilogram. That number, 7, is the result of some kind of division?

A Yes, it is.

Q Okay. How was that -- how was that derived, if you can explain it?

A The source data that was used in that bird test I believe was some poultry. I don't recall offhand which species it was. So to extrapolate from the test animal to robin, they used -- they divided the test results to get this number which is now extrapolating below the test data.

Q What was the division? Was it 2, 4, 6 or 8?

A I would have to look at that. I don't know offhand.

Q How do they decide which divisor to use?

A The taxonomic distance from the species of interest to the test organism that they relied upon.

Q And if the taxonomic distance is greater, is the divisor larger?

A Yes.

Q So if one is going from a chicken to an eagle, one uses a big number?

A Yes.

Q Whereas, if one is going from a chicken to a spruce grouse, you use a smaller number?

A Correct.

Q Are you aware of any studies that have measured the toxicity of the spruce grouse to copper or nickel?

A No, I not.

Q Are there any studies that measure the vulnerability to copper or nickel of North American birds of prey?

A I don't know of any offhand.

Q So you don't know if there are any such studies in the compendium that underlies the EPA protocol?

A There may be. I just haven't looked at it to search that answer.

Q Approximately how many studies are encompassed in the compendium that underlies the EPA protocol?

A It will depend on the different taxonomic groups. And if we're focused on the birds here, I think it's in the hundreds of studies that were used.

Q And for plants?

A The numbers that qualified for plants, I'm trying to remember. The numbers that were looked at were large, but the way the data were qualified to get the most appropriate and the most sensitive end points based on bioavailability, I think the plants studies for copper were probably a couple of dozen.

Q In reviewing the testimony of Steve Kish, did you take note of his testifying that the MDEQ model assumes that Kennecott will install a filter on the main vent stack that will effectively eliminate 85 percent of the particulate emissions from that stack?

A Yes, I did.

Q Do you know anything about how that filter will operate?

A That's a bit out of my expertise. I don't know the details of that.

Q So I gather you're not in a position to offer an opinion as to whether effective filtration of the main vent stack is technology feasible?

A I have no reason to not believe that it's technology feasible. And I think the other key part is I understand that's been incorporated into the permit -- into the air permit.

Q But you haven't seen anything suggesting what kind of a filter they're going to use?

A I have not looked at that in detail.

Q I think you testified that you briefly looked at the CRA deposition analysis?

A Correct.

Q But you did not review Mr. Vel's testimony?

A I did not.

Q Please accept my representation that the CRA analysis indicates that if the main vent stack is not controlled, the total particulate emissions from the operation of the mine will be 64 times as great as the MDEQ projects. If that is true, if the particulate deposition caused by the mine is 64 times greater than the MDEQ projects, would it be safe to assume you would not offer the same opinions you've offered today -- yesterday?

MR. PREDKO: Let me just place an objection, your Honor, to relevance. There is an 85 percent filter that's required by the permit. And so this line of questioning is just not relevant.

MR. DYKEMA: Your Honor has ruled on this relevance objection before. The fact is, the permit application that Kennecott filed designated that the stack would be totally uncontrolled. We have no information whatsoever as to how it's going to be filtered or whether the filtration will be effective or whether such a filter is even technology possible. So this is certainly relevant because the application that Kennecott filed designated an uncontrolled stack.

JUDGE PATTERSON: I'll allow him to answer.

Q Let me put the question to you again because I think --

A Please.

Q -- as I asked it before, I tied myself up in verbal knots. Is it safe to assume that you would change your opinions in this case if you were convinced that the particulate emissions from this facility of copper and nickel were 64 times greater than the MDEQ model projects?

A Not necessarily because I would need to look at how that would influence the deposition across the landscape.

Q If you were convinced that the maximum deposition in a particular location of nickel and copper were 64 times greater than the deposition that you show on slide 23, would you change your opinions?

MR. PREDKO: I'll just place an objection. There's absolutely no foundation for the concentration deposition being 64 times greater, your Honor. There's nothing in the record as to that.

MR. DYKEMA: On the contrary, that is exactly what Mr. Vel testified to.

JUDGE PATTERSON: The record will speak for itself. I frankly don't recall. It can certainly be answered in a hypothetical sense.

A Well, if I'm answering hypothetically, I would still need to look at the relationship and recall that what I was looking at here is the screening level portion of a risk assessment. If that case did occur the way you described it, what that would mean is that one would then begin to look at the next phases of risk assessment, so one would go beyond the screening level and begin to look at a more detailed analysis of what is going on there, and that would bring into play quite a number of different considerations. One would look at the form of that material, the bioavailability of that material, how it is mixed into the soil. And there are a number of other parameters that would be looked at. So the final opinion might be rephrased a little bit, but the ultimate conclusion might be very similar.

Q It might be. But if the maximum deposition rates were 64 times greater than the MDEQ model projects, if I understand you correctly, you're saying you would not be in a position today to offer the same opinions you offered yesterday. Instead you want need to do further analysis.

A I would have needed to do a little bit further analysis, but again that would simply be to refine a few areas and we're talking about spatial relationships here that are not captured fully by the hypothetical that you presented.

Q Okay. And would the same be true if the maximum deposition rates were ten times greater than the MDEQ projects?

A At ten times greater, there would be some interest in looking at the -- really just looking at the bird relationship and very possibly in a very small area look at the plants. But what I need to come back and reemphasize is that these values that are projected here are of the maximum deposition area, that there are substantial -- this is a fairly small zone of influence, and one would need to look at the spatial relationship of that zone to the remainder of the area of interest. And so I would think that even under those situations, the further analysis would only have minor modification on the strength of the opinions that I offered yesterday.

Q But you're not in a position now to say how much those opinions would be modified because you would need to do that further investigation.

A Some of it may be very cursory because I would need to know where it is and, from what I have observed, that elevated concentration that would trigger any further examination is largely, if not entirely, within the facility footprint.

Q Is that also true if the maximum deposition is 64 times the MDEQ projection?

A The majority of that -- my expectation, having looked at the model outputs, the diagrams, is that would still be largely within the industrial footprint.

Q And by the model output and diagrams, you're referring to the MDEQ model?

A Both. Both the MDEQ and the CRA isopleths that I've seen.

Q What's your understanding of the pH of the soils in the area?

A Slightly acidic in some cases, circumneutral in other areas.

Q Forgive me if I've asked you this before, but did you study the potential impact of particulate emissions from the mine, particularly sulfur compounds and their effect on acidification?

A In studying, if you mean did I review some of the information that was presented by the DEQ, yes, I look at those numbers and examine how they relate to potential impacts. Yes, I did.

Q Is it your understanding that the soils in the Yellow Dog Plains are very sandy?

A There are some sandy areas.

Q Are most of the soils in the Yellow Dog Plains sandy, or do you know?

A I don't know the percentages, no.

Q In the literature compendium that underlies the EPA protocol with respect to invertebrates, does that literature include studies of the vulnerability of mollusks to copper or nickel?

A I don't recall any studies that would be on those, no.

Q Do you have an understanding as to whether land snails are particularly vulnerable or invulnerable to heavy metal toxins?

A I don't know that they're particularly vulnerable.

Q Again, Doctor, we're looking at slide 16 with which you've educated us on fate and transport mechanisms. Can you generally describe for us how this system will be altered in the immediate area of the mine if all the trees are removed?

A Right in the industrial footprint you're talking about?

Q Yes.

A If all the trees are removed, it would -- there will probably be -- some of the understory species would become more dominant. There would be some grasses or there would be some shrubbery that could grow there. It depends on the amount of disturbance that's going on.

Q Well, assume with me for a moment that generally surface foliage is removed in the industrial compound itself.

A And we're talking about during operations?

Q Yes, sir.

A Okay.

Q What effect will that have on the fate and transport of metal-bearing particulates that fall in that area?

A Well, then they would be subject to -- if all of the vegetation is removed, and that would tend to minimize the numbers of soil invertebrate that would be active there as well, the possibility for some dust and some surface runoff might occur. But that gets into what the operational practices of the mine would be as to whether there's any dust allowed or that sort of thing.

Q But you will likely have more heavy metal particulates in the surface runoff as a result of the defoliation of the area?

A I would presume that would occur, yes.

Q And more percolation and leaching?

A Not necessarily.

MR. DYKEMA: Doctor, I expect others will have more questions for you. I'm finished, and I thank you for your patience and cooperation.

THE WITNESS: Okay.

MS. HALLEY: No questions.

MR. REICHEL: I have no questions at this time.

REDIRECT EXAMINATION

BY MR. PREDKO:

Q Doctor, Mr. Dykema was asking you questions about the diagram on slide 5 here. And I believe you said in response to one of those questions that for a scoping exercise done with the values here, that for one species you would require or want more scrutiny?

A Yes.

Q And, in fact, more scrutiny in this case was applied because you moved up to the Eco-SSL screening exercise?

A Correct.

Q And it was under that exercise, more scrutiny, that you determined that the levels in this case were, as we put it earlier, in the green, no adverse consequences?

A Correct.

Q And, therefore, no additional scrutiny is necessary?

A Correct.

Q Mr. Dykema was asking you whether the studies that underlie the EPA eco soil screening approach, whether there were laboratory studies that covered all species, and your answer was "no," they don't cover -- the laboratory species themselves don't cover every, single individual species.

A That is correct.

Q Can you tell us why, though, the Eco-SSL's are deemed protective of all species?

A There are two components to that. First of all, the procedures that were incorporated in the standard operating procedures, the scrutiny was to get studies that maximized bioavailability and had ecologically relevant end points of growth and survival and reproduction incorporated in them. Another aspect that is more, I guess, gleaned by having been in the profession for a couple of decades is the published literature favors publication of reports that report sensitivity of organisms. So whether they're university faculty or whether they're government research laboratories, and to some extent even industry laboratories, the focus is on getting species that respond. There have been a lot of studies done on the species that are -- that don't show a response to chemicals and those are very difficult to get published. So the bias, if you will, that exists in the literature is to move toward the most sensitive species, and that's what is reported. The environmental -- modern environmental movement is now about 30-some years old, maybe approaching 40 years, and there has been a lot of effort going in to try to find test organisms that can be relied upon to give us information. And so the regulations that are in place for protection of water and soil, and wetlands as well, have been largely dependent on the data from these kinds of studies. And so if there are gaps in the literature it's more likely that those gaps are on the high end, the more tolerant species.

Q In your opinion, Doctor, is there any other generally accepted method in your field of risk assessment other than the eco-SSL's that is appropriate for use in assessing risk in a case like this?

A I don't believe there are.

Q Mr. Dykema had asked you whether you had reviewed the testimony of Dr. Woods, research director at the Huron Mountain Club. And do you understand that -- where generally the Huron Mountain Club is located with respect to the mine site?

A It's quite a bit to the north and a little bit west, if I understand correctly.

Q And I was using my pointer to point to the demonstrative map we have here. Generally the lands are up in this (indicating) area?

A Okay.

Q Now, you've reviewed the MDEQ deposition analysis; right?

A Yes.

Q And can you show me with your pointer on that -- on the same map here where the maximum concentration levels will be deposited according to the MDEQ analysis?

A If my eyes are good enough for that distance, I would say that the maximum deposition area is approximately around the location where I believe it's -- the word "river" might be on the map there. It's very near that.

Q And for the record, you're pointing to a location that is just outside the red outline which represents Kennecott owned and leased land?

A Correct.

Q And you've also reviewed petitioner's deposition analysis, what's been referred to as the CRA report; correct?

A Yes.

Q And you reviewed the isopleth deposition chart that they prepared showing petitioner's version of deposition?

A Yes, I did.

Q Okay. Now, with respect to either the MDEQ deposition analysis or petitioner's CRA deposition analysis, either one, in your opinion what affect will particulates from the mine have on the area of the Huron Mountain Club up to the north?

A There is no expectation to have any affect that far away. The CRA isopleths in one way differed from DEQ because DEQ focused on a couple of areas of maximum deposition; whereas, the CRA gave a more complete family of contours. The center from the CRA isopleths was right within the footprint, and very rapidly declined as one moved from the center outward to where there were really trivial concentrations beyond a couple of kilometers away from the source.

Q And so what opinion do you have about whether any species of animals or plants or invertebrates that reside on the lands of the Huron Mountain Club -- what opinion do you have with respect to whether they will be protected?

A They will be fully protected.

MR. PREDKO: Thank you, Doctor.

MR. REICHEL: I have nothing further.

MR. DYKEMA: Just a few, your Honor.

RECROSS-EXAMINATION

BY MR. DYKEMA:

Q When you're referring to the isopleths prepared by CRA, do you recall if the deposition model maps you were looking at were based on the assumption that the main vent stack would be effectively filtered?

A I don't know if it was. I think it was, but I'm not certain.

Q The opinions that you've offered and that you've expressed in response to Mr. Predko's questions right now, those are limited to terrestrial impacts; correct?

A That's correct.

Q You noted that it's harder to publish a paper that shows a lack of toxic vulnerability than it is to publish a paper that finds toxic vulnerability?

A Yes; that's correct.

Q Okay. Now, you don't mean to suggest by that that the hundreds of species of birds that have not been studied or whose vulnerability is not in the EPA database -- you don't mean to suggest that all of those species have, in fact, been studied and have been found to be relatively tolerant to nickel and copper?

A Not at all.

Q Okay. Or the thousands of species of insects have not been studied?

A No; I wasn't implying that at all.

Q Or all the species of mammals that have not been studied?

A Same answer.

Q I think you said, just to take one example, you're not aware of a study of the vulnerability of the spruce grouse to copper and nickel?

A Correct.

Q So wouldn't it be fair to say, "We just don't know how vulnerable that bird is to copper and nickel"?

A Well, at one level you're correct; on another level we can bring other information to bear. And if they were markedly vulnerable they would not occur wherever there's soil concentrations of copper that are anywhere elevated, and that's just not the case. We find these organisms living on soils that have substantially similar amounts of copper that are here in Michigan and higher in some other places. So there's no field evidence that would point one to a hypersensitivity of these species that you're referring to.

MR. DYKEMA: Once again, Doctor, thank you.

THE WITNESS: You're welcome.

MS. HALLEY: Your Honor, I do have just a couple of questions, if I might.

JUDGE PATTERSON: Okay.

MS. HALLEY: Hi.

THE WITNESS: Hi.

MS. HALLEY: I'm Michelle Halley representing the National Wildlife Federation and the Yellow Dog Watershed Preserve; just a couple of questions.

CROSS-EXAMINATION

BY MS. HALLEY:

Q In looking at your experience it looks like you've been involved in many ecological risk assessment processes; is that correct?

A Yes, I have.

Q About how many?

A I have been the lead on probably 20 and I've been part of either producing or reviewing a hundred more.

Q Okay. What does that typically entail? What does the process typically look like?

A It depends on -- there's a wide range of experiences. There are a very few situations where one has the opportunity to get into the project right at the beginning, structure all of the investigations that would be undertaken and gather the data and then report that out. More typically risk assessments are done quite some distance in or sometimes almost at the end of a particular project, and in those cases it's usually because someone has identified a potential concern, and then one looks at the data. And so it covers the entire spectrum from a very detailed focus after it -- from the beginning to post analysis of all of the information that's been pulled together.

Q Okay. Is an ecological risk assessment -- would you consider that a component of the cumulative impacts assessment?

A It can be; it doesn't -- it isn't always.

Q In a situation where air deposition is known to be a part of the overall impacts to the close environment, would you say that it's an important part of the cumulative impacts analysis?

A It can be; it depends on what specific questions are being asked and how much rigor is deemed necessary to put in to that risk assessment; because there are situations -- and I think that in the case we're talking about here the initial analysis that was done of the application indicated that there wasn't going to be a substantial impact beyond the fence line and, therefore, there wasn't an initial need to even consider that. In hindsight, that may have been -- it may have been beneficial to have it, but it was still fully reasonable to bring it in much later.

Q All right. Now, in your experience of being involved in many of these data-gathering and processing settings, --

A Yes.

Q -- is there some sort of a set series of, you know, data that needs to be collected and analyses that need to be performed in order to conduct a cumulative impacts analysis?

A They're in -- if you look at all of them collectively there will be some patterns, but generally these are looked at as -- on a case-by-case basis to take into account what the specific issues are, what values are to be protected, what are the plausible mechanisms of connecting the valued resources to the activities that are going to be part of that project. So one of the things that is really important is to tailor that effort to the specific questions that have to be answered.

Q All right. Now, for a proposed underground sulfide mine, could you talk about some of those patterns for a cumulative impacts analysis that you believe should be part of the process?

A Well, I think that in this particular case the engineering information that is generated as part of the application forms the basis of -- that's the starting point. What are going -- what activities are going to be there? What's the industrial footprint? What are the types of resources that are going to be brought in? What are the emissions that are expected from those activities? And if we follow through that, I think that that was indeed provided as part of this application.

Q Just to be clear, I'm not asking you necessarily about whether you think that these steps were followed here or not; I'm asking in a more general sense.

A Okay.

Q Okay. So your step number one is the engineering information informs the process; that seems like a right place to start.

A Yes.

Q And then what?

A Then it's a matter of the context. Where is this located? What are the landscape features that are relevant to those activities? How do those relate to the valued resources that are in and around that facility?

Q And then what?

A Then it's a matter of determining how -- one of the bits of jargon we use is a "conceptual model." It's a depiction of how the world works, if you will. What goes on there? How do the connections between the activities and the resources occur, and are they plausible?

Q What are some of the processes you would want to look at in your conceptual model of interconnectedness and how things look together?

A I think much of it was depicted in the demonstrative illustrations I used on fate and transport. What are the relationships that are going to occur and to put that in spatial context. Where do these events -- where are these processes happening?

Q So are we talking about slide 16?

A Yes, that would be an example of it.

Q This one?

A That one, yes. But then that's just for the terrestrial. In there would be the other components that other witnesses are responding to.

Q Okay. So you wouldn't want to characterize the whole system and how it interacts; the whole ecosystem and how the different components interact?

A At one level, yes, and then focus in on those that are the most important questions.

Q Okay. And how do you do that focusing in process?

A That's part of this scoping activity if you were doing -- if you're doing this under a risk assessment framework. And almost -- we do these things even if we're not formally thinking about a risk assessment. We go through that high elevation view of the system and then focus in on those things that are noteworthy, and that's how one determines where to put the effort.

Q So you would anticipate that a process similar to the one you just described for us: the scoping, the screening and on up; sort of that triangle -- that rectangle put into triangles. That would happen for a number of different parameters?

A Yes, I would think. Yes.

Q Okay. Like what other parameters would you expect to see for an operation like this, just out of curiosity?

A Well, I would think that it applied to the different sources that we've talked about here at some length: the air raise system, the crusher, the water that was talked about, --

Q The water? I'm not sure what you mean.

A -- the witnesses before me. Doug, when he was talking about the impacts on fisheries and all those things. Those are all connected to that same type of analysis.

Q Okay. Air, water. What else?

A Well, all of the things that are relevant, which include the land, the land uses and so on.

Q Okay. And for those components you'd also, it sounds to me like, want to see what you call an -- what you refer to, I believe, as an "additive impacts analysis" as part of the scoping and screening process; is that right?

A If by "additive" you're implying that there are multiple activities in the vicinity that are impacting those resources, that is a typical thing that is done, yes.

Q What does that usually look like?

A It's often more qualitative than quantitative.

Q What components go into it?

A One illustration I believe has been mentioned here before is that the area just -- I'll be pointing here on the map -- just surrounding some of the industrial footprint, a good portion of that has been logged fairly recently. So that level of human impact on the area is taken into account, if you will, to recognize -- and really, to put it in context so that one's looking at that kind of a disturbance regime rather than some hypothetical landscape that may have never existed, or if it did it may have been two centuries ago.

Q So you look at historical uses -- logging in this instance -- in this area, the current shape of the landscape; right?

A Yes.

Q And do you try to look forward a little bit? For example, in this we know that in order to develop the surface facilities there's a plan to scrub about a hundred acres of surface. Would you look at that too if you know that's a foreseeable part of the plan?

A That would be a legitimate thing to consider at the beginning. How far one takes it depends on the context of the questions again.

Q Sure.

MS. HALLEY: Thank you, Doctor.

FURTHER DIRECT EXAMINATION

BY MR. PREDKO:

Q Doctor, just so the record is clear about which CRA analysis that you looked at, we're going to put up on the screen here what is Petitioner's Exhibit 81. And, Doctor, now looking at this, is this the CRA deposition analysis that you reviewed?

A Yes, it is.

Q And can you tell us again about where the maximum concentrations are predicted by petitioner's in this case?

A Yes, the -- for orientation the red outline is the property. The maximum concentration is -- excuse me. The maximum deposition is right at that very core and I believe that that -- I guess I'm going on memory more than sight. I believe that's 35 milligrams per meter squared per year is what that most -- innermost circle, ellipse represents. And from 35 this drops down going northward to somewhere near eight milligrams per meter squared. On the north end that same portion --

Q We're going to try to blow it up even further, Doctor, so that we can read it.

A You might just go over to there and change that -- there you go. Yes, I can see "35" right now. So on the -- going northward between -- right around seven micrograms of copper per meter squared is projected, and this is on an annual basis. By the time you get out -- if I remember the scale correctly, this is approximately two -- this line of two is less than a kilometer from the boundary here. And so the impact from there on just diminishes very markedly.

Q And so if I'm looking at the diagram correctly, the -- what is the furthest isopleth out that we can identify in this map? I believe the -- what I can read right there is ".25"?

A I believe that was correct.

Q Okay. And --

A But there's one outside of that yet.

Q And to be clear again -- and I think I misspoke, Doctor, and you corrected me. I called it "concentration," but actually what CRA's analysis shows is deposition in milligrams per meter squared?

A Correct.

Q What would you have to do to turn that into soil concentration?

