- SUMMARY REPORT -

AN INTRODUCTION TO RISK ASSESSMENT

A Two-Day Information Session and Discussion on Human Health and Ecological Risk Assessment

DECEMBER 23, 2011

Prepared for:

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Opening Comments

An Introduction to Risk Assessment (a 2-day information session on human health and ecological risk assessment), was held in the Katimavik C conference room at the Explorer Hotel in Yellowknife, on December 6 and 7, 2011. The session was co-hosted and co-facilitated by the Wek'èezhìi Land and Water Board (WLWB) and the Mackenzie Valley Land and Water Board (MVLWB). The session opened with a prayer. Violet Camsell-Blondin, Chair of WLWB, provided opening remarks, followed by Patty Ewaschuk (WLWB) who gave an overview of the agenda (Appendix A). Participants of the information session included: MVRMA Boards; federal, GNWT and aboriginal government; consultants; industry; and aboriginal organizations (see Appendix B for the participant list).

The purpose of the information session was two-fold: to ensure that all parties participating in Board decisions involving risk assessments in the mining industry have a good understanding of the topic, and to promote an open discussion about risk assessment. During the information session, participants heard about how and when to perform a risk assessment, community involvement in risk assessment, and some case studies of risk assessment in action. The information session was an open forum that provided plenty of opportunity for questions, comments, and discussion.

This report provides a summary of the key discussion points raised during the two days of the information session. All presentations are provided in Appendix D.

PRESENTATION: Introduction to Risk Assessment – Ken Froese, Ph.D., SLR Consulting

Dr. Kenneth Froese, Ph.D. presented "An Introduction to Risk Assessment. The presentation is in Appendix D.

Presentation Highlights

There are different frames of reference when examining risk – that is, it means different things to different people – the words are different but the concepts are the same. Sometimes the words are the same, but the meaning differs. It is very important to have a common understanding of terminology.

Group Exercise

Dr. Froese led the group through two exercises. First, the group identified risks associated with getting out of bed in the morning. This exercise illustrated that we all make decisions about what risks we accept in our daily lives. Then, the group identified risks, hazards, risk mitigation, and the management of negative outcomes associated with driving a vehicle. This helped to ensure that everyone had a similar understanding of risk assessment terminology.

<u>Risk Assessment Steps</u>

- Problem formulation (why are we doing this?)
- Exposure Assessment (are we being exposed? If so, how much?)
- Toxicology Assessment
- Risk Characterization (what do the risks mean?)
- Risk Management (minimize probability of occurrence and severity of the outcome)

Group Exercise

Dr. Froese led the group through an exercise to illustrate problem formulation. Using the participants' ideas, he drew a natural setting (forest, river, rocks, etc.); a mine and its various components (tailings, waste rock, roads, etc.); human elements such as families, communities, a sacred place, and trap line; and more. The diagram was also used to discuss hazards and risk mitigation. See Appendix C for a photo of the illustration.

Likelihood versus Severity

High Likelihood – low Severity – not too bad

Low Likelihood – high Severity – bad (things that you do not want to happen)

Levels of Risk Assessment

1. Scoping (broad - look at the scenarios)
2. Screening (put numbers to them – meet guidelines or not)
3. Detailed or site-specific (quantitative)

Other Key Points

- Risk Assessment is an iterative process.
- Direct community input is very important.
- EC_{20} is the chemical concentration at which there is an effect in 20% of the population. The effects response to increasing concentrations is not a linear relationship. There is almost never zero exposure to chemicals.
- Transparency and communication are key elements of risk assessment, particularly at the outset of the project.
- Risk Assessments are not for *making* decisions but to inform decisions.
- It is important to revisit the picture every time new information is received.

DISCUSSION: QUESTION AND ANSWERS on the INTRODUCTORY PRESENTATION

LEVELS OF RISK ASSESSMENT

Participant Question: Do risk assessments always start at scoping and move to screening, then the detailed level, or are there situations where you can start at a different level?

Answer: We typically start with scoping level, but if we already know that there is a big issue then it's okay to jump to the detailed level, as long as you understand what needs to be done in detail so as not to repeat work already done.

UNCERTAINTY

Instructor comment: Toxic Reference Values (TRV) are conservative and then a safety factor is added to account for uncertainties. For example, we use rodent studies as a basis for TRV development, and even though rodents are up to 98% similar genetically, there are still substantial differences. We attempt to account for these differences with safety factors.

Participant Question: We look at chemicals in isolation, but that may not represent reality.

Answer: It would be best to take into account mixture of compounds, but there is not much good information on this. We should account for immune suppression; early development of infants/toddlers; elderly (extreme ends of the spectrum), etc. A lot of time and money is being

spent to understand these aspects better.