A It depends on how much soil mixing one wishes to consider. If we use the same parameters that Michigan Department of Environmental Quality used, their mixing was in one centimeter of soil depth. If one takes a typical soil, the bulk density of the soil is 1.6. There are -- in a meter there is a hundred by a hundred, so when you multiply this out it turns out to be 16 grams per one square meter of soil at one centimeter depth. So to convert these deposition rates to a soil concentration of one centimeter depth, each of these numbers have to be divided by 16 and that would then convert -- 30 would be approximately two milligrams per kilogram of soil concentration in one year, and if we just round it off to ten years of operation that zone right in the very center -- that is, the 35 milligrams per meter squared -- one would be looking at approximately 20 milligrams per kilogram copper introduced into that tiniest of the circles. So by the time we get to the border on the north, we're talking about less than one-half of the milligram per kilogram copper concentration in the soil. And so in some ways this depiction, which I think is perhaps a more detailed air dispersion model than perhaps the DEQ used, it gives a lower value when one gets outside of the boundary than what the MDEQ used in generating its maximum concentration of 0.7 milligrams per kilogram copper.

Q And so by the time you get out to this isopleth right here that we identified as the .25, and we are in an area that's right outside the Yellow Dog Plains, this being the plains here, you would divide that .25 by 16 to get soil concentration?

A For the annual contribution, yes.

Q And when you do that, how would you classify the soil concentration in that area, or characterize it?

A It's clearly in a diminimus zone for any deposition. There's virtually no way that one would ever be able to see an elevation of soil concentrations resulting from this project, and there would be no expectation whatsoever of any kind of a biological response to that material being deposited.

Q And I imagine -- although, we don't have it here on this map -- if you carried these isopleths out, you continued to model further and further out -- and I'm pointing to now this -- our map on the board here -- and carried them out further and further and further -- if you characterized the amount just outside of the Yellow Dog Plains as diminimus in measurable, how would you characterize an amount that may be up on the Huron Mountain Club?

A Well, when you're in the diminimus zone, does it make any difference beyond that you're in any sort of analytical noise level, remembering that there is a regional deposition that's coming from wet fall and dry fall that is approximately equal to -- I think it's .8 -- .08 milligrams per kilogram soil. There's no way that you would ever be able detect this amount added into the natural regional background deposition.

MR. PREDKO: Thank you, Doctor.

MR. DYKEMA: One very quickly?

JUDGE PATTERSON: Yup.

FURTHER CROSS-EXAMINATION

BY MR. DYKEMA:

Q Doctor, do I understand you correctly that you're saying to convert a deposition rate of milligrams per square meter per year to soil concentration milligrams per kilogram you divide by 16?

A That's if one is going to mix it in one centimeter of soil.

MR. DYKEMA: Okay. Thank you. That's all.

MS. HALLEY: Nothing.

MR. REICHEL: No questions.

JUDGE PATTERSON: Thank you, Doctor.

THE WITNESS: You bet.

(Witness excused)

MR. PREDKO: Can we take a short break, your Honor?

JUDGE PATTERSON: Yeah.

(Off the record)

JUDGE PATTERSON: Are you ready?

MR. PREDKO: Yes, your Honor.

JUDGE PATTERSON: Okay.

MR. PREDKO: Kennecott calls Dr. William Adams.

REPORTER: Raise your right hand, please. Do you solemnly swear or affirm that the testimony you about to give will be the whole truth?

MR. ADAMS: I do.

WILLIAM J. ADAMS

having been called by the Intervenor and sworn:

DIRECT EXAMINATION

BY MR. PREDKO:

Q Dr. Adams, could you please state your full name and spell your last name for the record?

A Yes, my name is William James Adams, A-d-a-m-s.

MR. DYKEMA: Your Honor, if I may I'd like to take this moment to lodge our objection for the record. Mr. Adams' disclosure or recitation of testimony is about 12 words; in our view that's grossly inadequate. We had virtually no idea up until today what he's going to testify to. We were not granted any discovery, so in my opinion allowing him to testify is unfair. Also it was Kennecott's burden in submitting its application to demonstrate that this mine would not pollute, impair, destroy natural resources. Any testimony as to the toxicological impacts of this mine should have been submitted to the DEQ in the context of the application and made subject to public comment according to the statutory scheme. And for that reason as well we object to his being permitted to testify today.

MR. PREDKO: Rather than restate the entire response I had to the same objections of Dr. Kapustka's testimony, I would just refer back to the same response that I had and incorporate that here, your Honor.

JUDGE PATTERSON: And again, for the reasons previously articulated most recently in response in to the last witness I will overrule the objection.

Q Dr. Adams, where are you currently employed?

A I'm currently employed by Rio Tinto located in Salt Lake City.

Q Okay. And what is your position there?

A My position is I am chief advisor to Rio Tinto global program for product stewardship.

Q And within the scientific realm, do you have a particular expertise?

A Yes. My specialty is aquatic toxicology.

Q And I'd like to talk a little bit about your background, Dr. Adams. Can you tell us about your formal education and starting with your Bachelor of Science? You received a Bachelor of Science in 1969 and what was that in?

A It was in biological sciences with a major in wildlife and fisheries and a minor in chemistry.

Q And where did you receive that from?

A I received that from Lake Superior State College in Sault Ste. Marie, Michigan, and it's now called Lake Superior State University.

Q And you have a master's degree and you received that in 1971. What is that degree in?

A That degree was in wildlife management and wildlife toxicology, and I received that at Michigan State.

Q And what was your thesis for your master's degree?

A Yes, my thesis in my master's degree was on the study of mercury, particularly two different mercury fungicides that -- and I was studying the potential effects of mercury on birds and in particular on pheasants.

Q And, Doctor, you also have a Ph.D. that you received in 1976. What is that degree in?

A That degree was in fisheries and aquatic toxicology.

Q And where did you receive that from?

A Michigan State University, East Lansing.

Q And what was your doctoral thesis in?

A My doctoral thesis was on a study of toxicity and uptake -- bioaccumulation of selenium in fish and invertebrates.

Q Doctor, what do you consider your hometown?

A My hometown is Detour Village in the Upper Peninsula -- on the eastern end of the Upper Peninsula, and I still own a home there.

Q Okay. And to give us some sense of where that's at on the eastern end, what's the closest major metropolis?

A The biggest metropolis in the area would be Sault Ste. Marie, Michigan and it's about 60 miles to the northwest of Detour Village.

Q Doctor, you have numerous publications that are set forth in your résumé which has been admitted in this matter as Intervenor Exhibit 26, and you authored or coauthored some 90 publications. I don't want to go through every one of those obviously, but if you could give the court some idea of the kinds of things that you've published on, and in particular kinds of things that would relate to the work and analysis that you've done with respect to this case.

A Sure. Some of the early publications that -- early in my career published on selenium, a metalloid and that was dealing with fish and invertebrates. I did an extensive amount of research in the early '80's on toxicity of substances in sediments and I published a publication in 1983 that has actually become well cited worldwide. In more recent times my focus has been on both aquatic toxicology and avian toxicology; extensive work again on selenium. Recently working on the Great Salt Lake setting water quality standard for the Great Salt Lake. I've also published papers recently on copper and the effects of copper on fish and invertebrates.

Q Doctor, have you also written book chapters in the field of toxicology?

A Yes, I've written several book chapters including both organics and metals.

Q And have you authored any whole books?

A Yes, I've authored I think four full books that are in the field of either toxicology or related fields, and the most recent book I coauthored came out last year and it was on copper and sustainable development.

Q Do you have any publications on metal bioaccumulation or metal bioaccumulation factors?

A Yes. I coauthored a paper with Jim McGeer and Kevin Bricks where -- in fact, I have two papers. We specifically looked at bioaccumulation factors and bioconcentration factors for fish for a large number of metals. We subsequently -- that was the first paper, and the second paper subsequently looked at this in a bit more detail for some metals, and in particular for selenium.

Q And I understand you're currently working with and assisting the EPA with respect to copper criterion?

A Yes; that's true. When the draft notice for the development of the freshwater water quality criteria document came out in 1994, I believe, finalized in 1997 we approached the EPA to discuss whether or not a chronic -- acute and chronic criteria for marine systems could be developed in a manner that was consistent with the approach being used for freshwater; that is, an incorporation of a biotic ligand model into the water quality criteria document. The agency has subsequently agreed to that and we are working with them and developing a data set for copper for the marine environment.

Q Dr. Adams, I'd like to talk a little bit about your employment and your employment history. You said that you're currently employed for Rio Tinto. What are the kinds of things that you do for Rio Tinto?

A The kinds of things that I currently do for Rio Tinto cover a broad area. I said the official title is chief advisor for product stewardship, but that includes a broad range of environmental work. Part of the product stewardship program is aimed at understanding emerging regulations and emerging issues for metals, and that's on a global basis so that's primarily Europe, Australia and North America. Within that context I work across the company to ensure that as regulations emerge that they are in fact carried to the sites and that they are in fact adhered to. So a small part of my job is also visiting some of the sites on an annual basis to make sure that our operations are in compliance with local law and with our company standards. Another part of my job is to interface with government regulators on a regular basis with science-based -- where science-based issues are emerging. For example, I participated extensively at the United Nations in recent years on this issue of a strategic approach to international chemicals management. It's a program emerging at the United Nations that we try to unify chemical programs and the way chemicals are managed on a global basis. I also participate in meetings with the OECD, Organization for Economic Cooperative Development. And I particularly serve on a task force there at the present time as -- developing wildlife criteria for classification. I have previously worked for ten years with OECD on development of classification for classifying hazard of substances to aquatic organisms, and I also worked on a task force that developed a dissolution solubility test for metals. That's part of what I do. And I would say half -- the other half I'm responsible for managing a number of sites around Rio Tinto that is -- where we are required to do remediation.

Q And what does Rio Tinto do, the company?

A Rio Tinto is a major mining company. We are major producers of iron ore, aluminum, coal and copper; minor producers of uranium, talc, salt, boron, and a few other minor substances.

Q How long have you been in your position of chief advisor for product stewardship?

A I've been there six years.

Q And was that kind of a dual role? Did you have another role with Rio Tinto as a scientist?

A When I first joined Rio Tinto six years ago, I actually did join as senior scientist for the company. And this role emerged into this product stewardship program. And then this year they added responsibility of managing sites for remediation.

Q So new title, added responsibility?

A New title, yeah, more responsibility.

Q So do you --

JUDGE PATTERSON: Same pay?

THE WITNESS: Yeah, unfortunately same pay. Usual story, yeah.

Q So do you still perform duties as a principal scientist?

A Yes, I do. A good example would be the program that I've participated in for the State of Utah. I served on a science panel for the last three years for the State of Utah for the purpose of developing a water quality standard for the Great Salt Lake. This will be the first water quality standard that exists for the Great Salt Lake.

Q And what is Rio Tinto's relationship with Kennecott?

A Rio Tinto is the parent company. They own Kennecott 100 percent.

Q And prior to going to work for the parent company, where did you work, Doctor?

A Prior to working for the Rio Tinto corporate group, I was employed by the Kennecott Utah Copper in Salt Lake City. And I started there in 1995.

Q And what was your position there?

A My position there was director of environmental science.

Q And what kinds of things did you do as director of environmental science?

A The first five out of six years were spent doing risk assessment work. I was specifically hired to come and assist the company in making decisions, risk-based decisions, about which parts of the property needed to be remediated. So that work was done using risk-based approaches under the spirit of the Superfund. And so that's principally what I did during those first five years. The last year I had a slightly different job. I was director of environmental operations, and I was responsible then for environmental compliance and environmental operations for the Kennecott copper operation.

Q Dr. Adams, I understand that you worked for a number of years for Monsanto Company?

A Yes, I did.

Q And what does Monsanto do?

A Monsanto at the time I worked for it was the third or fourth largest chemical producer in the U.S. And they manufactured multiple types of chemicals, including some pesticides and industrial fluid.

Q What was your position with Monsanto?

A My positions at Monsanto varied across the 14 years that I was there. I initially -- it was my first major job out of college, so I started at entry level scientist. When I left I left as a science fellow.

Q And what kinds of things did you do, duties, responsibilities, over that 14 years for Monsanto?

A It varied a bit, but initially I was hired to come in and set up an environmental toxicology laboratory for Monsanto. This was in 1977. And Monsanto at that time felt they had a need to have a better understanding of both the toxicity and environmental fate of their substances in the marketplace, so I spent the next five or six years actually setting up a small aquatic toxicology laboratory on the site, and then also contracting an enormous number of studies at outside laboratories. After this five- or six-year period, I spent an extended period of time then actually research on waste treatment technologies and set up a small group inside of the company looking at approaches that could be used for soil remediation for treatment of effluents using principally bacteria.

And something that is not in my resume, but during that time period I think I authored about 300 reports for Monsanto.

Q And what is the gamut of those reports?

A Those reports covered extensive acute and chronic toxicity studies. It included studies on biodegradation of substances, it included studies on photolysis, hydrolysis of chemical substances. It included some studies referred to as Mesocosms, some microcosm studies. It included some field studies that we did, surveys of chemical concentrations in water and some cases biota sampling programs that covered across the U.S. looking for presence of Monsanto products in surface waters. And then later on several reports and publications on application of microorganisms to soils and wastewater, including one patent.

Q And I did -- I skipped a gap there. After working for Monsanto and prior to going to Kennecott, you worked at ABC Laboratories?

A Yes, I did. For almost five years I worked at ABC Laboratories, which is the name they go by, but the full name is Analytical Biochemistry Laboratories. It's in

Columbia, Missouri. And while I was there for that five years, I was hired as vice president. And the specific responsibility was to run and direct an aquatic toxicology laboratory.

Q And tell us about some of the studies that you've done or did for ABC Laboratories.

A Well, ABC Laboratories at that time was the largest aquatic toxicology laboratory in the U.S. And we had approximately -- I had approximately 45 to 50 people working for me. And we routinely did acute toxicity studies with a variety of fish and invertebrates and algae and some plants, duckweed, for example. We did chronic toxicity studies, so full life cycle chronic studies with fish and including fathead minnows. We -- those take about a year to do, so we would do one or two of those a year. We did fish early life stage studies with rainbow trout and with fathead minnows, with other trout species. And those studies take anywhere from 30 to 90 days to do, and we probably would run some 15 or 20 of those a year. We routinely did chronic studies with invertebrates that included Daphnia magna, water flea, a commonly tested organism. Typically, we might run 20 to 25 of those a year.

Q Dr. Adams, you were also a member of the United States EPA Science Advisory Board. What is that?

A The Science Advisory Board is a committee that has been set up by the EPA administrator to give advice on the science that the agency will use. And the Science Advisory Board consists of several committees. So depending, for example, the air committee reviews air regulations, air policy, air science. I was on the Ecological Processes and Effects Committee. I was there for ten years. And we reviewed the various pieces of science that would come forward from the agency. For example, all of the sediment work that was brought forward by the agency in attempting to set sediment standards was reviewed by this committee.

Q And how does one become a member of the EPA Science Advisory Board?

A The current process is one whereby there's a notice put in the federal register. You can apply yourself or you can be appointed, nominated by someone, or the EPA itself can ask you to become a member for consideration. In my case, they asked me would I consider joining the board if selected. I responded "yes." I provided my resume and details. And they then go through a vetting process, considered all of the persons that had been nominated. And at the end of this process, then, you actually receive a letter of nomination from the EPA administrator.

Q And although you've covered some of your project and research work already and some of the various positions you've had with different companies, tell us about the project work that you've been doing with the European Union.

A Yes. One of the emerging regulations in Europe is called REACH, and it stands for Registration Evaluation Authorization of Chemical Substances. This law went into effect in June of last year, and it regulates all substances in Europe that are either imported or manufactured in Europe in greater than one ton. It has broad implications of the amount of testing that's required for substances manufactured or produced in Europe. And this legislation has been in the works for at least eight years. And in anticipation of this regulation, the European Union was interested in an organic substance and a metal substance being tested through the process in advance of the regulation going into effect. The copper industry volunteered, meaning the European Copper Institute, volunteered on behalf of the copper industry to be that metal to actually then test the procedures that would be used under REACH for completing a risk assessment.

This risk assessment for copper means -- and this is the procedures that's now used and proposed in Europe -- means that you must consider all use phases of the substances and all forms of the substance. So we've looked at copper metal and some copper compounds. We have considered air, water, soil, sediment, and we had to test organisms appropriate to those media. We had to understand exposure levels across Europe. We had some 30,000 data points, for example, in our database for water and soil that would enable us to look at water and soil concentrations and sediments. And then we had to make comparisons between exposure concentrations and against effect levels for various organisms for the compartments I mentioned.

This process took us about four years, maybe a little more, and about $8 million to collect that Dataset. We submitted that Dataset in '05, 2005. It took two years, then, to have -- this was a 1200-page report. It took two years for the European Union country members, 25 member states, to review each section of the report section by section. We met quarterly with them going through this report. It was just approved in April.

Q And other than copper, were there any other areas of emphasis with respect to other metals that you were involved with?

A Yes. The legislation in Europe prior to the REACH legislation, was called the Existing Substance Directive. Under the Existing Substance Directive, they had a list of priority substances for which they wanted to have risk assessments performed. Zinc was one of those. And I participated to a lesser role, but I participated in the zinc risk assessment. Nickel was also one of those substances, and I participated in assisting that group with the nickel risk assessment, but once again to a much lesser extent than copper.

Q Now, those risk assessments that were completed for the European Union recently, how would you compare those risk assessments for metals like copper and nickel to previous similar risk assessments done in terms of comprehensiveness?

A Well, I've worked on a number of risk assessments, particularly the ones at Kennecott. And while the work we did was thorough, these risk assessments I would say are the most extensive risk assessments that I've ever seen on anything. I also reviewed the U.S. EPA reports to Congress to mercury, which are about this (indicating) thick. But nevertheless, when you have to consider water, air, soil, sediment compartments and the organisms that inhabit those compartments and exposure data for across Europe, these are extensively large reports and very thorough and comprehensive.

Q What work have you done for ASTM or ASTM standards?

A I joined the American Society for Testing and Materials in 1978, I believe. And at that time the ASTM served two functions; one, it allowed scientists to come together in an annual symposium; two, they issued a book from that symposium, and they also began the process of establishing standards for aquatic testing for various organisms. So I participated in those days in what they call the E-47

Committee -- subcommittee, I guess. And I helped write documents that are now used for early life stage testing, fish bioaccumulation testing, acute toxicity methods for various freshwater organisms. In particular, in the mid 80's I actually authored and chaired the subgroup that wrote the chronic protocol for Daphnia magna.

Q And what is the Daphnia?

A The Daphnia is a freshwater zooplankton. It's a small organism referred in common language as a water flea. It's probably one to two to three millimeters in size, commonly found in freshwater lakes. You would find it in Lake Superior, for example, or Lake Huron.

Q And did you also have involvement in ASTM bioaccumulation protocol for fish?

A Yes, I did. I worked on that document with the authors and reviewed it at various stages and subsequently reviewed it when it came up for renewal.

Q Doctor, are you a member of any professional societies or affiliations that would in particular relate to the type of work that you've done on this project?

A Yes. I'm a member of the Society of Environmental Toxicology and Chemistry, SETC. I joined that in 1978. I'm also a member of the American Chemical Society. I probably joined the same year. And I'm a member of the Water Environment Federation.

Q I'd like to get into the things that you've done for this project. And first, I'd like to talk about the kinds of materials that you reviewed in connection with your analysis. Have you reviewed mine permit application materials in this case?

A Yes. The one that I spent the most time on was the groundwater permit.

Q And have you reviewed actual permit or permit conditions?

A Once again, I didn't in -- I paid particular attention to the details of the groundwater permit and concentrations that would be injected into the ground.

Q And did you review the environmental impact assessment or portions of it?

A I reviewed some small portions of it when I thought they were appropriate to the details that I needed.

Q And did you review MDEQ deposition analyses?

A I reviewed some parts of that, yes, enough to familiarize myself with numbers associated with deposition rates.

Q And what else have you done or reviewed in connection with the work that you've done for this project?

A I reviewed in some greater detail some of the testimony of previous persons that were here, including Dr. Ejnik and Dr. Strand. And I also reviewed some portions of the CRA report that deals with air deposition.

Q And in part that was Exhibit 81 that we posted on the screen here --

A Exactly.

Q -- during Dr. Kapustka's testimony?

A Exactly.

Q Doctor, after reviewing materials and based upon your experience with aquatic toxicology, have you reached opinions in this case?

A Yes, I have.

Q And have you prepared some slides that will help us go through your opinions?

A Yes, I have.

Q And could you take us through your opinions, Doctor, that are on slide two here?

A Yes. I'd be happy to do that. These opinions are intended to be brief here and to be introductory to the discussion we'll have later. So first of all, I have concluded that it's my opinion that the state water quality standards for copper and nickel expressed here as three and 17 micrograms per liter as applied to the Salmon Trout River are protective for brook trout and other sensitive species in the Salmon Trout River. I believe that the copper water quality criteria, which is water quality standard which is set at three micrograms per liter, if adjusted for the amount of dissolved organic carbon that's present in the Salmon Trout would actually translate to a number of 11 micrograms per liter.

I will give some discussion and testimony today relative to previous calculations that had been made from air deposition and resulting calculations of concentrations of copper in the Salmon Trout. I believe those calculations are in err. Likewise, there has been testimony by Dr. Strand relative to the potential for food chain transfer of mercury and metals. I believe the model he used is inaccurate and the conclusions he drew are inaccurate.

JUDGE PATTERSON: Who was that again? I didn't --

THE WITNESS: Dr. Strand.

JUDGE PATTERSON: Strand?

THE WITNESS: Uh-huh (affirmative).

A And finally I've done -- made some calculations relative to soil and snow melt -- sorry -- soil and snow melt runoff from metals to the Salmon Trout. I do not expect to see effects of nickel or copper on the biota of this river.

Q Now, as we go through this, you have prepared some additional demonstrative slides to help guide us through your testimony?

A Yes, I have.

Q And if we could go to slide three, and this is just an overview of what you plan to talk about today. Can you just give us a brief overview?

A Yeah. Very briefly, each one of those bullets relates to a major topic that we will be covering in my testimony. So we will talk about fish and invertebrate sensitivity to copper, how sensitive are organisms. We will talk about the fact of do salmon species react to copper, does it interfere with their ability to find their home stream. We will talk about food chain accumulation of mercury and other metals. I will talk a bit about the fate and transport of copper as it might relate to the water quality standard and potential for effects in the Salmon Trout River. I will present rebuttal of Dr. Ejnik's testimony related to the risk of copper in the Salmon Trout, and we will have a discussion briefly on dissolved organic carbon, importance of dissolution, metal speciation. We will talk about the influence of dilution as to with the length of the stream. And finally, we will have -- I will present information on snow melt.

Q And the first topic on the list is aquatic species sensitivity to copper.

MR. PREDKO: And if we could put up slide five?

Q Can you tell us in general about water quality standards, what they are, what they're meant to protect, and then talk about the water quality standard for the Salmon Trout River?

A Yeah. So I'd like to take a moment to give a bit of detail on this, because I think it's important to understanding the degree of confidence one has in a standard once it's set. So water quality standards are first derived from a Dataset.

So in the U.S. the way the regulations work is that at the federal level U.S. EPA develops a water quality criterion. This criterion is actually contains a set of what they call criteria. Within the criterion -- I'm sorry. Within the criteria -- and each one of the metals has a water quality criteria document that has been prepared by the U.S. EPA federal government. There is an established procedure for deriving a water quality criteria. And I'll go into that in a little bit of detail.

But to understand how a water quality criterion results in a water quality standard, I make the following comment: Water quality criteria are the Datasets themselves that pertain to the toxicity that is associated with various species. And at the end of this process, a number is selected as deemed to be protective of the species that have been tested in the major organisms across the U.S. This water quality standard is set by the U.S. EPA federal government. It's been adopted by the state. The states generally adopt what the federal government has produced. They may choose to make it more stringent. They cannot make it less stringent.

So going back to how a water quality standard is derived, the regulation -- the rules for deriving a water quality standard were put in -- were finalized in 1985, and it's a document authored by Charles Stephan from the U.S.

EPA and coauthors. That method has been used since 1985 up until now to derive various water quality standards for a wide variety of substances.

The methodology requires at a minimum that you test eight different families. The intent here is to have a sufficient number of phyla in the families in the Datasets so that you have an understanding of the distribution of effects. Typically, the criteria documents have much more than eight numbers in it, but that's the minimum. And the way the U.S. approaches, they consider all data that's available in the literature and then in some cases require additional testing if there's insufficient data. And then they derive a final value. So it's a little bit complicated, but I think it's worth going through to understand the process.

I want to make it specific to copper, I think, because the copper is rather unique in the sense that there are more than 1,000 acute toxicity studies that have been performed with copper. And that covers quite a wide range of aquatic organisms.

Q And, Doctor, before you go on, can you tel us what is acute toxicity?

A Yes. The criteria methodology distinguishes between acute and chronic toxicity. Acute toxicity is intended to mean short-term and also it's intended to mean typically lethality. So most of the fish and invertebrate studies range from 48 to 96 hours, and you're measuring an end point where something died.

Q And chronic toxicity?

A Chronic toxicity is intended to encompass a major portion of the life cycle of the organism. So they're longer term studies. In some cases, for example, the fathead minnow, full life cycle chronic study actually starts with juvenile fish, raises them to adults, has them spawn and then subsequent raises the offspring. So that study takes more than a year. Other chronic studies are called partial life cycle studies. For example, rainbow trout early life stage study runs about 90 days. It starts with eggs and you expose the egg and sperm, the fertilization period, and you continue then the exposure to the organisms for 90 days after hatching.

Q And you were discussing -- I'm sorry. Did you have more on the chronic studies?

A Yeah, just a little bit.

Q Okay. Sorry.

A And the reason these partial life cycle studies are used and called chronic, meaning long-term, is the fact that there was a paper written by an author by the name of McKim in the mid 80's where he compared approximately 15 or 17 early life stage studies with full life cycle studies. And the conclusion from that was that those early life stages are the most sensitive and that, if you test during that time period, you have effectively demonstrated that you will get the same answer as if you'd have tested it for a year.

Q And before we got into the definition of acute toxicity and chronic toxicity, you were describing the studies that are out there for copper. Could you tell us more about that?

A Yes. As I mentioned, there's over a thousand studies that have been performed on acute toxicity. There's not near as many that have been performed on chronic toxicity. It depends on whose definition of chronic, quite frankly. The U.S. EPA has selected 26 chronic studies for its use in setting water quality standards. But, for example, when we did the work in Europe, because their definitions allow some slightly shorter studies, we actually had approximately 130 chronic studies in our Dataset for the European risk assessment.

Nevertheless, to stick with the U.S. approach, because that's what's been used for deriving the water quality standard that's used in the State of Michigan, as I mentioned, there are 26 chronic studies.

The U.S. has two ways of dealing with the data in setting a standard; one, you can take all of the acute data and rank them and select what amounts to the 95th percent, 95th most sensitive species on an acute basis. You divide by two, because remember I said it was mortality. If you divide the LC 50 by two, you generally arrive at a concentration that does not cause effects. That becomes the final acute value that the agency uses for its standard. So often when you see water quality standards you see two standards. You see an acute number and you see a chronic number. I've mentioned the three micrograms per liter. That is the chronic standard for -- set for the Salmon Trout River.

Q And how do you know that? Has Michigan adopted the --

A Yes.

Q -- EPA standard?

A Yes. So I've explained how you get to the acute number. The chronic number can be derived by two methods. One, if you don't have a sufficient number of chronic studies, let's say you don't have eight, the agency recognized in 1985 that this approach would be expensive and not all substances would you have both eight acute and eight chronic studies. They set the procedure in the following way: You must have at least three chronic studies. And for those three chronic studies you must also have conducted an acute study. And they look at the ratio, then, between the acute and the chronic toxicity. And they take the geometric mean of the three comparisons. If you have more than three, they use what they have. That gives you a ratio between acute to chronic. And they apply this ratio, then, to that final acute value that I mentioned earlier to derive a final chronic value.

MR. PREDKO: Next slide.

Q Can you tell us about the chronic tests and chronic values for invertebrate fish species?

A Yes. Just to briefly summarize here, as I mentioned, there's 29 chronic studies that have been used in the Dataset to derive the final chronic value. I should point out that, if you would go to one of the water quality criteria documents, they include all of the data that they reviewed and then they include the studies that were selected as and having been deemed to be acceptable for use and development of the water quality standard.

There are six invertebrate species for which there have been chronic studies, and there are some -- I'm sorry -- six invertebrate species and ten fish species. I summarized a little bit of information here on the fish just to show you the sort of the breadth of the toxicity values that might exist ranging from 4.9 up to -- for brook trout up to 60.4 for northern pike.

Q Okay. And you just mentioned the chronic brook trout studies. And can you tell us about insect sensitivity to copper?

A Sure. As I indicated, or maybe I didn't indicate but I will, there are four chronic brook trout studies that have been performed by authors by the name of Sauter and McKim. They each performed two. And the way the agency has dealt with those four chronic values is that they took the mean, the geometric mean, of the fours studies, which is 4.9 parts per billion. The actual values for those four studies in the reports that the authors issued range from 3.9 to 19.9. I would point out at this point that you can see that the water quality standard of three is lower than any of those brook trout studies that have been performed to date. Back to your question about the -- sorry.

Q Dr. Adams, I did notice in your slides when you talked about the water quality standard for the Salmon Trout River you said three micrograms per liter, and the slide indicates corrected for hardness of 27. Can you tell us how hardness effects toxicity?

A Yes. Going back to the 1960's, publications were put forth that showed that when you vary the water chemistry you also get a varied response from the organism. And people began exploring now what's the cause of this. So there have been quite a large number of studies looking at water hardness, which is typically measured as parts per million of calcium carbonate, and relationships, then, regression equations have been developed mostly on acute toxicity, have been developed that allow you to calculate what the change in the

LC50 value will be, or EC50, depending on which organism, what the amount of change will be as you increase the water hardness. So as a general rule, as you increase water hardness, you make the substance less toxic.

So in the actual water quality standard that's currently being used by the State of Michigan, there is a regression equation that allows for the adjustment of the standard as a function of the hardness of the receiving water.

Q And the three microgram per liter has been adjusted already for the hardness specifically of the Salmon Trout?

A Yes, it has. And you will find in a number of the depositions and in the reports that a number of around 27 ppm has been used and discussed as a reasonable number for the hardness of the Salmon Trout River.

Q And you told us about the brook trout studies with the values ranging from 3.9 micrograms per liter to 19.9 micrograms per liter, which are all above that three microgram Salmon Trout limit. Now could you tell us about insect sensitivity?

A Yes. I included this because in the scientific literature there's been a large amount of debate over what organisms are most sensitive. And in particular, which of the invertebrates are most sensitive. And specific to this issue, in particular, mayflies, caddisflies, stoneflies, which are macro invertebrates, they're insects, and the question has been are they more sensitive. They're important species. They're important because brook trout feed on them. And so then the issue really becomes how sensitive are they. So I do have -- I do have a slide on that.

Q Yeah. If you'll go to your chart here, which is on slide eight, --

A Thank you.

Q -- could you explain for us what this chart means?

A Yes. I took this from a publication by Brix, DeForest and myself. And we were looking principally at the relationship between acute toxicity and chronic toxicity. We wanted to -- we wanted to put in press some definitive statements about that relationship for copper. But in doing that, we also took a look at which of the taxa are the most sensitive. And so while I don't show fish on this particular graph, if I did, they would be similar to this line here (indicating) which is representing cladocerans under water fleas.

So to interpret this, across the bottom is the concentration of copper that was tested in a laboratory test system with these organisms. And I'll discuss what they are in a moment. And going up this axis, we title this Percent Species at Risk. Each data point reflects a separate test with a different organism. So what you can -- so let me describe the organisms. First cladocerans, these are the -- you've heard me mention several times daphnid species, for example, but it includes other freshwater organisms that you would typically find in Lake Superior, Lake Erie, Lake Huron. Crustaceans includes such things as shrimp, crayfish, organisms with a shell. And then the insects I think we've had quite a discussion. But for this purpose, they are some of the species that we've been talking about, mayflies, caddisflies, stoneflies.

What we see from this graph -- and I point out that this is acute toxicity -- in these invertebrates, these species of insects were the least sensitive, not the most sensitive. I will talk and we'll address later issues around chronic toxicity. But on the acute basis, they are the least sensitive.

Q And again, you said this but, if you were to put brook trout on this chart, where would brook trout go?

A Well, brook trout, the value was at 3.9 to 19. So it's the lowest one is going to be somewhere right in here (indicating).

Q Okay. And for the record, could you identify where you're pointing to?

A Sure. So I'm pointing that the brook trout would be located very close to the cladoceran, and we would be -- it would be plotted on this consistent with 4.9 micrograms per liter.

Q Okay. So you would agree that brook trout are fairly sensitive to copper?

A Yeah, I do agree that they're quite sensitive.

MR. PREDKO: Could you go to the next slide?

Q And you have listed here chronic values for different species. And could you tell us about the chronic values and how they -- how different species respond to copper?

A Yeah. I took this information from the U.S. EPA ambient life of freshwater criteria document for copper. In these documents the agency typically lists all of the chronic studies that they used and ones they didn't use. These are the ones that they chose to include in their assessment of the chronic toxicity. They don't appear in this order in the document. I rank ordered them here simply so that we could follow and eyeball down the range of values. And if you actually go to the document, you will see that there are more numbers on their table than my table. So I just want to be clear, the reason is that some species have been tested more than once and they show all the data. For purposes of making it fit on a slide, where there was more than one -- when a given species was tested more than once, exhibit, here on water fleas, I indicate there were actually three tests, so this table is slightly different than what would be in the document. But you see the values would range from 3.5 micrograms per liter. I should have put that on the slide, but these are in micrograms per liter.

You find a rotifer, a very small organism that is found in lakes predominantly. You would not expect to find it in the Salmon Trout River, because they can't fight against the current. They would be washed out. But the rotifer is the most sensitive species on a chronic basis in the Dataset. Brook trout are the second most sensitive, and then chinook salmon. You will notice that there is a caddisfly there. And so the caddisfly on a chronic basis, this species of caddisfly is fairly sensitive. And then there are a variety, a snail at nine and then daphnids cover quite a broad range, 4.9 to 19, so equally sensitive as the brook trout.

Q And what does it mean the chronic value when the values approach or exceed the value for a certain species?

A Yeah. What I didn't describe in discussing chronic toxicity, but I should have, is that chronic toxicity is set to protect against survival, growth and reproduction. Acute toxicity standard is set to protect against mortality. So each of these values, then, is derived from a test where a range of concentrations were viewed and they statistically defined where the no effect level was and they statistically defined where the effect level was. And the way the U.S. EPA derives a chronic value, they take the geometric mean of the no effect and the effect level. So this level has no effect and a lower level isn't -- I'm sorry. If this level here (indicating), a higher level, is an effect and the lower level is no effect, the actual threshold for where the effect occurs is somewhere in between. They take the geometric mean of those two values. So each one of these chronic values is a geometric mean of a no effect and a low effect.

So to exceed that value, if you were to have a surface water concentration at a site that exceeded a given value, the inference there would be if you were doing a screening level assessment you might begin to see effects on that particular group of organisms.

A common mistake often made in looking at an accedence is that, well, if the number is three for the Salmon Trout and it should go to four, we'll have catastrophic events happen. That would be a misinterpretation. The reason for that is that, as I mentioned, these are values for where threshold effects just begin. It's the lowest that could be statistically determined.

Q Earlier you mentioned the Sauter report.

A Yes.

Q And did Sauter study brook trout in environments at three micrograms per liter?

A Yes, he did.

Q What were the results of those studies?

A When he did his studies, he used a range of concentrations. And I don't recall all of them, but they started from very low concentrations, as long as three, and up to much higher concentrations. One of the interesting facets of his work is is that in his control water the control is always set up so that these are the organisms where you wouldn't expect to see effects and you don't add any copper to the test system. In his water he actually had three micrograms per liter in his test water. And that was in his control water. In those controls then you might ask yourself do you have a valid test if you've actually got copper in your control water. But then copper is an essential element, and every test that's ever been performed anywhere ever has had some copper in it. But it's good to document how much was there. The question you have to ask yourself is how do my controls perform in this test against the last 20 times I did it or some number like that. So the controls in his experiences were within normal ranges, and no effects -- observed effects are reported in the controls. So it is an interesting observation. Most of the time other authors would have had copper concentrations in their controls probably on the order of one microgram per liter.

Q And so the fish study by Sauter, then, with fish in water at the Salmon Trout River would experience no effect?

A That's correct.

Q And you discussed this a little bit earlier, and I'd like again for you to talk about the hardness and its effect on the water quality standard. And you have a demonstrative on slide ten, and you tell us how hardness may vary in different water bodies. Can you explain that to us?

A Yes. I thought it would be of interest since water hardness is used in adjusting the value for the Salmon Trout River. So I chose to use the equation that the agency uses for adjusting hardness. And starting with the water quality standard previously mentioned of three micrograms per liter for 27 milligrams per liter of hardness, I just then doubled each time 27 to 54, 54 to 108, and I thought it just would be illustrative of kinds of waters that might exist in Michigan. So with 27 parts per million for the Salmon Trout, you would -- you would expect to find something in the neighborhood of 54 in Lake Superior hardness. It might be a bit less than that, but this is the Great Lakes are in that region. And you would find values of around 100 in many of the lakes in Michigan. Of course, there's a distribution, and this is just an example. Because what I really wanted to show was that in going from 27 to 108, the value changes from three to ten.

Q And the three microgram per liter limit that we have for the

Salmon Trout, based upon the mean chronic values of all taxa, what do you conclude?

A Well, I conclude that first that the three microgram per liter is lower than you would have most places in the State of Michigan. That's a very soft water. When there's low hardness, scientists refer to it as being soft. So the value is conservative. It is low. And I also conclude that at three micrograms per liter it's protective for the species in the stream.

Q And that would include not only fish but also macro invertebrates?

A That's right; yes.

MR. PREDKO: Now the next slide.

Q Doctor, could you tell us about, first of all, what is dissolved organic carbon?

A Well, dissolved organic carbon is a term implies dissolved, it means that it is carbon that's in solution to be dissolved. Dissolved organic carbon derives from plant and animal material that's decaying usually on soil carried by water to a stream. If you've ever driven across the Mackinac Bridge and drove to Sault Ste. Marie, you would cross a couple of small rivers. If you looked, you would notice a lot of color in those rivers. So rivers with a lot of color are typically high in dissolved organic carbon. For example, if you've gone to Tahquamenon Falls in the

Upper Peninsula, you'll notice the river runs quite brown and it would be running on the order of 20 to 25 parts per million of dissolved organic carbon. So this is decaying plant and animal material that is in solution that is a part -- becomes part of the water body.

Q   Now, you read the testimony, you've said, of Dr. Ejnik?

A   I did.

Q   And Dr. Ejnik conceded that in doing his calculations he did not factor in dissolved organic carbon. Can you tell us, is it important to factor in dissolved organic carbon?

A   Yes. It's critically important. Over the years when people started studying what influences the toxicity of copper and other metals, including nickel, zinc, lead, cadmium, it became obvious after the EPA published its methodology for hardness adjusted, scientists recognized that hardness is not the only thing that influences the toxicity outcome. And in fact, studies have shown that the dissolved organic carbon is a molecule that's capable of absorbing metals when they're in the ionic form. So dissolved organic carbon, when I talk about it being dissolved, yes, it is some of it's dissolved, truly dissolved like putting salt into a glass, it's truly dissolved. But also dissolved organic carbon is a loose term in the sense that it's representing the amount of humic and phobic acid substances that are in water. These are large molecules. Some of them are truly dissolved, some of them are colloidal size, meaning they're submicron in size, but they're still in solution. They're in the water phase and they will stay in the water phase. They're too small to settle out. These molecules have very active binding sites on them, and they're capable of absorbing large amounts of metals when the metals are in the ionic state.

Q And so when you have a large amount of dissolved organic carbon in the environment on which metals are deposited, what happens?

A Well, what happens is is these substances that we're calling dissolved organic carbon are negatively charged metals. The common metals we're talking about here, copper, nickel, are when there are -- when they are dissolved they're positively charged. They both have a plus two positive failance. And that negatives attract positives in the chemistry world. And you will find, then, that the copper and the nickel are absorbed onto the molecule. That means they're no longer available, then, for uptake by the organism. I think it's fair to comment that in the early stages of this assessment when people were making these kinds of judges, people argued as to whether or not they really were available or not. So there's lots of literature out there now showing where people have used many, many organisms and studied the effect of dissolved organic carbon on its impact on the toxicity.

Q Now, Dr. Adams, do you have any knowledge based on your review of materials in this case about the levels of dissolved organic carbon in and around the Salmon Trout River?

A I've not seen extensive data, but I've seen some data that I believe Mr. Wiitala provided to me. And I've seen values of organic carbon in the river that are in the range of three to eight, something on that order. I'd have to see the data again to be specific, but I do recall that an average value for the river was 5.5 milligrams per liter of dissolved organic carbon.

Q And other than -- well, strike that. Next, Doctor, could you tell us about the Biotic Ligand Model? What is the Biotic Ligand Model?

A Yes. Let me define the words before we define the model.

Q Please.

A So Biotic is referring to biology, meaning an organism. Ligand is a term that chemists use to describe a substance in solution that's capable of binding the metal. So in this case it could be -- it could be dissolved organic carbon, it could be suspended solids, it could be the organism itself or it could be the gill on the organism, the gill on the fish.

In coming to an understanding that dissolved organic carbon is important if you're going to make an accurate prediction of what the toxicity is as a function of water concentration, scientists began to ask the question of why is that. Is there an underlying mechanism that we can get at so that we can better understand why dissolved organic carbon is playing a role in this?

There was some early work done at the University of Wyoming in Laramie where they actually exposed rainbow trout to copper. They removed the gills of the fish. I mean, you have to put all the science together, but there's long been the theory that copper is principally toxic to fish because it interferes with respiratory function of the gill and it interferes with sodium transport in the gill of the fish. So they actually exposed fish, rainbow trout, to copper, for 24 hours, removed the gills and measured the amount of copper on the gill. And it took some -- those are not very -- that's not a lot of tissue, so it took some very careful work. Once they recognized they could do that, they went back and performed a series of experiments where they varied the copper concentration. And, yes, they could indeed measure differences of the copper on the gill of those fish. And they then correlated that copper on the fish gill with mortality. And so what they derived from that is what we call a constant. And we call it the lethal accumulation constant. So what they showed was that every time they got to a certain concentration of copper on the gill, the fish died.

And so that, of course, has been tested many times with other organisms and other species. But it was the beginning of a Biotic Ligand Model. That's one piece to it. So what we've defined is that we understand why fish die when they get copper on the gill. The same thing, we now know daphnids die when they get copper on their surfaces. And probably respiratory surfaces, but daphnids are too small to measure gills. So we use the whole body. And this has then been done for anthropoids and other organisms.

I previously mentioned binding to DOC, dissolved organic carbon. So to actually build a model from this you have to then be able to actually calculate where is the copper going when it's in solution. A few years ago it simply wasn't possible to do that. Because, if you go back in the early 90's, the computers weren't capable of doing the kinds of calculations.

A theory was beginning to emerge, but we needed sophisticated systems to do this. So to be able to actually determine where is copper going once it's in solution, so let's define copper in solution. That's usually meaning it's in the free metal ion copper plus two state. That's one form. There's others that we'll talk about later. You have to be able to then predict did the copper go to the dissolved organic carbon, did the copper go to the suspended solids, did the copper go to the fish gill, did the copper go somewhere else or did it stay in solution? To do that it requires a speciation model. Speciation models were developed back in the 80's. They're computationally -- incredibly computationally complex. But with computers now it's quite simple.

So what scientists have done was take a speciation model, a model for sorption -- okay -- another scientist by the name of Ed Tipping developed a model that allows you to predict binding to dissolved organic carbon and then the binding constants that I mentioned to the gill, by taking all of those together and solving the equation simultaneously for a given set of water chemistry, so we know the carbon number, we know the copper number, we know the concentration of DOC in solution, the concentration of particles, we know the concentration of other ions, the hardness, chlorides, sulfate and so forth, this is all put into the model and we then make a prediction what will the toxicity be for this species at this concentration.

Q Dr. Adams, has the EPA adopted the Biotic Ligand Model?

A Yes. In the most recent update on the water quality criteria document, the federal water quality criteria, the approach has been modified over the one that I just -- for copper and copper only at this time. The approach is currently at the federal level is different than the one I described earlier in the way the standard is set. So, for example, I mentioned first they derive an acute number and then they apply an acute to chronic ratio. Well, they're doing something similar here except in this case they've used the Biotic Ligand Model to take all of those acute values that they've used in their Dataset and to normalize those values to a given water chemistry.