Participant Comment: After this response, another participant commented that risk assessors don't take into account compounds in combination – synergisms (more than just simple adding – could actually be 10x or 100x as bad). On the other hand, chemicals can actually suppress negative effects of other chemicals – so it's not always bad.

Participant Question: What is the best way for a reviewer to interpret the uncertainty associated with the risk assessment?

Answer: There is no single correct answer – it is important to frame uncertainties properly. We need to understand and balance uncertainties associated with the initial problem and how to resolve it. Uncertainties can serve as a guide for what needs to be done next. Having more data and more time doesn't always help to resolve uncertainty. We can't eliminate uncertainty.

Participant Comment: Reviewers should be more concerned if there is no uncertainty described by the risk assessor.

PROBLEM FORMULATION

Participant Question: Please elaborate on the problem formulation, its significance, and the importance of ensuring that it is being done right.

Answer: During problem formulation we create a picture to illustrate all the pieces that must be considered. It is important to interact with the right people (e.g., those affected by project). We must identify possible chemicals, possible stressors, etc. There must be open communication with those who have a stake and with regulators and the proponents (past and present). This stage is often passed over too quickly. We must revisit the picture regularly and change the picture/models with new info – as needed. We then need to understand and deal with any new information. If we don't take the time to do this at the beginning, the risk assessment may not address the primary concerns of the stakeholders.

SOCIO-ECONOMIC CONSIDERATIONS

Participant Comment: We need to understand the socio-economic aspects as well, including, job opportunities, partnerships / investment, positive or negative social impacts and whether we have the capacity to deal with them, stress. We need to balance the environment with economic development.

REVISITING THE RISK ASSESSMENT

Participant Question: How often should a risk assessment be revisited?
Answer: Risk assessments are not revisited as frequently as they should be. We need to ask questions like:

- Have we made the correct assumptions?
- Do the original assumptions still make sense based on the initial picture?
- Did we actually answer the initial questions?
- What happened, for example, to the Sacred Place?
- Have the correct choices been made?

Participant Comment: It is important to identify the goals of the risk assessment during the problem formulation phase – this helps to manage expectations.

RISK ASSESSMENT METHOD

Participant Question: It is not clear exactly how risk assessment is done. Is the result of the risk assessment qualitative or quantitative; is it a set of weighted criteria? How is the process

standardized to reduce subjectivity?

Answer: There is clear guidance on how to do risk assessments, how to quantify risk and the advantages / disadvantages of risk assessment. Regarding subjectivity: if we have the right stakeholders at the beginning, then we should have the ability to determine the best way to quantify and qualify risk. Where we don't have quantitative data, there are very powerful ways of collecting and analyzing qualitative information.

Participant Comment: Regarding subjectivity: risk assessment comes up with the best prediction. But MVEIRB uses subjective but informed judgement. That's why there are co-management boards. There is a combination of different values and the board relies on subjective (although un-biased) informed evidence. The values of stakeholders also come into play.

TRADITIONAL ECONOMY

Participant Question: Is traditional economy considered in risk assessments?
Answer: Yes it should be, but typically it has not been.

VULNERABILITY AND RESISTANCE

Participant Question: How are vulnerability and resilience dealt with during the risk assessment process?

Answer: We touched on vulnerability with the discussion on immune deficiency and developing infants and the elderly. Resilience is the ability to cope and build up a tolerance. This is generally poorly dealt with. We deal with these concepts in part by using conservatism and erring on the side of caution. We can reduce but not eliminate uncertainties. How much data is necessary? Sometimes collecting more data will not help to answer our questions. Our answers need to be defensible but uncertainties will remain.

CERTIFICATION OF RISK ASSESSORS

Participant Question: For those relying on others to do the risk assessments – should they look for certain credentials / certification, for increased comfort behind what is presented to the reviewers?

Answer: Some provinces have professional certification or a roster of environmental professionals. Accreditation is useful. It also helps if expectations are clearly stated at the beginning. It's good if the Boards are brought in at the Problem Formulation level – transparency is good for building trust.

Participant Comment: Risk assessment requires expertise from many folks in various disciplines. Risk assessment should be accompanied by follow-up field monitoring. Even if the risk quotient is greater than 1, the real world may tell a different story, since the real world is complex and allows systematic integration. It is a good process but does require expertise.

Participant Comment: Risk assessments are very multidisciplinary.

Participant Comment: Look at the team – it is good to have a certified risk assessor on the team but it is great to have experts, even though they are not certified.

Participant Comment: The concept of likelihood versus severity is important. The level of severity helps to assess the level of uncertainty that is reasonable.

PROTECTION LEVELS

Participant Question: Explain protection levels.

Answer: We determine the protection level early on with the stakeholders. It may be a body measurement value or a population decline.