One of the questions that has come up over the years is is, "Why do I get one answer in one lab and a different answer in a different lab when I'm testing the same organism?" Well, you can account for most of that for metals if you adjust for the water chemistry that was used. So if one lab used -- as I showed earlier, if one lab used 27 and another lab used 54, you're going to see a factor of two difference in their results, at least that much. But if you go back and take the water chemistry from each one of those studies -- and there may be 100 of them in that acute date set -- and you set the water chemistry to all -- some reasonably soft water, say, 27, you will take the variability out and you can now compare your species to the same water chemistry across a given range of concentrations. U.S. EPA has used that approach now to normalize their data to develop their final acute value.

So the approach now is not a water hardness adjusted value or a simple water hardness equation. It's a more complex equation. And rather than show it as an equation, we simply say the values are adjusted by the Biotic Ligand Model.

MR. PREDKO: Okay. Go to the next slide.

Q You've used the word "speciation." Dr. Ejnik testified that he did not account for speciation when he did his calculations. Is it important to account for speciation?

A Yes. As I mentioned in the previous description of the Biotic Ligand Model, if you can't account for speciation, you can't account for the amount of binding that's going to occur to various ligands, important ligands, like the gill on -- a fish on a gill -- sorry -- the gill on a fish or you can't account for amount of binding that will go on to dissolved organic carbon. So what I --

Q And I should have asked you to define speciation for us.

A Yes. I mean, chemists use the word Chemical species and it's spelled the same as a biological species. But to a chemist, a species is referring to a specific form of the metal in a given solution type. So let's -- I use this slide as an example of chemical species of copper. If you were to take a soluble form of copper, like copper sulfate, which is often used as an algicide or Bordeaux treatment on grapes, and if you were to put it in solution, what you might find is first some free copper ions at very low levels. And free copper ions are referred to as copper plus two. So they are in the ionic form. They're positive. You would also find various forms of copper hydroxide. And there are actually at least four different forms of copper hydroxide depending how you represented it. But I showed here in this figure two of the most common forms of copper hydroxide as $CuOH^+$ or $Cu(OH)_2$.

Another form of copper that exists in solution is copper carbonates. We've previously talked about hardness and we've talked about metals associated with hardness, magnesium, sodium. They're present with carbonates. Well, copper also associates with carbonates. And you would find some copper carbonates in most surface waters. Now, one of the important factors of these species is is that as you increase the pH of a system you go from this form to this form. So if you don't account for all of the important parameters in the test water, you won't know what speciation is and you will not be able to make a prediction of how much copper is going to bind on the gill of a fish.

Q Okay. And is that the important lesson here is that different forms or species of copper are not equally bioavailable?

A That's right. And they're not equally toxic. The free metal ion, the copper plus two, is the most toxic form. It's also -- it's also the one that's typically present at the smallest concentration. That's a broad generalization, but that's generally true.

I failed to say something I wanted to say, though, that when we're getting at the importance of this, when you adjust the value of three micrograms per liter for the average amount of DOC that's present in the Salmon Trout River, that water quality standard would go from three micrograms per liter to 11 or 11.5 micrograms per liter.

Q And so how do you account when you're doing a calculation for speciation?

A The way this speciation is accounted for is actually done in the Biotic Ligand Model. The model is available on a disc now. You can get it from the U.S. EPA website. It's all set up so that all you have to put into the model is the relevant water chemistry for the site of your interest. So if you wanted to run this for the Salmon Trout, which I did, you would have to know just enough of the water chemistry at the Salmon Trout to put in there. So you would want to put in the dissolved organic carbon and you'd want to put the hardness in and other constituents of the water body. The model then calculates what the standard should be for that water type.

Q And we've been talking about the Biotic Ligand Model. And you prepared for us on slide 13 a chart or a diagram. Can you tell us, it seems to sum up for the Biotic Ligand Model, but tell us what's going on in this chart.

A Sure. This is a classic graphic of trying to provide a scheme for showing the importance of speciation, the importance of binding and ultimately how you make a prediction of toxicity. And this picture is taken from some work done by Dr. Robert Santore. He's actually at HydroQual photograph. He is the author of the Biotic Ligand Model that has now been adopted by the U.S. EPA. And what we're showing here is is that we're going to have some metal and most of the metals we typically talk about, cadmium, copper, nickel and zinc, are -- mercury, are plus two. So in this case, it's represented ME, meaning metal, but we could substitute Cu there for copper. What it's saying is is that when you've got copper in solution and you understand what the species are, and the model calculates that for you, those various species are going to compete with various ligands that exist in the water. So you could have particulate carbon, POC, particulate organic carbon, or you could have a DOC, dissolved, meaning some is in suspension, some is particulate, but you have to -- some is dissolved, but you have to account for the amount of binding that occurs between this metal and this substance.

In each one of these arrows there's a rate constant that's put in there. So people have determined -- okay -- how much will DOC absorb for this form of copper, how much will it absorb for this form of copper. So you know the actual constant that goes in there. And the model has that all built into it. Down here (indicating) you've also got other competing ions that are in the water. We've discussed hardness. And so the model has to account for the amount of calcium, magnesium that's present in the water. There are other factors like chlorine and carbonate. So those substances also have a chance to interact with particulate organic carbon and dissolved organic carbon. They also have a chance to interact with the gill on the fish.

This bit of it is saying, look, the fish has got to regulate both pH and its sodium content in its body. Copper in this case can interfere with the regulation of sodium and pH in the body. Calcium over here also competes for the gill and can potentially provide protection against interference of sodium regulation. This fracture also absorbs the metal, provides protection against interference here. So we're trying to do a competitive estimate of where's the metal going, how much of it will get on the gill. So remember we're back to toxicity results when we get too much metal on the gill and how much will get there under what water condition.

Q And so the Biotic Ligand Model is a tool to correct for or to account for some of those things that Dr. Ejnik did not?

A Exactly.

Q And did you run the results or did you run the Biotic Ligand Model for this matter?

A Yes. I had an associate run it for me, to be clear. But we ran the model and we ran -- and I gave one example here where we used the average DOC for the stream. And to get a -- just a feel for what -- is it really important or not. And so you'll see the criterion would go from three to 11.3 if we took a typical average value of DOC in the water system.

Q Okay. And so it's the level of dissolved organic carbon that will bind with the copper will actually increase the water quality level?

A Yes. As you increase the -- it is fairly linear in that regard. And as you increase the dissolved organic carbon, holding everything else constant, the water quality standard would go up. And to be -- to make sure that it's understood what the federal government is recommending is is the way they view this approach being used is permits are set site by site. And what they envision in the use of this is is that when you are setting your permit limit for your site, we put the water chemistry for your site into this model and you calculate what the copper standard would be for your site. So unlike other water quality criteria where they say, well, the chronic number for the U.S. for hexochlorobenzene is some number, one part per billion, and that's the number everywhere, there is no one number for copper for the U.S. It is a Biotic Ligand Model calculation, and it's recommended that it be run site by site by site.

Q And so the new chronic copper criterion that you calculated with the Biotic Ligand Model, 11.3, then, and so the levels are able to get up to the 11.3 without effects on fish?

A That's correct.

Q And specifically here we're talking about brook trout? Is that the -- or is it protective of all?

A Well, it'd be protective of all species, recognizing that as far as we know all species are reacting the same way. That maybe leaves myself open a little bit by saying it that way, so let me comment on all we know. In doing this European risk assessment, we were challenged repeatedly on that issue. So what we had to do was go back and expand the database that we had on species that had been tested. And we did that. So we went and looked at various taxa that had not been tested to see if this group of organisms still reacts the same way. If we put this much copper into a test system, could we predict the toxicity for that organism before we even did the test? Then you do the test and you ask yourself, "Okay. Did I predict the answer right?" So that was one way of validating it.

Another way of validating it, and I just published this paper this -- in fact, it may be in press yet. It might not be quite out. We looked at waters around the world. We collected waters from Chile, looked at waters from San Francisco and some waters from Europe, and we predicted what the toxicity would be in those waters. And those waters were selected purposely to have a wide range of hardness, DOC, pH and other parameters. We made a prediction of the toxicity before putting any organisms in. We then verified the toxicity by testing each one of those waters with Daphnia magna, in some cases with other species.

In the final risk assessment report in Europe, we received acceptance of -- by the member states of Europe that in fact it appears based on extensive data now that this approach works for all the organisms that are in the Dataset. And that Dataset reflects, then, the Biotic Ligand Model applied to all organisms in the Dataset at a given water chemistry.

Q And so given the DOC values in the Salmon Trout, you would expect all species in the Salmon Trout to be protected at that level?

A Yeah. Let me -- yes. I think it's fair to point out, though, that DOC also varies in the stream. Sometimes it'll be higher and 11.3 would be bigger. And there would be times where the DOC would be lower. So in those cases, you would not expect as much correction.

Q And again, you used for your correction the average or mean --

A I used -- I used the average.

MR. PREDKO: Your Honor, we're about to move on to another subject matter, and I notice that it's about lunchtime.

JUDGE PATTERSON: Okay.

(Off the record)

Q Dr. Adams, we're about to move on to another topic. But before we do, can you tell us -- and this is the area that we just covered. But what happens to the water quality standard for the Salmon Trout River when it is corrected for the presence of dissolved organic carbon?

A Yes. As we discussed this morning, it's a dissolved organic carbon, and its ability to reduce toxicity of copper to aquatic organisms, you can recalculate the water quality standard using an approach published by the USEPA in its last update of the copper criteria document in 19- -- sorry -- 2006 in using this Biotic Ligand Model approach. And an average dissolved organic carbon for the Salmon Trout of 5.5 parts per million, the standard would go from 3 to 11 micrograms per liter.

Q The next area that I would like you to cover is aquatic species sensitivity to mercury. And again, you've created some slides to help us go through this. But can you first tell me, what is the most common form of mercury in streams?

A The most common form of mercury in streams and flowing water systems is inorganic mercury. Inorganic forms are forms such as mercury chloride, for example.

Q And have brook trout been tested within organic mercury?

A I have not found any data for brook trout -- chronic data for brook trout, so no. To my knowledge, no.

Q Have other species in the same family as brook trout been tested for mercury?

A Yes. There are data for Coho salmon, for example.

Q Now, you indicated on the slide here water quality standard for inorganic mercury for the Salmon Trout is .77 micrograms per liter. Where does that come from?

A That value is a value that has been selected by the state of Michigan as a water quality standard for protection of aquatic organisms.

Q Okay. And is this another standard that Michigan has adopted from the EPA?

A I can't answer that directly, because I spent most of my time looking at species sensitivities on the federal document and only selected the state final value from their document in terms of what they selected. So whether they did a direct one-to-one adoption from the federal document, I can't respond.

Q And what will this value, the .77 micrograms per liter, protect?

A This value is designed to protect most of the species that are in fresh water systems.

Q Now, the next bullet point, the value set by the state of Michigan for protection of wildlife and humans is a much lower value, .0013 micrograms per liter. Can you tell us what this value is set to protect and how this value is calculated?

A Yes. Most water quality standards, like the .77 or the 3 micrograms for copper, those are based on studies that are done with either acute or chronic toxicity studies for the aquatic organism. There was a program initiated back in the 80's called the Great Lakes Water Quality Initiative, and that program was set up to derive a value for mercury and dioxins that would not only be protective of aquatic organisms themselves but for organisms that are dependent upon aquatic life. So for example, birds, mink, other organisms that are known -- otters, that are known to feed on fish, this value is set up to be protective of those organisms as well as the organisms, aquatic organisms. In order to do that, they had to take into account not only water exposure; they had to take into account dietary exposure. Taking those two together and considering the fact that mercury does accumulate through the food chain, in order to back-calculate a value in water that would make sure that the fish levels are not too high, this is the value that was calculated.

Q Okay. And so this value, the .0013, is based on toxicity levels for mink?

A Yes.

Q And if we go to the next slide, Doctor, you prepared for us a diagram here to show aquatic species' sensitivity to mercury and some of the levels that we just discussed for Michigan. Can you take us through this diagram?

A Yes. This diagram is similar to one I showed this morning, so -- but let me sort of give a little tutorial on this. Along the X axis on the bottom we're looking at mercury concentration in water expressed in micrograms per liter or parts per billion. On this axis, the vertical axis, we're looking at species sensitivity distribution; I labeled it. It's actually -- the values are running from 0 to 1. This type of graph is actually called a cumulative frequency distribution graph. And what we're looking at is the range of toxicity values that are ranked in order of their toxicity. And it's set up this way with values from 0 to 1 simply so that at any point if you want to know what's the 50th percentile species that's sensitive at that percentile, you can draw a line along this (indicating) way and say, "Well, that species is the 50th percentile. This is the 10th. This is the 5th percentile."

Why do it that way? Well, the state -- the USEPA federal guidelines requires that 95 percent of the species of the nation's surface waters be protected. So with this kind of graph you can quickly calculate where the 95th percentile is. Each one of these dots here reflects, then, a different test that has been performed. In this case these are your standard chronic tests where water exposures over long periods of time. And then I put a few arrows on here just to make the point there's a bit of discussion. If there was a brook trout I would have put it there, but the best I could do was put a sum on it for Coho; it's at about the 55th percentile most sensitive. Some other fish species are more sensitive, by the way; fathead minnows are more sensitive; blue gills are more sensitive. But this happens to be where the salmon species is. We've had a bit of discussion about stoneflies, mayflies, caddisflies. Well, for those species that have been tested on a chronic basis, they are the least sensitive.

Q Okay. And again, on a chronic basis you mean what?

A On a chronic basis I mean a long-term study that encompasses a majority of their life cycle.

Q And so as far as sensitivity to mercury, then, what can you extrapolate about brook trout based on the values for salmon?

A Well, it would be an extrapolation. And once again, the guidelines require protection of 95 percent of all species with a caveat; if there's a commercially important species that appears to be the below the criterium that's set, the government has the right to set the number lower to protect commercially important species. I would -- the only information I have would be to come back to the salmonids species and say it would probably be at least that sensitive. But it hasn't been tested.

Q And you also have on this diagram -- and I'm not sure if you mentioned it. If you did, I'm sorry. I'll ask you to repeat yourself. But there's a Michigan acute standard there.

A Yes. When water quality standards are set up, they set up acute standards and chronic standards. And those are used in different ways in setting permits for discharges to surface waters. And so -- and it's written into your permit, then, what you're allowed to do in terms of a mass of material that's allowed to be discharged that translates to concentration; first, to ensure that you don't cause lethality or acute toxicity; second, over the long term you may not exceed the long-term chronic value for protection of the full life cycle in sensitive organisms. So when you actually get a permit, there are two different conditions in your permit. And so they're set at 1.4 micrograms per liter -- and the numbers are kind of run together there.

I'm sorry -- but they're 0.77 micrograms per liter.

Q I'd like to move on to the next topic, which is olfactory response and copper. First of all, what is olfactory response?

A Olfactory response is a term that's used to describe the ability that fish have to sense chemicals. So in the nares, or the nasal passages of a fish, they are able to chemically sense the presence of chemicals in water. And, in fact, it's that ability to sense chemicals in water that allow certain species to come back to the stream to spawn in which they were originally raised. And, in fact, some fish hatcheries do what they call chemical imprinting. They actually expose salmon, for example, on the west coast in fish hatcheries to a chemical called morpholine. Now, the reason for that is that the fish as juveniles imprint on this -- they've learned this, now -- chemical. When they're released they'd perhaps, depending on the species, be out in the ocean two to four years. When they come back, if there's a small amount of morpholine dripped into that stream near the fish hatchery, they will find that stream and they'll come right back to the fish hatchery.

So I believe that it's important for the fish species, particularly salmonids, to be able to come back to their home range to find the stream in which they were born.

Q What has studies shown about the effect of copper on olfactory response?

A There's been a number of studies that have been done. Actually, a friend of mine who said he did a literature review said he found approximately 100 studies that have looked at olfactory response, ability of fish to detect chemicals and in particular copper. Copper is not the only one, but it is a chemical that is frequently looked at. And there are a rather large number of reports indicating that at low concentrations of copper, perhaps at or below in some cases, people have argued that concentrations below the water quality standard interfere with the ability of salmonids to find their home stream. These studies are done in the laboratory. They're set up with test water where copper is put into the test water. The fish is put into flowing water, and the fish has a choice in terms of -- it's a behavorial-type study. The fish has a choice in finding a certain section of this fish stream that's set up. And what they show is is that they're unable to make the right choice.

Q Who is the primary author of those studies?

A Well, a couple of studies that have gained some prominence were done by an individual by the name of Dr. Hansen and his co-authors. And I'm aware of two publications that they had. Dr. Hansen did his work at the University of Wyoming in Laramie, Wyoming, and did work in that laboratory with salmonids using water from a well system; not regular water, so a very clean water, so a very soft water, low in dissolved organic carbons, low in hardness. So this test system would have been designed to maximize the potential to see the effects.

Q And did Dr. Hansen in his study consider the effects that dissolved organic carbon may have?

A No, he did not. And, in fact, very few of the studies that have been published have considered whether or not DOC, dissolved organic carbon, would provide a substrate for which would reduce the bioavailability and hence reduce the potential to interfere with olfactory response. I recently started a small research project on this project. And I've been doing it with Dr. Joe Meyer, who was working at the Laramie laboratory at the time this work was done. And when Dr. Hansen and his co-authors did this work, they didn't consider DOC, and furthermore they didn't publish the actual value of DOC that was in their water. If Dr. Meyer, having worked at the lab for many years -- he was a professor at the university there -- knew that the water -- the amount of DOC in that water would have been very, very low. I think I previously mentioned that most surface waters would have 1 to 5 milligrams per liter of DOC. The Salmon Trout averages 5.5. I expect around 1 in Lake Superior. We went back to the laboratory. I had Dr. Meyer go back to the laboratory and collect the water sample from the same system that they used before; in fact, several samples. And we had it analyzed. And the amount of DOC in the well water that was used as the test system there, in fact, had very low levels, .05, so a factor of 100 less than what we find in the Salmon Trout River.

Because of the importance of DOC, this would have profound effects on the study. For example, if he had run that study with 5 milligrams, not .05, our hypothesis is that he would have got very dramatically different results. To follow that up, then, what we did was we were fortunate enough to have a paper be published in 2008 by an individual by the name of Dr. McIntyre, who works for NOAA, National Oceanographic Atmospheric Administration, in Seattle. He's a reputable scientist. He published a paper on olfactory response for salmonids. They also thought that DOC would be important in terms of whether -- whether or not the fish would detect copper. In fact, they investigated not only dissolved organic carbon; they investigated hardness as well, which is the classical substance known to reduce metal toxicity. They published a paper; reported that, in fact, hardness did provide some small protection. They did note that DOC in their test system, and they -- it ranged from less than 1 to around 6 microgram- -- 6 milligrams per liter, so certainly the range of interest to us for the

Salmon Trout River.

They reported that, in fact, they found some modification of the toxicity; in other words, when they increased the DOC, in fact the toxicity decreased or became less slightly. Nothing as dramatic as I showed here this morning for the Salmon Trout where I showed it going from 3 to 11, or almost a factor of 4; they were talking about factors of 2. And in their conclusions they concluded that while there is some potential, that they didn't consider either hardness or DOC to be a major -- for protection of olfactory response. However, we noticed in that paper that there was a discrepancy between the toxicity values they were reporting in one table versus the way it was presented in the figures. And Dr. Joe Meyer, who is a good computational chemist, went through this, contacted the authors, had quite an extensive round of discussion with the original author, and finally together they concluded that what they had published in that one figure was in error; that, in fact, you might see differences of factor of 4. The author has agreed to republish the figures and has submitted this figure now to the Environmental Science and Technology.

We, in turn, got his data and took a look at the dissolved organic carbon data and the toxicity values -- excuse me a moment. We used the Biotic Ligand Model that I previously mentioned, which is designed -- to be perfectly honest, it's designed for gills. It is designed to estimate the toxicity in fish as a function of a copper on gills. So we are asking ourselves, "Well, if I apply this same model and assume that the nasal passage is somewhat similar to a gill, can I get close to making accurate predictions as to what they saw?" So basically this is -- as I said, it's preliminary research. We haven't published it yet. But when we run the model on this and we make this prediction, we get pretty close predictions between what we would expect and what we see from the use of the model. To do this correctly longer term it's our goal to actually go back and instead of having a measured constant for copper to gills, we will need a measured constant from copper to the nasal passages of a fish. That would increase the accuracy of the model.

But what the data shows today is is that if you have the presence of DOC in the normal concentrations that you find in surface waters of the U.S., it is going to provide protection against olfactory detriment. And at the standards that are set for that -- set for a given stream based on the Biotic Ligand Model, it will be protected.

MR. DYKEMA: Your Honor, I'd move to strike the extensive recitation of hearsay in that last narrative response. I'll just leave it at that.

MR. PREDKO: Well, your Honor, he's talking about studies that Dr. Adams and other experts commonly rely on. And that kind of evidence is admissible, especially in this proceeding, under APA 75.

JUDGE PATTERSON: I'll overrule.

Q Now, Doctor, I was about to ask you, and would that apply here to the Salmon Trout River?

A Well, the issue here on the Salmon Trout, of course, is the issue of the coastal brook trout, which spends part of its life history in the stream. And because it's one of the few remaining populations that returns -- goes out into the lake and returns, the supposition is that it would be very important for those fish to find their home stream to come to spawn. And my conclusion would be is that with the amount of organic -- dissolved organic carbon that's present in the Salmon Trout, it would be more than adequate to protect from any olfactory problems that would occur.

Q The next subject that I'd like to discuss is food chain accumulation of mercury. You talked a little bit about inorganic mercury and had some discussion of organic mercury. Can you give us some more information on that? And first of all, maybe to give us a little more context, tell us about common examples of mercury.

A Sure. The most common example of mercury that I think most of us are familiar with is what we used to see in thermometers. So the silver liquid, often called quicksilver, that many of us as children chased around on our desktops -- or at least some of us did -- is elemental mercury. So a chemist would call it zero-valent mercury. It's not ionic. It is the -- the element is placed on the periodic chart, so to speak. Another form of mercury is -- and that is inorganic, meaning there's no organic substance to it. Other inorganic forms include mercury compounds. Classic ones are mercury chloride or mercury sulfate or mercury nitrate.

Organic forms of mercury, though, are really what are important in terms of food chain accumulation. Most often mercury is released from point sources as an inorganic form. And when it's introduced into water or into soil in some cases, the organisms that are present there, particularly the bacteria and particularly in environments that are rich in carbon and environments that are lacking oxygen, the mercury is changed to an organic form, and this is called methylation. It's called methylation because the form of mercury that is produced, there can be two different forms, monomethylmercury or dimethylmercury. And a chemical term, methyl is a CH_3 group, so you've added carbon and hydrogen onto the element mercury, giving it properties of both a metal and an organic substance. The uniqueness of this is, is that a methylmercury is much more accumulative in organisms than inorganic mercury and is the principal form that is transported up through the food chain.

If you were to take a fish and analyze it for total mercury, which is what is most often done because it's the easiest to measure for, what you would find typically is 90 percent or more of that is present in the fish as methylmercury, sometimes as high as 99 percent.

Q Now, you talked about the food chain. Can you tell us, what is biomagnification?

A Biomagnification is a term that's used to describe that as you go from one segment in the food chain to a higher segment in the food chain, you get an increase in the concentration of the substance. As an example, if you -- if a fish was eating an invertebrate and there was no biomagnification, you would say the fish is at -- if the mercury was one part per million in the invertebrate it age and if there was one part per million in the fish, you would say there was no biomagnification because they both have the same concentration. However, when you look at an increase of mercury from one level to the next level and it gets larger, so we had one part per million in the invertebrate and we've got two parts per million in the fish, that is an indication of a small amount of biomagnification.

The term really applies across multiple steps in the food chain. It's rarely used to look at one step. And

I will show in a later slide how this works, but in concept and in definition in textbooks, for example, you will find it discussing increase across at least two steps. And the reason for that is, is that there are certain -- not all organisms accumulate mercury the same way. You can go to -- take a particular organism like a barnacle, for example, and you can see that they probably will have an increase in one step in their diet where you may look at ten other organisms and not see it. But when you track it across from algae to invertebrates to fish to birds, for example, and you see it increasing across each step of that food chain, this is referred to as biomagnification.

Q Do some substances increase in the food chain more than others?

A Yes. The term was first applied not to metals but to organic substances. And in particular, it was applied in early days, back in the 60's to DDT and you may recall that one of the famous books that came out was one by Rachel Carson I think in 1963 called Silent Spring, and she heralded this kind of issue already that people were aware of DDT passing through the food chain, getting into the eggs of birds causing eggshell thinning and declines of birds. And I will show in a moment some data.

Another substance well-known particularly in Michigan for biomagnification is our PCB's, polychlorinated biphenyls. But relevant to this case, it is also known that mercury biomagnifies.

Q And you've prepared for us a slide, slide 24. And this slide shows bioaccumulation of DDT. Could you take us through this slide?

A Sure. Go get the full impact of biomagnification, it needs just a little bit of explanation, but clearly you can see as you go from left to right the numbers get bigger. And along the bottom are various species starting with plankton, so they're at the bottom of the food chain, shrimp, further up, fish, another fish and then four birds. And this was data published at Woodwell, et al in 1967, a rather sentinal paper at this point. And what's on this axis are numbers going from 1 to 10 million. And this BAF is a term that's bioaccumulation factor. So let me explain that.

A bioaccumulation factor is a ratio between what's in the water and what's in the tissue. So let's take the plankton. This plankton organisms have -- they're at 1,000, so they have 1,000 times more DDT in a plankton than what you're going to find in water. That, by the way, is not unusual. You would see that for many substances in the first step, about a thousandfold difference between water and the first step in the food chain. What doesn't happen in many chemicals is, is that it never gets any higher than that. The next organism feeds on the plankton. He has the same level. The fish feeds on it. They have the same level. The bird feeds on it, and it doesn't go up. This is clearly not the case here with DDT. As we go from the plankton to the shrimp, the shrimp is already at about 3,000. So this shrimp being exposed to water and feeding on this plankton now has got 3 times as much as this plankton did. By the time we get to this fish, it's at about 12,000. So now this is 12 times more than the plankton. When we get to this first common bird, common tern, it's at almost 100,000. So this organism has about 100 times what the plankton had in it. So gives you a relative feel of biomagnification. Across that fourth step we see an increase of about a factor of 100.

Q And you also provided a slide, the next slide, slide 25, to show bioaccumulation of mercury and some other metals.

A Yes. I was asked to speak to this by the US EPA Office of Research and Development a few years back, 2000, 2001, something like that, and I prepared this slide. And the issue was about bioaccumulation factors and then transfer to higher organisms, so this is not quite as sophisticated as the previous slide, but I do introduce another term that I need to define here. Fish trophic transfer factors, when we talk about biomagnification, that's the word that describes the increase over time.

Trophic transfer is just a trophic level is one step in the food chain. So in going from one step to the next step is referred to as a transfer factor. So in just plain language, if the plankton hit 1 part per million and the fish had 2 part per million, that's a trophic transfer factor of 2. If you have a trophic transfer factor of 1, it means that what the fish -- the fish has the same concentration as what it was feeding on. So for these -- for this particular calculation we didn't go to birds. We only went to large fish, and then we looked at what was in their diet. So for mercury again, we see trophic transfer factors of averaged 6 for the dataset that we looked at. I put selenium in here because I probably have published more on selenium than any other metal. It's a material I did my Ph.D. thesis on, and I'm involved with it almost on a daily basis.

And the selenomethionine being an organometal again like methylmercury, I thought it would be a reasonable comparison, and you should take the form of selenium that would be most likely to bioaccumulate. It's about 1. Lead is -- there's a number of articles showing that as you go up the food chain in lead, it actually decreases a little.

Q And how does that happen, Doctor?

A Well, one way it happens is -- I mean, this is a little bit of a generalization here because I'm using multiple fish and varied diets, to be open about it. But not all organisms treat metals exactly the same way. So even for a given metal, different organisms excrete it at different rates and they uptake it at different rates. And some of the larger organisms excrete lead at a higher rate than some of the organisms lower in the food chain. And copper, once again, also, as you move through the food chain, is slightly less than 1. So we do not see a buildup of copper in the food chain. The same is true for nickel. And I would add, from having reviewed a lot of literature on this, the literature is fairly replete with examples where copper does not biomagnify.

Q Now, Dr. Adams, you said that you reviewed the testimony of Dr. Strand for the Petitioners in this case; correct?

A Yes. I reviewed, not all of it, but some of it and particularly the part that related to bioaccumulation and biomagnification.

Q Now, Dr. Strand testified that the transfer of metals or mercury through the food chain could increase by as much as 100 at each level. Do you agree with that?

A No. I think his -- he used an energetic model to try to make this demonstration that as you go up the food chain at successive levels, because as the organism gets bigger, you have to eat more, and therefore you actually accumulate more. And his testimony was interdispersed with references to mercury, sometimes metals. One time he made reference to lipid accumulation, and of course that's not important for metals. And I suspect what he had in the back of his mind was discussion around materials like DDT or PCBs. But I've already showed for DDT, which is one of the more -- is one of the substances with some of the higher biomagnification that I've ever seen, that the step changes are not a factor 100 from one level to the next. They tend -- I did show 1 of 10 or 11, but I don't see factors of 100.

But there's something more fundamental here. This bioenergetic approach that he talked about, well, it has been used to model PCBs in Lake Michigan, for example. US EPA has used it and there is papers out describing how you could use a model that accounts for the amount of food, the calories you get, the levels of PCBs, and they built a model around that. It does work for PCBs. It's definitely not appropriate for metals. And the papers that I -- this slide that I put here is -- you know, is evidence that at least for lead, copper and selenomethionine, because that's all I'm showing, that these trophic transfer factors are less than 1.

Q And does the literature support that copper, nickel or selenium would increase significantly?

A Let me address those maybe separately. We had to look at copper extensively as part of this European risk assessment that we discussed this morning so -- in submitting that report which had been provided. We looked extensively at this, and we do not find that copper biomagnifies through the food chain. And that result has been accepted by the European Union. Selenomethionine has not -- or selenium has not undergone that same sort of rigorous review, but there's multiple papers in the literature. There is one paper published by Dr. Robin Stewart who works for US Geological Survey in California who looked at selenium transfer through the food chain in San Francisco Bay, and she did show a small amount of biomagnification in one part of the food chain when she was able to use regular -- she was able to stable isotopes, traced the diet through a portion of the food chain and showed that for water to plankton to a particular clam, you do see some biomagnification less than a factor of 2 but still a little bit. Otherwise we don't see it. I have not seen for nickel. I have not seen it for lead. I looked a lot of times at selenium in other environments, and I have not seen it.

Q And how does the length of the particular food chain affect your analysis?

A There's a number of factors that actually come into play when you're looking at biomagnification. One is the length of the food chain, so how many steps in the food chain is there before it gets to the organism? Because as we showed in the previous slide, if you're the fourth one up and you're feeding on number 3, your diet is going to be much, much higher than if you were feeding on number 2 in that. So the more steps there are before you feed on a diet that's containing PCBs or DDT is going to have a big impact on what resides in your body. Now, I'm contrasting that to metals where, of course, that's not going to make any difference in the metal environment because it's not accumulated as you go through the food chain. It's not going to matter whether you're -- if you're number 4 feeding on number 3.

There's a couple of other factors that are important, and US EPA has laid these out quite nicely in their report to Congress for mercury. One of them is age of the fish. For example, most of the discussion usually comes around fish and how many trophic levels are there of fish in the Great Lakes, for example. Quite often they put them in four different categories depending on their feeding strategies, whether they're bottom feeders, they're planktivores or whether they're a first trophic level carnivore or they're a top-level carnivore. So where you are in this trophic status is important.

The of the fish is important and how long has it been exposed and how long has it been to feed. And finally, the size of the fish is important. And one other very important factor for PCBs and DDT is what's the body fat of the organism? Because these organism -- these materials are known to be soluble in body fat. They call it lipid soluble. Organisms like lake trout which have higher body fat than other species tend to have higher levels of PCBs and DDT.

Q Now, with respect to bioaccumulation of mercury, what would you conclude about bioaccumulation of mercury in the Salmon Trout?

A Well, we don't have a lot of data that work with, so I can only say and reflect on what I've learned from other sites and how it might apply here. So first of all, if there's fish tissue data for the Salmon Trout, I haven't seen it. So I actually don't know what the concentrations of mercury are in fish in the Salmon Trout. But I have seen numbers for the water concentration. And the numbers that I've seen are in the range of 1 to 3.5. I guess I saw 1 value of 5 parts per trillion, not parts per billion, so we've been talking micrograms per liter for copper which is parts per billion. Now we're talking nanograms per liter parts per trillion so a factor a thousand lower. So copper water quality standard is at 3 micrograms per liter. I'm now talking about concentrations of total mercury in the Salmon Trout at 1,000 times, actually 3,000 times less. So they're ranging 1 to 3 parts per trillion. Those are the concentrations that have been -- that I've seen that have been reported for the Salmon Trout. So I cannot say what the fish stations would be, but based on looking at these levels in other parts of the world, I would predict that the fish there are going to be somewhere in the .1 to .2 part per million of mercury.

Q And how does the oxygen content of the streams affect that analysis?

A Well, as I mentioned earlier, most mercury that enters in the water systems comes as an inorganic form. And for the streams in particular that have short residence times from the headwaters to the lake, you're not going to have a lot of time for convergence to occur. To be more specific, you don't have a long residence time that allows for inorganic mercury to be converted to organic forms, methylmercury. Nevertheless there would be some of that. But in my assessment here, based on what I've read from other streams, I have assumed that while there's 1 to 3 parts per trillion of mercury in the stream -- total mercury, I am assuming that most of it is inorganic mercury. Once again, I have not seen any data that would split this out.

Q The next --

A Can I --

Q Sure.

A I didn't answer one aspect of your question. I'm sorry. The importance of oxygen, which is what you asked me, is that in -- you have a very oxygen-rich environment in the

Salmon Trout River. It's usually oxygen-poor environments where you see the greatest conversion of inorganic mercury to methylmercury.

Q The next topic and we covered this a little bit yesterday with Dr. Kapustka, and that is the fate and transport. And this is a slide that we looked at with Dr. Kapustka, but can you tell us what this slide means to you?

A Yes. Thank you. The reason we -- I decided to use this slide again today was that we're eventually going to have a discussion, I'm going to give testimony as to what concentrations might get to the Salmon Trout River as a result of air deposition. And there's a number of factors that actually affect the rate and extent of which metals move through ecosystems. And so this diagram here is intended to provide an opportunity to have a discussion around inputs to a system, what happens in a system and how much leaves it. So if we want to make a system, for purposes of our example, be the distance from the mine shaft vent to the Salmon Trout River, if that's the system and that's the system I'll be talking about today 'cause that was the area that Dr. Ejnik used in his testimony and we will eventually get to that. Then we will talk about, okay, we have inputs coming from the mining operation, and in this case the inputs are atmospheric inputs. It's assumed that it's coming out as a -- and expressed as PM-10 as well as metal particles. And we have some output, meaning in this case, some unknown, unquantified amount might reach the river. And if you do what we call a mass balance, if you can measure all the components of this system and all of the amount that's leaving, they should add up to what went into the system. That's usually difficult to do and it depends on how good your analytical results are. But the idea of a system is, is that if you've got the mass balance understood, then you've actually demonstrated you understand your system. So maybe we could go to the next slide.

Q Sure. The next slide, slide 29, Doctor, we do have wetlands in the area of the Salmon Trout, and you've created a diagram to show us how fate and transport may work in a wetland. Can you explain this diagram, please?

A Yes, I will. And the reason I put that there is that much of the area of the headwaters around the Salmon Trout are classified as wetlands. Some of it, indeed, is wet. Others of it are jurisdictional wetlands, but -- and this model is intended to show that we've got some deposition coming in by air transport. and we'll talk about amounts later. We may have some movement of metals across land a function of rainfall, for example, or snowmelt perhaps. These constitute the inputs into this area we'll call the headwaters of the Salmon Trout for purposes of this discussion.

After these two input parameters are -- have allowed to operate, then the issue becomes, okay. Now it's on the soil, and what's happening? So we see a number of complex reactions that can occur on soil. Soil types in and around the headwaters of the Salmon Trout are rich in plant life. They're also rich in organic matter in the soils. Some of it has some conifers, forested. Some of it has a number of smaller tree species, dogwoods for example, perhaps some willow, lots of ferns, grasses. And because I've explained at some length today already the importance of organic carbon and binding metals, particularly copper but also nickel, we would expect that as the metal is deposited onto the soil or moved into this area by water flow, we would expect a large amount of absorption.

We would also expect some complexation. So let me explain the difference. Absorption means the dissolved organic carbon has pulled it in. The carbon being negative, the metal being positive, they're attracted. Complexation is a different process. Metals are known to complex with other ions. Same sort of process, the metal is positive, other ions are negative. The two would come together. When that happens, some of those complexes are insoluble. For example, what you do see, two complexes that are very common in soil. One is iron oxides and iron hydroxides. Those are surfaces that would absorb copper or nickel and hold it in place. Another one is the organic matter. And then finally soils that are rich in organic matter are frequently also rich in sulfides, so the reduced form of sulfur. The sulfides are negatively charged, the metals are positively charged, and metal sulfides that are formed are extremely insoluble. So other are some of the processes that are doing on here in this sort of wetland. Wetlands are well-known and well studied for their ability to complex metals and remove metals from solution. And, in fact, you'll find in the literature instances where wetlands have been constructed -- they call them constructed wetlands. They're constructed and permitted by various states and used as water treatment facilities both for organics and for metals. And it is the sulfides that are present in these wetlands that are principally responsible for complexing metals and taking them out of solution. It's not the factor. I mean, those wetland are constructed to have extensive amount of plant life in them and it's the recognition of both the carbon and the precipitation as a sulfide mineral that's going to remove it.

So the predominant process here is one of complexation and storing the metal on the soil with some small amount then finally crossing the wetland and perhaps reaching the stream.

Q The next slide, Doctor, slide 30 is a similar slide but we're now reaching the point of the stream. And can you tell us what happens with respect to fate and transport when the metal reaches the stream?

A Yeah. And the reason for -- yes. And the reason for putting the slide here is that there hasn't been discussion of this, at least that I've seen in testimony given so far, as to what actually happens once the metal is in the stream provided it gets there or what is happening with natural metals in the stream. So in the stream there are also a number of processes that are going to occur along the length of the Salmon Trout River before you get to Lake Superior. Some of these processes are somewhat similar to what happens in a wetlands, but, of course, you've got an aqueous media now. So some particles will settle onto the sediments so that's one aspect of it. Other particles will absorb then to dissolved organic carbon as we discussed this morning, and some of it will be taken up by animals and there is some bit of burial of the metal into the sediment. We looked extensively at what happens to metals in lake systems, and in fact, I helped to get a paper together on this for the International Council of Mining and Metals, but nevertheless publications that are cited by Dominick Vittorio (phonetic) shows -- he summarized in the literature where he was looking at lake systems, whole lakes and a number of field experiments where people put large cages in the field and then looked at, okay, where do metals go in aquatic systems, and how long do they reside in the water column? So what you find overall as not overall summary is that you find -- in lake systems you will find most of it going to the sediments over time. In a stream system you're going to -- it's going to be a different scenario. You will have some of it going to the sediments. You will also have some of it being carried with the flow of the water out of the system. So, for example, if you were to measure copper in the headwaters of the Salmon Trout, you will find .2 to .4 micrograms per liter. When you get downstream, you're still finding something in the range of .2 to .3 micrograms per liter downstream.

Now, there's a couple of things happen along the way. One, you do see some absorption and settling to sediments. You also see additional runoff into the stream from natural processes. You also see the stream gaining in flow. It's a dynamic process, and I just want to introduce the concept here that within streams there are also mechanisms for loss of metals.

Q In a case like this where you have some level of particulate metal that will be introduced into the air and deposited on the ground around a waterbody, is it important to account for fate and transport?

A Yeah, absolutely, because the whole point of putting these graphics together is that when estimates are made of transports to the river and these estimates are termed "screening level" or worst-case estimates, the point I would really want to make is that they really are worst-case estimates because the processes that are going to occur here and the processes that are going to occur in the wetland are going to remove most of the metal before it ever gets to the stream. So when we're supposing that a certain deposition gets there and a certain percentage, particularly a large percentage gets to the surface waters, those are really worst-case scenarios, and intended to be, as Larry Kapustka showed yesterday, if you pass the worst case, you're done.

MR. PREDKO: Your Honor, we have one last major area to go into. Could we take a break before we do?

JUDGE PATTERSON: Sure.

MR. PREDKO: Thank you.

(Off the record)hen

JUDGE PATTERSON: Whenever you're ready.

Q Dr. Adams, we've been talking about the transport of metals in this case through the air onto the land and potentially into the Salmon Trout River. Questions have been raised in this case as to what extent copper or nickel may reach the river and result in exceedance of the water quality standard or affect the environment, the aquatic environment and the fish. You said that you read Dr. Ejnik's testimony and also

Dr. Strand's testimony. Now, Dr. Ejnik did what I guess is a mass transport calculation and concluded that the copper deposition into the Salmon Trout River flowing off of the land would be sufficient to essentially destroy the aquatic environment of the Salmon Trout River. Do you agree with Dr. Ejnik's conclusion?

A No, I don't.

Q Now, In connection with making that conclusion he did go through and make a calculation. Have you reviewed his calculation?

A Yes, I have.

Q And you've prepared this slide for us that shows certain assumptions that Dr. Ejnik made, and I'd like to go through some of these with you. And we may have to switch to another exhibit. The first assumption is that Dr. Ejnik assumed that the headwaters of the Salmon Trout or areas thereabout that will cause deposition into the Salmon Trout is 3.1 miles squared. He testified that he eyeballed that area. Can you tell me what you think about that assumption?

A Well, as a scientist I don't think you should eyeball something. If you're going to make an affirmative statement about the environment that is going to be destroyed, I think you ought to have specific information and it ought to be accurate, and you ought to be able to represent the accuracy of the number.

Q Dr. Ejnik testified that he used what we put up on the screen here which is Petitioner's Exhibit 81 to essentially eyeball that calculation. And can you show us essentially what Dr. Ejnik did and tell us why you specifically don't think it was a good idea?

A Well, the area that he's talking about as being 3.1 square miles is in this vicinity right here (indicating). And it's termed to be the headwaters of the Salmon Trout. And that is the general vicinity of the headwaters of the Salmon Trout, so we're not disputing that. And I don't know whether the number is 3.1 or 3.9 or some other number, but I just don't think you should eyeball something. It could be very accurately calculated. Nevertheless, my concern is not so much over the actual number that is there. There's a more fundamental issue here. He secondarily also picked one of the average isopleths, so each one of these contours represents a different amount of deposition. And what he did was picked one value here of one gram per meter squared per year adjusted to .66. And he was asked in his testimony if that value reflected an 85 percent reduction with the use of a filter, and he responded, yes, it did. It was unclear in his testimony as to why he went from 1 to .66 'cause that's clearly not an 85 percent reduction, but as best as I could determine from digging into the documents, the 1 reflects the 85 percent reduction. So 1 gram per meter squared per year is already adjusted. And there was a need to further adjust it by 33 percent down because the total mass estimated to be emitted -- or I'm sorry -- deposited -- total deposition rate was based on emissions from the source, and those emissions were in excess of the permit limit. So this 33 percent brought the overall amount of release back to compliance with the permit assuming 24-hour, 7-days-a-week operation at the maximum amount. That's my understanding of where .66 milligrams per meter squared per year comes from.

Q And that was his next assumption that we had on slide 29 was that the deposition rate would be .66.

A That's correct. What I didn't quite answer on this one is, is that once again, to be precise, you will have to actually integrate the area that's in these curves and use a real value that reflects your best estimate of the deposition rate across the entire area as opposed to saying, "Well, it sort of averages .66. I think I'll use that as an average."

Q Now, one of the assumptions that Dr. Ejnik made was that a steady state was reached at 120 days. And before I have you comment on that, Dr. Ejnik, while he could not cite a specific reference for his method of calculation, testified that this is a method of calculation that -- the way he did it, that you could find in any environmental textbook. Would you agree with that statement?