INCREMENTAL RISK

Participant Question: What is incremental risk?

Answer: Agencies work to account for naturally-occurring compounds (e.g., arsenic). If only the Canadian Council of Ministers of the Environment (CCME) guidelines were used, all of our yards (in Yellowknife) would be identified as having hazardous concentrations of arsenic. Incremental risk accounts for background levels. Human activities may increase the background level by a certain amount. Every location is different, which is why we sample for site-specific concentrations. For estimating a project's incremental risk, historical data are good and it is important to do a baseline study to understand the situation before a project begins. For illustration purposes, we can think of the straw that broke the camel's back. If we do not examine the health of the camel to begin with and monitored its health (maybe it was old or developed weak knees) and didn't know how many straws the camel was already carrying, we might continue adding straws one at a time, until finally one straw breaks the camel's back.

Question: Couldn't we look at incremental risk another way? If background concentrations are high, maybe we should not allow more arsenic into the environment, particularly given that there can be cumulative effects.

Answer: This is where monitoring comes in. We should understand ways to monitor for true health effects. It is very difficult because health effects are hard to sample – we need a certain population base to do statistics. Also, if you think that the natural value is high, you can look at other areas (e.g. Bangladesh) where arsenic is high and compare with Yellowknife.

Participant Comment: In thinking of our exposure (e.g., to arsenic) from a particular project, we must consider the total amount of impact for all sources, including food sources (store foods and country foods), which is often where most of our exposure comes from. It is easy to be side-tracked by the risk posed by a project if the risk is not put into the context of other exposures unrelated to the project. We must remember the question we are supposed to be addressing.

HOW FAR INTO THE FUTURE DO WE LOOK?

Participant Comment: Regarding preliminary screening: standards are built to withstand certain storm events or other calamities at some level (e.g., 500 year storm event). But if we are looking at a dam, it has a long life span. We should be looking at the applications and how long the dam will last. Do the math and look at how long it is supposed to be there.

PRISTINE ENVIRONMENTS

Participant Question: Is risk assessment ever used in a pristine environment?
Answer: This is not what regulations were set up to do. Regulators should make it clear that if there is a best practice in mining, it should be used. Stakeholder values should be taken very seriously.

PRESENTATION and Q&A: Is Our Wild Food Healthy? – Edna Willier, Lesser Slave Lake Indian Regional Council

The presentation illustrated the role a community played in a risk assessment used to determine whether wild food in the area of an incinerator is safe. See Appendix D for a copy of this presentation.

Participant Question: The risk assessment concluded that moose is still safe to eat. Have the posters worked? Are people getting out and hunting again?

Answer: Many people hunt elsewhere still. Health Canada took blood samples from 50 people. The

analysis revealed that concentrations (of chlorinated dioxin equivalents) were higher in some people. The same people were sampled again in 2002 and the concentrations were quite low in comparison.

Participant Question: You say you are now moving into the second phase of the risk assessment. When is enough enough? When will the risk assessment end?

Answer: We don't know. It is an on-going process.

Participant Comment: Moose hunters near Wrigley, NT, killed a moose and it had marble-sized lumps in the meat. Green pus was oozing out, too. They had been asked to send in samples.

Answer: Some of the moose in the study contained worms, green pus and white cysts – not in the meat so it is ok [to eat].

Participant Question: The next phase involves lake monitoring – do you see the results fitting in to the overall risk assessment?

Answer: We don't know.

PRESENTATIONS: Case Studies of Risk Assessment in Action

Day 2 of the risk assessment information session began with presentations on case studies:

- When Should You Do an Ecological Risk Assessment and What Can an Ecological Risk Assessment Do for You? – Amy Sparks, Environment Canada
- Giant Mine Remediation Risk Assessment – Bruce Halbert, SENES Consulting (Giant Mine Remediation Team)
- Risk-Based Closure Criteria – Gord MacDonald, Rio Tinto
- Examples of Risk Assessments from Ekati – Marc Wen, Rescan
- Risk Assessment at Con Mine – Ron Connell, Newmont

Appendix D contains the PowerPoint presentations. All questions were asked to be held until the Discussion Panel following this segment of the workshop.

DISCUSSION PANEL

An approximately 1 ½ hour-long discussion period, facilitated by Ken Froese, started the afternoon. Panel members included Amy Sparks and Jody Klassen (Environment Canada), Bruce Halbert and Lisa Dyer (SENES/PWGSC - Giant Mine Remediation Team), Ron Connell (Newmont – Con Mine), Marc Wen (Rescan – Ekati Mine) and Gord MacDonald (Rio Tinto – Diavik Diamond Mine).