A No, not the way he presented it. You can find, of course, descriptions of what steady state is and how might construct a simple steady state model, but you would not find it explained the way he explained it.

Q And can you tell us what is wrong with the way that he explained it?

A Yes. The general concept of steady state is, is that if you're having input into a given system -- and I discussed earlier you've got both inputs and outputs -- as you continue -- as you start to put metal into the system, it's going to go to various places. So it may go to the soil. It may go to poor water in the soil. It may go to the carbonous in the soil. It may bind the particles. Some of it may move off site, but if you do this long enough and you maintain the conditions constant so you don't change any of the parameters in the model, you don't change the dissolved organic carbon, you don't change the porosity of the soil, you leave everything the same and all you do is continue to add metal to the system over time, it will come to what people call equilibrium, or more commonly called steady state, meaning, all right, all of these phases are now at equilibrium. All of the constants are satisfied for absorption, desorption. The leach rate is now constant. The percolation rate down is now at equilibrium. When you reach that state mathematically what happens is, is that if you put another -- I'll use 14.7 because that's his calculation. If you put another 14.7 pounds on this given area, you would expect 14.7 pounds to go somewhere. So it's 14 in; it's 14 out. You're now at all processes at saturation and at equilibrium. That's the process that he was describing, and he chose the numbers that were convenient in the sense that it allowed the math to work rather quickly for this testimony. So the way he explained it was, he said, "Well, the first day there's 14.7 pounds and some of it runs off. The second day there's another 14.7 pounds deposited on the headwaters, and some of that runs off, plus some of the one that was there on day 1. On day 3 you add another 14.7, and now you've got some from day 1, day 2 and day 3. And you keep doing this until you reach day 120." And if I use this assumption of 5 percent loss, at that point, he said, "I'm at a point now at equilibrium" -- sorry -- "steady state where the 14.7 pounds that's coming onto the water" -- "onto the headwaters is now leaving the headwaters."

So let me -- before we get into whether or not there really are 14.7 pounds going to the river, let me just comment on the model. I've been involved in this kind of modeling exercise for the last four or five years with various groups one of which is at the United Nations. This kind of modeling is currently being done under the United

Nations Environmental Program, UNEP, and it's under a program called Long-Range Transport of Transboundary Pollutants. Three of the substances being evaluated are cadmium, nickel and mercury.

These models are used as and designed as steady state models for the intent of asking the question for certain regions of the world, particularly in Europe, how long will it take to reach steady state? And when I do get there, will those concentrations in soil be toxic? And so for purposes of this discussion I think it's sufficient just to summarize and say that the time periods to get there depend on the metals and, of course, the system. But they're not in days. They're in -- in the shortest they're in decades, and most of the metals are in centuries. And, of course, if they were in decades, you would find massive concentrations of metals everywhere. You don't.

So to make an assumption here that we're going to reach steady state in 120 days is a gross error. Secondarily, I published the book 2006 that deals specifically with metals, deals with fate and transport as well as their persistence in toxicity and bioaccumulation published by SETAC and coauthored it. There is a chapter in there, in that book, that specifically deals with this sort of modeling and it has a discussion about steady state and how long it takes to get there.

Q Now, Dr. Adams, Dr. Ejnik's results were that an increase in copper concentration in the river of 3 micrograms per liter. What would you have to assume to get that number?

A Yup. I'll quickly just review the calculations so it enables you to understand how you get there. So starting with .67 grams per meter squared --

Q And feel free, Doctor, if you think it will help illustrate your testimony, to use the flip pad that's behind you.

A Can I just take the microphone off or --

JUDGE PATTERSON: No, you have to leave that on.

Q You're kind of tethered.

A I'm not actually going to do the math, but I'm going to put the numbers up so that if somebody wants to do it, they can do it. But .66 grams per meters squared per year is the deposition rate that he used. So I'm using his numbers now to repeat his calculations, and then we'll discuss the accuracies and inaccuracies. And this is then distributed over 3.1 miles squared. And what you have to do then is convert miles squared into meters squared. So how many meters squared are there in 3.1 square miles? When you've done that, you can multiply times this (indicating) and you get total mass to 3.1 miles squared. Once you've got the total mass, if you divide this by 365, you get units now of mass per day, so grams per day.

This calculation was, going through this, that there would be 14.7 grams per day placed on the headwaters of the Salmon Trout. So that's how he gets a loading that goes to the river. Now, remember he's said at steady state what goes onto the property comes off the property. And that was his assumption. So 14.7 grams being applied at steady state now after day 120, whatever else comes to the site is going to leave.

Q Do you believe that's a logical assumption?

A No.

Q Why not?

A Well, as I previously said, other researchers who have done steady state models indicate that it would take many decades, if not, in some cases, centuries to achieve steady state, and so I don't believe this at all. And I'm going to sort of demonstrate that here in just a minute. To further complete his calculation, since we've now got 14.7 grams per day onto the headwaters and 14.7 grams per day going into the stream, you divide it by the stream flow. So the flow is 2 cubic feet per second. So if you convert 2 cubic feet per second into liters, you can then -- and if you convert grams to micrograms, you can calculate how many micrograms are going to be in a liter of water. And his calculation is that if you actually put 14.7 grams into 2 cubic feet per second per day, you would increase the concentration of copper in the Salmon Trout by 3 micrograms per liter. And further, if you add what was already in the Salmon Trout of .2 in the headwaters, his measurement and his data, that you would now have 3.2 micrograms for the year in a solution on average and that this would exceed the water quality standard that would be necessary for the Salmon Trout River.

JUDGE PATTERSON: That was what, Doctor?

THE WITNESS: I'm sorry, sir?

JUDGE PATTERSON: What was the level established? You said it would exceed the --

THE WITNESS: Oh, oh. The level that's been established is 3 micrograms per liter. He calculated with this calculation the river would then flow at 3.2.

Q Now, Dr. Adams, Dr. Ejnik conceded that he did not consider dissolution of the metal when he did his calculation. Can you tell us first what is dissolution and whether it's important?

A Yes. There's a few factors that ought to be considered in this overall approach. If you're looking at deposition of metals onto the headwaters and it's coming from air deposition, it's going to be predominantly as particulate. And since this is a mining operation, it would be fair to assume that the particulate matter, at least most of it, would be derived from the orebody or some portion of the mineral processes at the site, meaning it's mineral in nature. And, in fact, in Dr. Ejnik's prepared document he made that assumption that copper was going through the river as being derived from ore.

Because of the work we've been doing for this European risk assessment and, as I mentioned earlier, in one of my experiences here of working for the OECD, we developed a method for measuring dissolution of metals. And that was over a ten-year period. That methodology was approved in April of this year and it's now a formal method accepted at the United Nations and OECD. But in preparing the actual method and then taking it through a round-robin test to ensure the method is accurate, we also tested some substances of interest to the mining community. We tested nickel sulfide, nickel disulfide, we also tested complex copper sulfides as present in copper concentrate from copper ore. These tests were performed in flasks, temperature controlled. The media selected was media that would have been used to test either fish or Daphnia. It was specifically designed to be able at the end of the test, if you wanted to, run toxicity test. And the pH ranged from 6 to 8, and we did it in soft to moderately hard water, both soft to moderately hard water.

What we observed in testing these materials -- and these tests, the ones I'm specifically referring to, were tested over 24 hours. Other tests were done longer, but the ones I'm referencing today are 24 hours. And we used test concentrations of 1, 10 and 100 milligrams per liter, although most of them were done at 100 milligrams per liter. So that's sort of the test condition. It's rather vigorous shaking. It's 100 rpm's so that's a rather vigorous shaking. It's designed to maximize the dissolution if you can. If it's going to be soluble, can you make it go into solution? So, for example, if you were to put copper sulfate in this test, it would be in solution in about 30 seconds. If you put copper sulfide in there, after 24 hours, you will see between 3 and 10 percent of it in solution. And the nickel sulfide is also in that range. It's a little more soluble than the copper sulfide, but it would be in -- still in the range of maybe 3 to 15 percent depending on what test concentration you used, point being that the majority of it, even after we purposely tried to put it in solution, is still not in solution. It's still present as a particle. So not considering this in your calculation, his calculation which got him to an increase of 3 micrograms per liter assumed that whatever copper went to the river is 100 dissolved, all in solution, all bioavailable for uptake by the fish. So there's actually two errors there. One is, should have corrected for dissolution by some amount. He admitted he didn't correct for it, but he should have corrected for it by some amount. I took the -- I just referenced the data here of 10 percent.

If you use that value and you said the 10 percent went into solution, the increase in dissolved copper in the river wouldn't be 3 micrograms per liter; it would be .3. If you add that to what was in the river of .2, you're now at .5 micrograms per liter.

Q And how does that compare to the state water quality standard?

A Well, it's 6 times below the water quality standard. The water quality standard is 3 unadjusted for dissolve organic carbon. But at 3, a number that considered dissolution would be well under the state standard.

Q And you said unadjusted for dissolved organic carbon and the first thing that you testified about today was that adjustment. What figure do you end up with if you adjust it for the mean dissolved organic carbon?

A Well, it needs a little bit of explanation. You either -- in using this Biotic Ligand Model to adjust for carbon, you either have to adjust the standard up, which would take it from 3 to 11 compared to the .5 we were talking about, or you would have to adjust the bioavailability of the exposure side down. You can't do both. That's double dipping. So if we adjusted it up, we'd be comparing .5 against 11 micrograms per liter. If we adjusted it downward, we would be comparing 3 microgram per liter standard against something that's less than .5. Now, I didn't run the BLM, so in the previous calculation when I adjusted it up, the fraction that's bioavailable is 30 percent. So if it's linear, you could say that only 30 percent of that .5 is going to be bioavailable.

Q Now, your recalculation that you just did used all of Dr. Ejnik's assumptions as to the 3.1 miles and the .66 grams per meter squared. And based on that, that recalculation, do you have an opinion, Doctor, as to the effect of the copper that may be deposited from the mine again assuming for my question that Dr. Ejnik's calculations, initial calculations were correct?

A Yeah. And my conclusion is, is that using those calculations and making some adjustments for dissolution, and further, if they were adjusted for bioavailability, that we're going to see only very, very minimal increase in dissolved copper or nickel in the Salmon Trout River. And this will be well below any of the effect levels that have been reported. I wanted to make one more demonstration of this, if I could, in terms of why this doesn't work the way it's presented. And I just want to present the sort of following logic flow. At his steady state of giving 14.7 grams per day into the river, I looked at it a little differently still using his numbers. And I said, "Well, what if we think about it in the following way: If I took 120 days and 14.7 is being deposited on the soil every day for 120 days, I can total up how much metal has actually been deposited after 120 days." I don't remember the exact number, but it's something like 1764 or 1700-and-some number of grams. And if I take the total flow -- and now I'm going to assume that all of it, 100 percent, not 5 percent, 100 percent goes into the river. And if I take the total flow for that same 120 days and divide total flow into the total mass, I wind up with the same number that he does, 3 micrograms per liter. It's just mathematical gyrations because he took it down to per day, per -- volume flow per day. I took the total amount into the total flow for the same time period. My point is, is that it's totally illogical to assume that over 120-day period that you'd lose 100 percent of the metal that's on the soil.

Q Now, Doctor, you've only talked about copper here, and that's because that's what Dr. Ejnik talked about. What would you expect for nickel?

A There's a couple reasons for talking about copper because, first of all, as you said, Dr. Ejnik focused on copper, and my reason is the same as his. Of the two metals, copper has the lower water quality standard. And while copper was a -- hardness adjustment is at 3; nickel's at 17 micrograms per liter. So the assumption here is that since the orebody is approximately equal in copper and nickel, that -- and the emissions for those two metals as having been estimated coming from various sources at the operation are quite similar, the assumption is, is that if you make your calculations for copper, the more toxic of the two metals, then it will definitely be overly protective for nickel.

Q Now, you said that it's totally illogical to think that all of the metal deposited on the soil is going to get into the river. Do you have other support for that in the studies that you reviewed and researched for this case?

A I think the primary support for me comes from sort of the following thinking: Dr. Ejnik reported that the Salmon Trout headwaters has .2 micrograms per liter of copper in it which is an extremely low value, by the way. It's a very, very low value for copper. And I'm not disagreeing. I'm just making an observation that most surface waters typically have 1, to 2 or 3 micrograms per liter of water -- or copper. However, I found an interesting article by Sweet et al in 1988 that indicates they had been measuring wet and dry deposition of metals in the Great Lakes region, so Lake Erie, Lake Michigan, Lake Huron and up on the western end of Lake Superior. And they actually report then a concentration of copper in rainwater, and the concentration of copper in rainwater that they report was 0.9 micrograms per liter. And they collected samples over -- I don't remember the exact period of time, but it's not one sample, so -- because their other values are expressed in grams per meter squared per year.

Now, there have been issues about snowmelt and runoff and how much would be carried to the stream and so forth, so take the snowmelt condition where you've accumulated snow over the winter and I would expect snow to have the same amount of copper in it as rainwater. You've got all this snow stacking up on land over four or five months and it melts and runs into the stream in the springtime. Even his springtime measurements were in this range of .2, .3, .4. So the point of this little exercise is to point out that if all that snowmelt contains .9 and the stream is -- increases significantly at some point. There was some discussion of flashy streams here, Dr. Workman -- stream increased -- volume can increase dramatically and we're not seeing much of an increase in the concentration in the stream during snowmelt of copper, then there's only one other conclusion that I can draw; that most of that copper was absorbed as the water was running across land.

Q Now, you talked about snowmelt and Dr. Ejnik did not do any sort of snowmelt calculation but it has been suggested in this case that copper building up in the snow over the wintertime would then enter the Salmon Trout River during the spring melt and cause a pulse. Now, did you do a calculation again using some of Dr. Ejnik's assumptions?

A Yes, I did. I decided to stick with his calculation because we've already been through the math; we've already explained the weaknesses of it. I've already said that it is an extremely conservative approach. So I take his numbers and what I did was I -- it's sort of similar to what I just described. I said, "Well, okay. So we've had this amount of material that is 14.7 grams per day that's been deposited on the snowmelt. If I put all of it, 100 percent, in a 30-day window and not 120 days, so I'm going to assume we get a really warm spell in April, we melt all the snow. It runs to the river and it's had four months of time to accumulate metal particles on the snow. What will the concentration be over that 30-day period when the -- when it's running into the stream?" Well, it's -- if we used 120 before and come out in my calculation of an increase of .3, by reducing it by a factor of four we're going to increase the concentration by a factor of four. So I multiplied -- I used 30 days, not 120 days to simulate snowmelt. I would predict using that scenario that the copper concentration, assuming it all went in, would be 1.2 microgram per liter increase. This does account for dissolution.

Q Did you say it does or it does not?

A It does.

Q Does that calculation in any way account for the dissolved organic carbon?

A It does not.

Q Okay. And that further adjustment, what would that do?

A It would reduce the bioavailable copper in the range of 60 to 70 percent.

Q And even without that further adjustment, how does that calculation of 1.2 compare to the water quality standard?

A It's almost a factor of 3 less than the water quality standard. The water quality standard being 3; this being 1.2, plus .2 in the background would bring you to 1.4, so you're slightly less by half -- correct myself -- about half of the water quality standard.

Q Now, Doctor, you've got part of what I'll say is your calculation still using Dr. Ejnik's and CRA's assumptions about deposition. Could you just for purposes of the record flip the page and put the rest of your calculations accounting for dissolution?

A Actually, this is -- be fairly short. If we use estimates that Kennecott has developed and I believe were previously discussed here of 61 pounds total being emitted from I believe the main stack vent, and I -- first of all, I'm not an air deposition person, so if I get some of this wrong, then I'm repeating from memory what I remember reading. But I do recollect using 61 pounds.

Q Well, first, Doctor, before you do that -- and maybe I misspoke, and if I did I apologize. What I'd like you to do is to put your end number, the numbers that you just talked about --

A Oh, from the snowmelt?

Q From the snowmelt.

A Sorry.

Q And also the other calculation you did about raising the dissolved copper in the river .3 micrograms per liter.

A Sorry. Yes. So we'll term them number 1, which would be a recalculation of Dr. Ejnik's calculation. I calculated using dissolution that the increase equals 0.3 micrograms per liter. River flow was 0.2. You take the two together, the average concentration during this time period of 120 days would be 0.5 micrograms per liter. So that's calculation 1. The second calculation was snowmelt. And in this calculation, snowmelt 120 days of deposition and 30 days of melt. Using those values I calculate an increase of 1.2 micrograms per liter, so I reduced the days by a factor of four, which reduces the amount of flow you have to divide into the total mass. So by reducing the flow the number is going to go up; it's going to be absolutely linear, so this .3 becomes 1.2. And there was, again, 0.2 micrograms in the headwaters. This brings us to 1.4 micrograms per liter over this 30-day period.

Q Now, Doctor, it's also been suggested that metals runoff that were deposited on the land and then runoff into the headwaters of the Salmon Trout River would then flow downstream down the river and cause a toxic plume in Lake Superior. Can you tell me what you think about that?

A Well, my first reaction to that is that having looked at the kinds of concentrations that we're talking about in terms of deposition that this would be highly unlikely for a number of reasons. One, the loading to the system is too small. Two, the stream gains a large amount of water as you go down river. And in fact -- well, at the headwaters we're at two cubic feet per second. Average flow is near the mouth. There is around 44 cubic feet per second. So the gain in flow is about a factor of 20 as you go down the river. So if you're further assuming the source is near the headwaters you've got a factor of 20 dilution before you reach Lake Superior, plus any dilution that you would get as the stream flows into Lake Superior. So I find it highly unlikely that the small amount of material that's being deposited in the headwaters would ever create a situation where we have a plume and affects at the mouth of the river.

Q And the calculation that Dr. Ejnik did and that you recalculated, again, using some of his assumptions, where are you talking about that on the map that we have, --

MR. PREDKO: What exhibit is that?

Q -- Petitioner's Exhibit 32 -- where are you talking about those concentrations being?

A Well, I'm talking about them being on the mine -- on the mine site with the Salmon Trout River running through this area.

Q Okay. So --

A It's in the immediate vicinity of -- they say it's 120 yards or so from the mine vent.

Q Okay. And so in or around the headwaters of the Salmon Trout?

A That's right.

Q Okay. And I think you've heard some testimony about the coaster brook trout and you mentioned it today?

A Yes.

Q And you're aware that the coaster brook trout, the population -- and I can't see from my seat here, but is well north of that area, miles north downstream from the headwaters of the Salmon Trout and the coaster brook trout -- there's been testimony that there are impassable barriers, falls that the coaster brook trout cannot pass, and so, therefore, it is limited and can't get upstream. Now, given what you've said here today, what affect do you believe that the metals from the mine will have on the coaster brook trout?

A Well, given that even under the worst-case condition that we looked at, which was using the calculations of Dr. Ejnik, and assuming a hundred percent of it goes into the river during the snowmelt and the concentration of copper would increase by 1.2 micrograms per liter, I concluded that there will never be concentrations in the vicinity of coaster brook trout that are approaching toxic affect levels.

Q Now, what about the aquatic species that exist in and around the headwaters? What is your opinion as to the mine's affect on those?

A There are brook trout in that area. We recognize brook trout are sensitive. There are other organisms that are quite sensitive. However, in any of the calculations we've made we've not developed a scenario that exceeds the water quality standard, unadjusted for DOC. Even in the worst-case scenario that I came up with, which is not adjusted for dissolved organic carbon, we're still at 50 percent of the standard of three micrograms per liter. So I don't see any problem there. Further, if you ignored all of my calculations and took Dr. Ejnik's calculations as it originally was presented of three micrograms per liter, and you actually adjusted for organic carbon, there still wouldn't be any problem.

Q Doctor, can you tell us again the conclusions that you've reached in this case? And feel free now that you've given the bases for those conclusions to add more context as you do so.

A Yeah. Okay. So we reviewed a little bit about water quality standards for copper and nickel and how they're derived, and that they are currently adjusted for water hardness and their values as would be applied to the Salmon Trout are 3 and 17 micrograms per liter respectively for copper and nickel. And we also discussed and I conclude that if the water quality standard for copper were adjusted for the average value of DOC in that river using the Biotic Ligand Model, the standard would be 11. -- it would be 11 -- approximately 11 micrograms per liter. I add that this approach that I'm discussing is not unique; it is actually written into the USEPA water quality criteria document for copper. I have reviewed testimonies given on the Salmon Trout from Dr. Strand and Dr. Ejnik and we've relooked at the air calculations resulting from mining operations. While we believe the concentrations in air may be on the high side and we disagree -- I disagree with the modeling approach he used, I conclude that there's not going to be effects of air deposition on the Salmon Trout River. I also have concluded that the approach that was used to discuss how mercury would be transported through the food chain by Dr. Strand is inaccurate and inappropriate to be applied to metals. It's inaccurate for organics, but it's highly inaccurate for mercury. And we -- I did take a -- make a calculation of snowmelt, which might represent sort of a worst-case condition. And under that condition I still do not calculate that there would be any impact on the stream. There's one other point I didn't make on snowmelt but I'd like to. The assumption here has been all along that the metal concentration would actually increase with snowmelt. It's not -- there's no degree of certainty that that will actually happen. When I look at the data there and I look at other substances that are currently in snow: iron, manganese, aluminum and I look at the spring runoff I see very small increases in the Salmon Trout River during the spring. What you've got during snowmelt is not only do you perhaps have the opportunity for deposition on the snow, you also have the opportunity for increased dilution, because now you've got a mass of snow that's sitting there. And what nobody has done is calculated the rate. What's the rate to the snow versus the expanded amount of water that's there? So these are really meant to be worst-case scenarios. And under the worst-case scenario of all of the metal being available that was deposited into the stream in a 30-day period, we don't -- I don't calculate an exceedence of the water quality standard.

MR. PREDKO: Thank you, Doctor. Judge, I do have quite a few exhibits that I would like to enter. Can we take a break and come back? I've got to organize some of the exhibits.

JUDGE PATTERSON: Yeah, that's fine.

MR. PREDKO: Thank you.

MR. DYKEMA: Your Honor, just before we break I'd like to ask permission for something. Mr. Wallace and I have agreed to divide up the cross-examination. I think it will help us get through it more quickly if you will allow us to do that.

JUDGE PATTERSON: On that promise --

(Off the record)

MR. PREDKO: Thank you, your Honor. I think I said that Dr. Adams CV was Intervenor Exhibit 26 already admitted by stipulation. The next exhibit I would offer is Intervenor 27, which is the EPA Ambient Water Quality Criteria for Mercury.

MR. DYKEMA: No objection.

MR. REICHEL: Just give me -- no objection.

JUDGE PATTERSON: No objection it'll be entered.

(Intervenor's Exhibit 27 received)

MR. PREDKO: The next exhibit is Intervenor 31, which is entitled, "Hazard Risk Assessment Assessing Acute and Chronic Copper Risks to Freshwater Aquatic Life Using Species Sensitivity Distributions for Different Taxonomic Groups."

MR. REICHEL: No objection.

MR. DYKEMA: Was that discussed by the witness?

MR. PREDKO: I believe it was relied on by the witness and for the most, Counsel, for reference the exhibits are identified within Dr. Adams' demonstrative slides.

MR. DYKEMA: I'm sorry to be a pest, but can you tell me where that one is identified?

MR. PREDKO: I knew you were going to ask me that.

THE WITNESS: The one with the mayflies on it, the four lines?

MR. PREDKO: Yes. Eight.

MR. DYKEMA: So that's Bricks, DeForest and Adams?

MR. PREDKO: Yes.

MR. DYKEMA: No objection.

JUDGE PATTERSON: Ms. Halley, I don't mean to ignore you. Do you have any position?

MS. HALLEY: No, I'm sorry. I'm deferring to Mr. Dykema.

JUDGE PATTERSON: Okay. I assumed that because you weren't responding. Okay. No objection, that will be entered.

(Intervenor's Exhibit 31 received)

MR. PREDKO: And next is Intervenor 34, which is an EPA paper, "Affects of Exposure to Heavy Metals on Selected Freshwater Fish."

MR. REICHEL: No objection.

MR. DYKEMA: I'm sorry. Chris, where was that?

JUDGE PATTERSON: I can't find it either.

THE WITNESS: Do you want me to comment?

MR. DYKEMA: Please, by all means.

MR. PREDKO: Please.

THE WITNESS: Well, I believe that's the report by Sauter; is that right?

MR. DYKEMA: Okay. So that's Sauter 1976?

THE WITNESS: Yeah, that is used to come up with values for chronic brook trout values. And I don't know the slide number, but I -- we talked -- we had a slide that said "brook trout" and you asked me to address the four brook -- you asked me to address brook trout, and then I think we had a table that listed the species of fish that had --

MR. PREDKO: Slide 6.

THE WITNESS: And there's a table that follows that that lists all the species with the brook trout values culled from Sauter.

MR. DYKEMA: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: Okay. No objection, that'll be entered.

(Intervenor's Exhibit 34 received)

MR. PREDKO: Next is Intervenor 36, which is entitled, "Metal Toxicity to Embryos and Larva of Eight Species of Freshwater Fish to Copper." And this is the

McKim publication.

MR. DYKEMA: McKim and Benoit 1971?

MR. REICHEL: McKim, Eaton and Holcomb 1978?

MR. PREDKO: Yes.

THE WITNESS: Once again, the same as before. Those contributed to the brook trout. McKim ran two of the brook trout studies, so --

MR. DYKEMA: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: Okay. No objection, it'll be entered.

(Intervenor's Exhibit 36 received)

JUDGE PATTERSON: I'm sorry. The number of that again, please?

MR. PREDKO: 36, your Honor.

JUDGE PATTERSON: Okay. Thank you.

MR. PREDKO: Next is Intervenor 37, "The Facts of Long-term Exposures to Copper on Survival, Growth and Reproduction of Brook Trout." This is the McKim and Benoit article.

MR. DYKEMA: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: No objection, it'll be entered.

(Intervenor's Exhibit 37 received)

MR. PREDKO: Next is Intervenor 39, which is the

"Effect of Dissolved Organic Matter Source on Acute Copper Toxicity to Daphnia Magna." We may need your help again, Doctor.

THE WITNESS: Well, I relied on that in preparing discussions on the Biotic Ligand Model. And I don't know that we had specific slide other than one that said "Biotic Ligand Model." Will you please address this?

MR. PREDKO: You relied on this in forming your conclusions?

THE WITNESS: Yes.

MR. DYKEMA: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: I believe it's referred to on slide 11, just for the record. Okay. There's no objection.

THE WITNESS: Okay. Good.

(Intervenor's Exhibit 39 received)

MR. PREDKO: Next is Intervenor Exhibit 40, which is entitled, "Gill Surface Interaction Model for Trace Metal Toxicity to Fishes; Role of Complexation pH and Water Hardness."

THE WITNESS: Yeah, it would be slide 11 again.

MR. DYKEMA: 40?

MR. PREDKO: Yes.

MR. DYKEMA: It's not cited on slide 11.

JUDGE PATTERSON: 39, 41 and 47.

THE WITNESS: It was a paper that I used in -- I relied upon in forming opinion once again about complexation capacity for carbon for copper.

MR. DYKEMA: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: Okay. 40 will be entered.

(Intervenor's Exhibit 40 received)

MR. PREDKO: Next is Intervenor 41, which is "Copper Toxicity in Relation to Surface Water-dissolved Organic Carbon Matter: Biological Effects to Daphne Magna," and this is a publication written by Kramer, Jak, Van Hattum, Hooftman and Zwolsman to distinguish it from one of the others here.

MR. DYKEMA: What number?

MR. PREDKO: 41.

MR. DYKEMA: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: No objection 41 will be entered.

(Intervenor's Exhibit 41 received)

MR. PREDKO: Next is Intervenor 42, which is the "EPA Aquatic Life, Ambient Freshwater Quality Criteria for Copper," the 2007 revision.

MR. DYKEMA: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: No objection it will be entered.

(Intervenor's Exhibit 42 received)

MR. PREDKO: Next is Intervenor Exhibit 43, which is the "EPA Ambient Water Quality Criteria for Copper," 1984.

MR. DYKEMA: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: No objection 43 will be entered.

(Intervenor's Exhibit 43 received)

MR. PREDKO: And next is Intervenor 47, which is the "European Union Risk Assessment Report for Copper."

MR. DYKEMA: Is Dr. Adams an author?

THE WITNESS: No.

MR. DYKEMA: Did you testify about that paper today?

THE WITNESS: I did. We talked this morning about the species sensitivity distributions. We talked about the extent of the database. And I also talked about the fact that the Biotic Ligand Model's used extensively in that report to demonstrate application to a wide array of species.

MR. DYKEMA: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: Being no objection that too will be entered.

(Intervenor's Exhibit 47 received)

MR. PREDKO: And last, your Honor, is Intervenor 605, which is entitled, "Atmospheric Deposition of Trace Metals at Three Sites," the Sweet article.

MR. DYKEMA: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: There being no objection it will be entered.

(Intervenor's Exhibit 605 received)

MR. PREDKO: That's it, your Honor. Thank you. I'd pass the witness.

MR. REICHEL: Counsel?

MR. PREDKO: Oh, I apologize, your Honor. Thank you. I would offer as Intervenor 651 for demonstrative purposes only Dr. Adams' PowerPoint slides.

MR. DYKEMA: As demonstratives, no objection.

MR. REICHEL: No objection.

MR. EGGAN: And again, your Honor, on that issue in order for the sake of consistency --

JUDGE PATTERSON: Finally hear from Mr. Eggan.

MR. EGGAN: Well, we have to put something on the record today, but I would object on the same grounds that I objected to previously.

JUDGE PATTERSON: Okay.

(Intervenor's Exhibit 651 received)

MR. PREDKO: And we will mark it as soon as possible, but as Intervenor 652 I would like to offer as demonstratives the recalculations and I think there are two pages of that flip chart.

MR. DYKEMA: No objection.

MR. REICHEL: No objection.

JUDGE PATTERSON: Okay. No objection those two will be -- both pages will be marked as Intervenor 652.

(Intervenor's Exhibit 652 received)

MR. PREDKO: Yes, your Honor.

MR. REICHEL: Your Honor, I've no questions at this time, but I reserve the right to ask questions based upon cross-examination.

MR. DYKEMA: Good afternoon, Dr. Adams.

THE WITNESS: Good afternoon.

MR. DYKEMA: I introduced myself before; I'll do it again. My name is Peter Dykema; I represent the Huron Mountain Club.

CROSS-EXAMINATION

BY MR. DYKEMA:

Q When were you first asked to assist the Kennecott Eagle Company with analysis if the potential toxic impacts of atmospheric deposition?

A I believe it was early in 2008, probably late January or early February.

Q Were you asked why anybody at Kennecott Eagle or anyone else within the family of companies to consider that issue at the time the initial application was being prepared?

A Well, I don't know the date of the initial application, so --

Q Well, if it was well prior to 2008 would the answer be "no"?

A Then the answer would be "no."

Q Were you asked at any time whether there would be adverse environmental consequences to operating the mine with no control on the main vent stack?

A No.

Q Are you familiar with any other underground sulfide mines in which the main vent stack has an effective filtration system on it?

A I'm not aware of any other sulfide underground mines that has a filtration system on it; no.

Q Do you know anything about the kind of filtration system that Kennecott Eagle intends to install on the main vent stack?

A No, I don't.

Q I believe you testified that you reviewed those portions of the Environmental Impact Assessment that were relevant to the opinions that you were going to offer today; is that accurate?

A Yes.

Q In those portions of the Environmental Impact Assessment that you reviewed was there any discussion at all of the potential harm to natural resources from particulate emissions from the mine operation?

A Not in the sections that I looked at. I was very selective in what I chose.

Q Were you at any time asked to consider the potential adverse impacts on natural resources should acid mine drainage develop at this facility?

A I was asked to review the work that Dr. Ejnik had done. I don't know what you call the report that he prepared before his testimony he -- there was -- there were statements in that report where he made some estimates of potential for reduction of pH in the stream as a function of sulfide deposition in the area. I did review his testimony.

Q But the testimony you're referring to and the report that you're referring to is talking about sulfide deposition?

A Yes.

Q Not contamination of the groundwater in the underground mine workings?

A That's right.

Q What are the indicia of adverse impacts in a chronic toxicity study?

A The classical answer to what do we measure in a chronic study is we look for effects on survival, we look for effects on growth of the organisms, and we look for effects on reproduction.

Q Okay. So on survival if you have a dead animal you have an impact?

A Yup.

Q Okay. How do you determine -- how much stunting of growth is necessary in order to have a positive finding in a chronic toxicity study?

A It can be a very small amount, for example. The way this is done is that -- it might be best to describe a test. But to take a early life stage study, which is a chronic study for rainbow trout, for example, or take the brook trout studies. You start with eggs and -- say, 30 days post hatch; at this point the fish are big enough that they're now swimming around, they've absorbed most of the yolk sack and you can then measure them without killing them. So you can do this photographically, for example, or you could do it a couple of other electronic ways. That's usually done, let's say day 30, day 45, day 60, day 90. At the end of the experiment then the fish are sacrificed and they are actually measured and weighed, each individual fish. And in order to have a -- something that's referred to as an affect there must be a statistical difference in the size of the organisms of those in the treatment versus those in the control. Because there's actually quite a large number of fish that are used in these early life stage studies to be as many as 30, maybe 60 in some cases in each treatment, in each replicate, so you -- by the time you add that up you've got maybe 120 fish at a given treatment. The ability to detect a significant difference is actually very large. So it can be as little as a half a millimeter, so a very small amount.

Q You explained that dissolved copper works its mischief with fish primarily by attaching itself to their gills?

A Yes.

Q There are other ways in which copper deposited in a water body can have harmful affects on fish, are there not?

A Yes.

Q One, for example, would be if the fish ingests invertebrates that have themselves somehow ingested copper or other metal?

A That is a way in which copper can be accumulated in the fish, yes.

Q I'd like to talk with you a little bit about dissolved organic carbon and its effect on copper toxicity. I believe you said that you based your estimate of DOC in the Salmon Trout on three measurements that were taken?

A I might have said that; I don't recollect that I said three.

Q Well, let me open the question up then. How did you derive your estimate of average dissolved organic carbon in the Salmon Trout?

A I contacted Mr. Wiitala. I asked him for data that was available for the Salmon Trout and he sent me a table of values. But to be honest, I don't -- I do not remember exactly how many values were in the table.

Q I understand you don't remember exactly, but can you give me a ballpark?

A I think it was more than ten.

Q Do you recall what time of year those measurements were taken?

A My recollection is, is that they were sampled at four different times across the year. I think that classically they had spring, summer -- I guess three different times. They had the spring, summer and fall, and they usually had a category called "snowmelt."

Q Would it be fair for us to assume that dissolved organic carbon in the Salmon Trout is at its lowest in midwinter?

A It will be lower in midwinter. It'll be one of the lower values in the table, yes.

Q And I think you acknowledged on direct that there will be substantial fluctuation in the amount of dissolved organic carbon in the stream?

A It will vary by a factor of two probably, maybe a little bit more than that.

Q When copper is bound with dissolved organic carbon, what happens to it?

A Well, when the copper is bound to dissolved organic carbon it moves with the carbon. You usually don't think about it that way when we're in a lake system, but when you're in a stream system the organic carbon molecules move, the copper is going with it.

Q Will some of it settle into sediment?

A Not usually.

Q Is it still toxic?

A No.

Q I think you said that the Michigan standard for mercury that is expressed is .0013 micrograms per liter?

A Nanograms.

Q Nanograms? Excuse me. That's a significant difference, isn't it?

A A thousand.

Q I think you said that standard was designed to protect against the combination of atmospheric toxicity and bioaccumulation?

A It's designed to protect wildlife who feed upon fish, so it is protecting from what is going into the water from air, but it's basically protecting uptake across the gill from water and uptake from mercury in the diet.

Q So in the case of a fish that is both exposed to mercury in the dissolved -- dissolved in the water and is exposed to mercury by eating animals that themselves contain mercury, the object of this lower standard for mercury is to protect against both things?

A It is designed to protect against both things, but it's not designed to protect those aquatic organisms in the system against both things. It's designed to protect the organisms that are called "aquatic dependent organisms"; that is, those that are not in the system: the mink, the eagle, the birds. Within the system itself the value that is deemed to be protective of those organisms is .77 micrograms per liter.

Q Thank you. In the course of your direct you used the term "bioaccumulation" and also a term "biomagnification." Are those terms interchangeable?

A No. Bioaccumulation is a term that's used to describe how much metal goes into an organism, so "bio" being the organism, "accumulation" meaning systemic use of the word. If you accumulate something you're increasing your concentration over time. That's a given organism at one level in the food chain. The biomagnification is looking at how much bioaccumulated at the first level, and how much is now bioaccumulating at the second level.

Q You mentioned two studies by Hansen on the impact of copper on salmonid olfactory function?

A Uh-huh (affirmative).

Q What resulted the two Hansen studies? What results did they achieve?

A Well, I don't have the exact values memorized, but I could give you the general conclusion from it. What they concluded was, is that; one, copper does interfere with the ability of fish narrow physiology, and in fact prohibits at certain concentrations their ability to choose in a laboratory setting which part of the stream they would migrate to in a flow through system. So it is effectively interfering with their olfactory response.

Q Do you recall what the copper concentration was that they tested?

A No, I don't, but I recall their conclusion, which it was that the copper concentration that they used were slightly below the ambient water quality criteria for that hardness.

Q Do we know at what age anadromous salmonids can print for the chemistry of their natal strain?

A Well, I'm not an expert on it, but what I've read is that it occurs at -- very early in their life, and so it would be in the first couple months.

Q One of your slides showed bioaccumulation or rather the trophic transfer factors for four materials: methylmercury, a form of selenium, lead and copper. Do you recall that?

A Yes.

Q And this related specifically to fish; is that right?

A Yes.

Q The copper study; do you recall how many species of fish were -- produced the fish trophic transfer factor that you represented on that slide?

A I don't know the number of species. I recollect that the actual number -- calculations that were made, distinct calculations I think were nine.

Q Does the fish trophic transfer factor vary substantially according to the fish's diet?

A In a given lake system where all other things are equal, the answer would be no.

Q In a river?

A In a river system I would give the same answer. I would say no.

Q Do you have the fish trophic transfer factor for nickel?

A I do not.

Q Am I right that your -- the metals you focused on in preparing your opinions for today, the mercury and the copper, didn't include nickel?

A I focused heavily on mercury and -- copper in particular and mercury secondarily, and only a little on nickel; enough to at least look into the nickel water quality criteria standard and made a few calculations of water hardness for nickel.

Q I want to explore with you the notion that soils can reach a saturation point for metals and stop taking them out of transport. Is it in fact the case that, for example, wetland soils can reach the limit to how much of a given metal they can take out of circulation?

A Over a very long period of time with massive amounts of metals being put into a system, the answer would be yes.

Q And the amount of time it would take would depend upon the rate at which metals were being introduced in the system, would it not?

A It would depend on several things. Rate would be an important one. It would depend on the size of the system. It would depend on the organic matter that's in there and the -- and how much organic matter is there, and it would depend on the rate of flow of water through the system, and it would rate -- depend on the extent of the vegetation in the system.

Q You talked about European studies of how time it would take for soils to reach steady state for metal contamination. Do you recall that?

A Yes.

Q What kind of deposition rates were at issue in those studies?

A I'll have to give you a generalized answer here because I don't remember exact values, but if I describe the process I think you'll get the feel for how it was done. The intent of that work that was being done for the United Nations was to look at what's going to happen with soils in Europe under the current condition of atmospheric deposition. So while I don't know the actual numbers of atmospheric deposition, we did look a little bit at atmospheric deposition here in the U.S. If it's similar it would look something like the values I presented. But I don't know those values in Europe.

Q What is it here in the U.S.?

A We're seeing for rainwater it was .9 micrograms per liter. I think Sweet reports something like 2.3 grams per meter squared per year on soil.

Q 2.3 grams per meter squared per year?

A But I would like to look at the Sweet reference if we're going to get into that.

Q Well, this isn't a memory test, but it -- I'll find the answer in Sweet?

A You will find the answer in Sweet.

Q And will I find the answer regarding the European issue in any of the papers that Mr. Predko introduced into evidence?

A No. They are available on the U.N. website.

Q Dr. Ejnik has done baseline water quality studies of the Salmon Trout and I think some other streams for several years. Am I right?

A It's my understanding.

Q As I understand it you don't have any quarrel with his baseline data collection?

A No, I'm actually quite impressed with it.

Q As I understand it from your demonstratives he found the concentration in the headwaters of the Salmon Trout, copper, to be .2 micrograms per liter?

A Yes. That's what he stated in his testimony.

Q And I believe you said that that's really low?

A That is low.

Q Does that tell you anything about the purity or pristineness of the stream?

A Yeah, I would think so. I mean, taking that together with the other data I saw for other metals for that, I would say it's a very clean system.

Q Based on your expertise of water quality and the things that compromise water quality, is it your conclusion based on the data that you've seen that the headwaters of the Salmon Trout are an extremely high quality aquatic environment?

A Based on my review of the water quality data that I've had to look at I would say yes.

Q I believe you also said that Sweet's study measured atmospheric deposition of copper in rainwater of .9 micrograms per liter?

A That's what they report in their paper, yes. For both copper and nickel.

Q So is it exactly the same for both --

A Yes.

Q -- or ballpark?

A No, no, same number.

Q And I think you said that's their number for atmospheric deposition in the United States?

A Actually that value I'm citing was from the station that they had at western Lake Superior.

Q Can you be more specific where it is?

A As close as I can get without pulling the paper is that it's, I believe, in the Houghton-Hancock area, but that's the best I can do.

Q In your opinion would it be safe to assume that atmospheric rain deposition in the area of this mine is going to be very similar to that found by Sweet in the Houghton-Hancock area?

A That was my assumption.

Q I'm interested in the fact that the Salmon Trout has .2 micrograms per liter, whereas rainwater is .9 micrograms per liter. Does that suggest to you that at least at the headwaters the Salmon Trout is predominantly a groundwater fed stream?

A I think there's a couple of explanations that you can look at. One is, is that all of the water coming to the stream is groundwater; that's one explanation. And we know that's not true; it does rain there, snow does melt. Two, all of the metal that's in the snowmelt or rainwater is removed before it gets to the stream. Or three, more realistic, the stream is a mixture of surface water runoff from snowmelt and rain, and groundwater fed.

Q But is the difference between the .2 and the .9 -- do you take that as evidence that there is a substantial groundwater contribution to the stream?

A Well, I took it as actually that it appeared to me that there were substantial removal mechanisms for copper before the rainwater and groundwater reached the system. And the reason I did that is is that when looking at the data that I had for surface water concentrations of metals and I looked across many of the metals, I particularly focused on samples that they claimed were measured during snow melt. There's been lots of discussion around snow melt, but one of the assumptions here is is that when the snow melts it reaches the stream rather rapidly and we see dramatic increases in the stream flow. At that time I think you would have to argue that a significant portion of the flow in the Salmon Trout would have been derived from snow melt. So under that condition, it's difficult to understand why the concentration of metals didn't go up in the stream. It's either went to the soil or it went to the stream.

Q When you calculated your spring runoff scenario, you assumed that the snow accumulation is four months?

A That was -- yes, because I was -- that's correct. I was trying to be consistent with the four-month period Dr. Ejnik had used for his calculation of the math that I demonstrated here. So, yes.

Q He assumed four months of snow accumulation?

A No, he did not. He used a generic model which was four months during the year. He didn't specify. He simply said, "Over a 120-day period this much would accumulate. I assume this much goes to the river." And he didn't discuss snow melt or not.

Q And you assumed that the snow pack in the spring runoff will run off over 30 days?

A I used that assumption. And this was something that I picked up from Dr. Strand's testimony. He made a comment in his testimony about snow melt and the importance and the late spring melting of snow in late March. And he referenced maybe a 30-day period. So I used that as an example.

Q If I understood you correctly, you spent a lot of time in the Upper Peninsula.

A Well, I get there periodically. I still have a house there and I spend two weeks there every summer. And if I can get there in between times at Christmas or Easter, I do that, too.

Q Are you ever there for the spring runoff?

A Yeah.

Q Most of it can happen within just a couple of days, can't it?

A Not where I live. Up on the eastern end of the peninsula and when I was growing up in the 60's and 50's up there, now it started -- when it finally warmed up late March, you would see snow starting to disappear. And sometimes snow was way late into April before it was gone.

Q You said that in your recalculation of the Ejnik analysis you calculated with snow melt a 1.2 microgram per liter increase in dissolved copper?

A That's correct.

Q And you said that that was after applying a 10 percent dissolution rate?

A Correct.

Q So prior to the dissolution rate, the increase is 12 micrograms per liter?

A Under that set of conditions, which I previously qualified by saying that I didn't think the calculation was -- the approach was done right. But, yes.

Q Where did you get your estimate of average flow at the mouth of the Salmon Trout of 44 cfs?

A I can't answer that, because I don't recall. I was looking at a table of flow rates for several sites. And I'm sorry. I simply don't recall which table I was looking at.

Q Am I right that you haven't offered here an analysis of the potential acidification effects of a particular deposition?

A I did not.

Q In talking about the dilution of the copper that's introduced to the headwaters as the river grows and goes downstream, did you take account -- into account at all additional particulate deposition that would occur downstream?

A No, I did not consider additional particulate deposition.

MR. DYKEMA: Thank you, Dr. Adams.

MR. WALLACE: Dr. Adams, my name is Bruce Wallace. I'm going to try very carefully not to ask anything you have been asked previous. Could we look at slide 29, please?

CROSS-EXAMINATION

BY MR. WALLACE:

Q Now, what you were doing here this afternoon was using Dr. Ejnik's methodology but criticizing some of his assumptions; correct?

A Yes; yes.

Q You didn't do your own study with your own methodology, take your own approach that would be better than Dr. Ejnik's in your mind?

A I didn't.

Q Okay. Do you have in mind a way of doing this that would have been better than Dr. Ejnik's to determine concentration of copper in the headwaters of the Salmon Trout River?

A I considered this at some length actually and decided not to make the calculation because, in my view, there's no way to do it accurately with the limited amount of information that's available. And that was part of the reason of showing the complexity of the interactions that occur, just moving the short distance through a wetland zone to a river it actually would take a fairly sophisticated model to do that and to do it right. And so in the time frame we had, I decided rather than just taking some sort of worst case assumption and changing the assumptions and opening myself up to the same criticisms that are there, I would simply point out that this is an inappropriate way to do it.

Q Okay. Well, the time frame that Kennecott's had is several years; correct, sir? They've had several years to study the headwaters of the Salmon Trout River and predict concentrations of copper in those waters?

A I'm sure they've been looking into a lot of things over the last few years. And I think one of the issues -- if I were there and were asked to have done that study, I wouldn't have done it.

Q But when you said in the time frame available, were you saying in the several years available to Kennecott that's not enough time to have come up with a more sophisticated way of studying the Salmon Trout River than, for example, Dr. Ejnik did?

A No. I mean, if you -- if you think that's a high enough priority that you should do it, I would say several years is enough time to do it.

Q But as far as you know, neither Rio Tinto nor the MDEQ tried to model the predicted concentrations of copper or nickel in the waters of the Salmon Trout River in connection with this permit application; is that fair to say?

A I have not seen a sophisticated model. The DEQ did a modeling exercise where they looked at deposition rates again into 36 square miles, came to the conclusion that based on their estimates of deposition rates and the mass of the -- all of the material going into the surface water area that they looked at, that in fact there was not going to be a problem from air deposition. It's we had quite an extensive discussion yesterday from Dr. Kapustka about scoping level, screening level and definitive level. Usually when you do these sort of screening level studies and you conclude using rather severe worst case conditions that there's no problem, you stop.

Q Well, I guess all I'm trying to make clear here, if I'm understanding clearly, is that other than Dr. Ejnik's study, nobody else has done a study specifically trying to calculate the concentrations of copper and nickel as a result of mining in the headwaters of the Salmon Trout? You didn't do it and you don't know anybody else who has done it?

A Well, that's not quite accurate.

MR. PREDKO: Objection; mischaracterizes his testimony. He just told you MDEQ did a calculation.

Q A calculation or reached an opinion that there would be no problem, is what I think you said?

A They did a calculation that was of the same type that Dr. Ejnik did. And it's been entered as an exhibit. I don't have the exhibit number, but it's been entered.

Q Okay. Well, I don't have the exhibit number either. But did you see the exhibit that was created by the MDEQ that undertook to calculate final chronic values for copper in the Salmon Trout River using two different assumptions; one 100 percent dissolution of copper in the water, and the other 50 percent? Did you see that document?

A I don't believe I did.

Q You would agree with me that the calculations that Dr. Ejnik did using 5 percent and .5 percent of the copper deposited on the land that would reach the Salmon Trout waters is considerably more conservative than 50 percent and 100 percent in the DEQ exhibit I'm describing to you, would you not, sir?

A I think that's not a proper characterization of those studies. Well, I thought you said you hadn't seen this. I'm just representing it to you 50 percent and 100 percent. I'm asking you really a simple question. Is 5 percent and

.5 percent used by Dr. Ejnik a much more conservative set of assumptions than 50 percent and 100 percent used by the MDEQ in the exhibit that's been put into evidence earlier?

A No, it's not. If you --

Q Why is that?

A Well, you're going the wrong way with the numbers. If we just stick with the scenario you've laid out, if one assumes 100 percent is available, that's the absolute worst case. Whatever the amount is that's going there, that's as bad as it can get. If you only assume 5 percent is going there, then you've reduced the amount that's reaching the stream by 95 percent and, therefore, it won't be in the stream. So it's a much less conservative approach. The approach is flawed, but the approach is much less conservative.

Q Well, maybe we're having a semantic difficulty. But in any event, did you do an analysis of Dr. Ejnik's calculations using .5 percent? I think that's a "yes" or "no" question, sir.

A Well, I'm thinking about all of the calculations that I made over the last while on this. If you remember Dr. Ejnik's testimony, he actually stated that it didn't make any difference whether it was .5 percent or 5 percent.

Q Well, excuse me. He didn't actually say it didn't make any difference. He said the difference is how quickly you'll reach steady state; correct?

A That's correct.

Q That's the difference in this?

A But what he was inferring was that once you reach steady state, so if you use 5 percent or you use .5 percent, you get the steady state by his model at a different time. But when you get there, that steady state, the amount going to stream is still the same 14.7 grams per day. In that sense, it didn't make any difference whether you used .5 percent or 5 percent. We're simply talking about the time to steady state. The amount reaching the stream is the same. So this degree of conservatancy here is irrelevant in making this kind of calculation.

Q Well, I thought you were making a point to us earlier, sir, that in studies you were familiar with it would take hundreds of years to reach steady state.

A The reports that I mentioned indicate that, yes.

Q Okay. And that's a significant difference between reaching steady state in 120 days, isn't it, in terms of environmental impact?

A Yes, significantly different.

Q Now, you looked at the headwaters of the Salmon Trout and you criticized Dr. Ejnik as being, you know, essentially unscientific in using 3.1 miles squared; correct?

A What I said was is that -- yes. I'll answer it "yes."

Q Okay. For the purposes of this study, it doesn't really matter, does it, sir, what area he used as long as he was consistent once he selected an area, because surely there is an area of 3.1 square miles at some point along the headwaters that describes the land drained into that point on the headwaters; correct?

A There is 3.1 square miles there somewhere.

Q Right. So for the purposes of these calculations, the use of 3.1 square miles by Dr. Ejnik doesn't skew any numbers, does it, sir?

A Well, I think it does. It depends where you place that 3.1 square miles and how close it is to the river system. Because the longer you transport over land the less likely it is to get there. Secondly, it depends on how you position the 3.1 square miles over the river stream system and because of the distance from the source. So if you wanted to do it accurately, you would go on the map and you'd trace it out and you'd calculate the area.

Q Okay. And you didn't do that, sir, did you?

A I did not do that.

Q You could have, but you didn't think it was important enough in your criticism of Dr. Ejnik to do it yourself, did you?

A That's right.

Q And I wonder, this .9 milligrams per liter atmospheric wet deposition pre-mining figure that you've used for --

A From the Sweet -- from the Sweet --

Q From the Sweet study.

A Yeah.

Q Okay. You eyeballed that to transport it from someplace in western Lake Superior to the Huron Mountain area, didn't you, sir?

A I looked at the data that was there for not only Lake Superior but for the other stations that were in the Great Lakes. They were all quite similar for copper, but they varied a bit.

Q That's not any more extreme form of eyeballing than -- or less than Dr. Ejnik did to come up with 3.1 miles which you went on to use; is that fair to say?

A I'll give you a "yes" on that one.

Q And I guess another thing I wonder about here, sir, this exhibit slide 29 is meant to be a list of Dr. Ejnik's assumptions; correct?

A Yeah; yes.

Q Okay. Isn't the 120 days in the fourth bullet point a calculation? That's not an assumption. That's a result of his calculations, is it not, sir?

A It could be. The way he put it in his statement, in his testimony, he indicated that, if you do this addition and subtraction, addition, subtraction, that you would get the steady state at 120 days. There were no actual data presented that I saw. So but you could characterize it as a statement, if you like.

Q As the result of this calculation, it's rather than an assumption that he pulled out of the air and calculated from?

A Yeah; yeah.

Q Okay. And that would be a different figure if you would track through his calculations using .5 percent per day; correct?

A Yes.

Q All right. Now, I thought I understood you to say that Dr. Ejnik had somehow failed to calculate the 85 percent control that this filter is supposedly going to have if it works on the stack; is that right?

A No; no. Just a mis-communication. It's my recollection is is that he was asked under testimony if he had. You asked him under testimony if he had considered it, and he said he did.

Q Said that he did, yes.

A He did.

Q And do you know how he considered it?

A No.

Q Did you understand --

A What he said -- what he said was, "I had to redo the calculation."

Q Did you understand that the CRA map that was up here earlier --

A Yes.

Q -- with the contour lines that that was a map based on the 85 percent control?

A Yes; yes; yeah.

Q Okay. Does the pH of water affect its ability to dissolve metals?

A Yes.

Q Okay. And as a general matter, does lower pH, in other words, greater acidity, increase its ability to dissolve metals?

A It does for some metals. It does for the ones we've been discussing here.

Q Okay. Because you made reference to a study, some European study, I think, where copper sulfide and copper sulfate, nickel, sulfide were dissolved and the ability to dissolve them was measured; correct?

A Yes.

Q And I think you said that the pH that was used for those studies was between six and eight?

A Yeah.

Q Okay. And then you gave us the numbers that resulted?

A I give a generalization of it in the range of 5 to 10 percent for copper and -- or 3 to 10 and 3 to 12, I think, for nickel.

Q Okay. And what do you know about the pH of the headwaters of the Salmon Trout?

A I've looked at the pH data. It's generally running above seven. There are excursions in either direction. It does have lower values in the spring.

Q The calculations that are shown on the flip chart in front of us where you started with .66 grams per meter squared per year and you worked through the calculations that Dr. Ejnik worked through; correct?

A Yes.

Q Okay. Those were correct calculations? You checked --

A Yes.

Q -- his numbers and they were right?

A Yeah; yeah. We verified them.

Q Okay. Would you mind flipping to the next page there, sir? Okay. And this next page, which I guess is going to also be an exhibit -- it hasn't been marked yet -- but begins with the words "Recalculation of Dr. Ejnik"; correct?

A Correct.

Q And at the end of your -- kind of your bottom line for recalculation of snow melt conditions is 1.4 micrograms per liter; correct?

A Total concentration in the stream using this set of assumptions.

Q Okay. Just slightly less than half of the water quality standard?

A That's correct.

Q And if we took Dr. Ejnik's assumptions and moved them closer to the MDEQ's assumptions in the exhibit I was describing to you; in other words, let's say, instead of 5 percent per day we used 15 percent per day; and you did another recalculation of Dr. Ejnik, do you agree that the water quality standard would then be exceeded or violated for the Salmon Trout River with that simple change of one assumption and the direction towards what the MDEQ itself used? I think I'm just asking you an arithmetic question here really.

A Well, I think the answer is "no." If I actually just repeated what he did, which I think is wrong, then, yes, the concentration would go up.

Q Okay. And if you used an assumption of 15 percent, it would go up over the water quality standard for the Salmon Trout, would it not, sir?

A It would. But the model is -- the model he's using is wrong.

Q But you don't have a better model, do you?

A Well, I wouldn't use -- I wouldn't use that model, because his assumption of steady state is wrong on the time frame. And so these have dramatic differences. And I made the calculation here that if you took all, everything that's deposited in a 120-day period, not 15 percent, 100 percent, and put it in that stream, you will have a three microgram per liter increase. And that's ignoring dissolution, ignoring dissolved organic carbon. So arguing over whether 5 percent or 15 percent, you know, just take it all.

Q And if you take it all, you contaminate this river so no fish can live all the more faster, don't you, sir?

A No. What I'm saying is, if you take the total deposition that we're talking about, 14.7 grams per day for 120 days, you multiply that total out, put it in the stream, divide it by the stream flow, you get a three microgram per liter increase.

Q The 120 days that he calculated, that's the calculation you redid and found no fault with, isn't it, sir?

A I -- if you -- there's two --

Q I mean, could you answer that question? And then you can explain it. But you didn't find any fault with the calculations he used to say steady state would be reached at 120 days?

MR. PREDKO: Objection; mischaracterizes his testimony.

A First of all, I've said that the model is wrong. It shouldn't be 120 days. And that --

Q It's the only model we've got, sir, so let's go with it here for a minute. Is the math right?

A The math in his broken model works.

MR. WALLACE: I have nothing further.

JUDGE PATTERSON: Ms. Halley, do you have any questions?

MS. HALLEY: No, Your Honor.

JUDGE PATTERSON: Mr. Eggan?

MR. EGGAN: No, Your Honor.

MR. PREDKO: I do have just a couple, Your Honor.

JUDGE PATTERSON: Okay.

REDIRECT EXAMINATION

BY MR. PREDKO:

Q Dr. Adams, just to be clear, none of the recalculations that you did with what you characterize as Dr. Ejnik's broken model correct for the amount of dissolved organic carbon that exists; correct?

A That's correct.

Q And if you did make that correction, what would be the result?

A If we corrected for the average amount of dissolved organic carbon that's in the river, it would elevate the three microgram per liter standard to 11. And it would increase the amount of safety or distance between what the concentrations that will result in the stream and the concentration that would be the new standard.

Q Now, Mr. Dykema had asked you something along the lines if whether you had ever seen a filtration system in a vent stack on other mines. Do you remember that?

A Yes, I do.

Q Now, based upon your years of experience in the mining industry, could you compare this mine to other mines with respect to efforts taken to minimize potential impacts to the environment and natural resources?

A Yes. In my responsibility of environmental responsibilities in the company I have opportunities to visit many mines, and that includes mines in Australia, mines in South Africa, including the copper mine, an underground copper mine in South Africa, which I audited last year. I spent a week there last year and I was there two years ago. I've also been at the underground mine in Chile, El Teniente, the biggest underground copper mine in the world, and several other copper mines around the world, including the Kennecott copper mine in Salt Lake City where I worked for six years. And that's the largest copper mine in the U.S.

There's some rather distinct differences between this copper mine and many of the other mines. First of all, this is a very small mine. We're projecting something on the order of 500,000 tons of ore per year. We will produce that much at Kennecott in a week, just to put it in perspective. So the actual size of the mine, the amount of rock that's going to be moved and so forth, this is a very small mine. Secondly, or additionally, there have been extraordinary efforts gone into the design of this mine to insure the safety of the mine and to insure that every aspect of the mine is under control from an environmental perspective. And that includes things like making sure the roads are watered, making sure the trucks are covered when anything is being hauled, making sure that any waste rock is stored in the building; that dust is absolute minimized to the minimum. A filter will be put on the air vent from the mine shaft, which is indeed unique, and that the wastewater treatment system is without a doubt the most complicated wastewater system that I've seen in my mining experience. It is a marvelous piece of engineering design which, of course, it's designed to treat water and get it back to drinking water standards before it's reinjected.

In my opinion, this will be the absolute best mine that we Rio Tinto has in its portfolio when it's in operation.

Q   When you say the best mine in its portfolio, the best mine as to what?

A   The best mine in terms of its environmental performance and potential release of substances offsite.

MR. PREDKO: Thank you, Doctor.

MR. REICHEL: I have no questions, Doctor.

MR. WALLACE: I do have a couple more. Could we look at 31 for a moment?

RECROSS-EXAMINATION

BY MR. WALLACE:

Q Just to be clear, this 11 micrograms per liter that you put up in Exhibit 31, that is not the water quality standard set by law in the State of Michigan, is it, sir?

A No, it's not.

Q Okay. It's just something you've calculated as an alternative to the legal standard that exists?

A It was calculated as an alternative using the U.S. EPA water quality criteria methodology for setting water quality standards for copper that was originally issued last year.

Q Okay. The legal standard in Michigan for copper is three and for nickel it's 17; correct?

A Yeah. Adjusting for hardness, yes.

Q Are you a shareholder in Rio Tinto?

A I own a few shares of stock; not many, but a few.

Q Okay. Do you have any idea of what this orebody is worth?

MR. PREDKO: Objection, Your Honor. First of all, I didn't cover any of that in my redirect, and so it goes beyond the scope of my redirect. Plus, I believe Your Honor has already ruled on this issue with another witness, this kind of information is clearly proprietary, highly confidential and is not relevant to anything going on in these proceedings that relates to the application for mining permit.

MR. WALLACE: And my answer is I think that his answers on redirect, as well as some of his other answers here today, have raised questions of bias which I'm entitled to look into. And if the exact number is a matter of proprietary concern, which I find hard to believe because I've read it in the paper, we could make a record separately.

MR. PREDKO: Well, Your Honor, that goes to the heart of it. And Mr. Lewis made this objection when you ruled on it before and said that this area was just off limits, you know. The day after any value is put out there, it's going to be in the newspaper, and that's exactly why they wanted to get that information out in the public is to prejudice this mine.

JUDGE PATTERSON: I'll sustain the objection.

MR. WALLACE: I have nothing further, then, sir.

EXAMINATION

BY JUDGE PATTERSON:

Q Doctor, if you could, going to number 16, if you could do that, the water quality standards for inorganic mercury for the Salmon Trout is .77 micrograms per liter, is it?

A Yes.

Q Where does that come from? Is that in the permit?

A No. And I probably could have characterized that better.

In the slide that's either before or after it where I show all of the data for mercury, if we could -- there we go. This Michigan chronic water quality standard for aquatic life of 0.77 is a standard set by the State of Michigan.

Q For any body of water?

A That's right. It's not specific to the Salmon Trout.

Q Okay. And the value set for protection of wildlife and humans is --

A Yes.

Q -- 13-1,000th's of a --

A Microgram, yes.

Q Much, much lower than that?

A That's right. And that also is a State of Michigan standard that had been adopted.

JUDGE PATTERSON: Okay. All right. I was slightly confused about that. Thank you.

MR. DYKEMA: Your Honor, may I ask one very quick follow-up to that?

JUDGE PATTERSON: Yeah; sure.

RECROSS-EXAMINATION

BY MR. DYKEMA:

Q The second bullet on 16 talks about the water quality standard for inorganic mercury. Is the value in the fourth bullet also inorganic?

A Well, that's -- it takes a bit of an explanation to answer that. This is actually a backwards calculation from if you know what the effect level is in the diet of mink and you know how much water they drink and how much diet they eat, you have to start backwards calculating then what will the concentration need to be to protect the mink. So the water number is inorganic, but the dietary contribution along the way is organic. Sorry. It's a complicated process. But when mercury enters the diet of organisms, it becomes an organic form. And so in the water the inorganic form is measured. But and actually it's reported -- if I remember right, it's reported as total mercury, I believe.

MR. DYKEMA: Thank you.

MR. PREDKO: Nothing further.

JUDGE PATTERSON: Thank you, Doctor.

MR. PREDKO: Your Honor, Kennecott does have one more witness, because he's been out of the country and unavailable. He will not be able to testify until next week. I've had discussions with --

JUDGE PATTERSON: You mentioned that previously.

MR. PREDKO: -- Petitioner's counsel, MDEQ counsel. I think that we're going to accommodate that schedule and allow him to testify on Tuesday. Other than that, that would be the end of Kennecott's witnesses.

MR. WALLACE: I would just like to put on the record, because I think this has been communicated, Tuesday is a day that I simply cannot be here. This would have been my witness, and I asked that we do it Wednesday or Friday or some other day next week, if we could.

MR. PREDKO: I guess nobody's ever communicated that to me, Counsel, especially you, which is who I would expect to hear it from.

MR. EGGAN: I mentioned it to Mr. Lewis this morning.

MR. LEWIS: Yeah, before lunch. And I suggested he talk to Mr. Predko.

MR. PREDKO: Well --

MR. WALLACE: So I'm respectfully asking if we can do this a different day next week I would appreciate it. We're taking him out of order, which is an accommodation. And he was scheduled once before and I was prepared to examine him and then he was rescheduled. This was early on in the trial.

MR. PREDKO: Right. And the reason that he was rescheduled is because the time that Petitioner's were taking with their witnesses was just frankly taking too long and we wouldn't have had time for him anyway. But that said, Your Honor, I have to call him and check.

JUDGE PATTERSON: Okay.

MR. PREDKO: He is in and out of the country. If Tuesday is not the only day that he can do it during the course of this trial, we would be happy to reschedule.

MR. WALLACE: We're not adverse to doing it out of the country, of course.

JUDGE PATTERSON: It depends on where.

MR. DYKEMA: South of France would be nice.

JUDGE PATTERSON: So you want to start tomorrow?

MR. REICHEL: Well, Your Honor, we have our first witness ready to start. His direct examination is -- I cannot complete in time today.

JUDGE PATTERSON: Is that Mr. Maki?

MR. REICHEL: Yes, it is. And I was just going to, for the record, Your Honor, in the interest of moving forward, I've intended to waive opening statement. My intention is, whether it be today or tomorrow, to start Mr. Maki's direct examination. So I'll leave it to --

JUDGE PATTERSON: I prefer to do it tomorrow morning.

MR. REICHEL: All right. I'll be happy.

JUDGE PATTERSON: Frankly, I need some office time.

MR. REICHEL: That's fine. I'm happy to accommodate that.

JUDGE PATTERSON: Okay. See you in the morning.

(Proceedings adjourned at 4:37 p.m.)

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