Participants were invited to ask questions about any of the presentations from Day or Day 2. Summaries of the discussions arising from these questions are presented below.

The statements below are viewpoints expressed by various presenters and participants, and should not be considered fact or as statements that everyone necessarily agreed with.

PUBLIC PERCEPTION / STAKEHOLDER ENGAGEMENT

Transparency and communication are very important in the risk assessment process. Proponents need to get out there and have open dialogue with stakeholders. Risk management needs to be

communicated and it is important to make sure that people understand when changes are made and why.

Risk assessors need to help people understand what the numbers mean – generic guidelines versus site-specific criteria. You need to be careful how this gets worded to ensure the results are communicated accurately and simply. One way is to tie exposure and risks back to certain chemicals that people can relate to (e.g., smoking). Communication at the outset of risk assessment is critical and should be on-going throughout the process.

Risk assessors need to be able to answer basic questions: "Can you drink the water?". This brings the results to a level that is meaningful to people. It boils down to risk communication. Risk assessors need to take the analytical results and boil it down to a level that is informative to the general public.

- **Transparency**
- **Relationship with the community**
- **Communication / Public Consultation**

Early engagement with stakeholders to determine how people use the land, who uses the land and for how long, is very important. You need to "think outside the box" and take into account future land use. Ask yourselves as risk assessors: "Have we made an effort to determine what the stakeholders care about?" It is too easy to do a desktop study where risk assessors get hung up on numbers and then are not able to answer questions from the community.

PROBABILISTIC FRAMEWORK IN ASSESSMENT / UNCERTAINTY

In some assessments, risk assessors get into looking at uncertainties from a probabilistic perspective. The inputs and outputs can be expressed in a probabilistic way when modelling risk.

For example, there is uncertainty around how much moose browse and what they are browsing. Assessors can make their best estimate and express this as a range. These ranges get wrapped into the output calculation.

Monte Carlo is a mathematical approach that is often used in risk assessments. This approach is less embraced by regulators because it doesn't give a single number answer but a range.

Probabilistic risk assessment is very systematic from a scientific perspective but for the public, it needs to be boiled down to what are the numbers and what do they mean?

ITERATIVE PROCESS OF RISK ASSESSMENT / ADAPTIVE MANAGEMENT

It is important to re-examine how the project happened and adjust accordingly within the framework of the process.

If a screening level or preliminary risk assessment indicates higher than accepted values, then risk assessors should go back into the field to clarify/examine. Perhaps something was initially assessed as a major risk but re-examination reveals that it is not. There are often follow-up monitoring programs to establish whether or not there really is a risk.

It is important to examine multiple species and species diversity; sampling a single species or trophic level is not enough as it is only a small part of the puzzle.

CHEMICAL SYNERGIES

There is a lack of ability to account for chemical synergies. Chemical synergies are not well understood. How do synergies (outside chemical) contribute to local vulnerability?

Epidemiology – it's very difficult to link health to environmental concerns, and it costs a lot.

Environmental effects monitoring may expose synergistic relationships. Monitoring can reveal synergistic effects that may not have been expected form the risk assessment.

CONDUCTING A RISK ASSESSMENT

The government should maybe pay for the baseline studies, but the developer should undertake the risk assessment by way of a third party consultant, and the regulators should review it. It is important that the risk assessment be peer-reviewed in that it helps with public perception - this is the best way to go.

ASSESSING CUMULATIVE IMPACTS: INDUSTRY COLLABORATION

Collaboration and coordination among the mines does occur regarding risk assessment and cumulative impacts. There are examples whereby multiple proponents feed information into models and thus conduct a collective analysis. Ideally this would also involve the GNWT and could even occur across territories, such that people are speaking the same language and are collecting similar information. The example of caribou population decline was discussed.

Diavik commissioned a study evaluating the winter road. The results of the study determined that to putting money into upgrading the winter road, in light of global warming and intensity of use, would not be worth it from the mine's perspective given its operational life. The report from the study was handed over to the GNWT.

ALTERNATIVE OPTIONS

Risk assessment is used to help make decisions, but when looking at the outcomes of a risk assessment, you also have to look at the financial aspect. In some cases, the cost is so high to mitigate that you have to change the option to reduce the risk.

An options analysis should be done. There is a regulatory point when you have to present alternatives with rationalization. Decisions occur all of the time within the framework. Sometimes you have to go with the more cost-effective option.

Environment Canada can help in choosing options. The narrative goal of the risk assessment doesn't change based on cost. The technical review panel can also help make the choice. Another revisit of the picture might need to be done in order to fill in the gaps.

Following a risk assessment, the decision to go ahead with the project may be based on financial reasons or the social aspect.

TOXIC VS NON-TOXIC FORMS

Arsenic is found in grocery foods in a non-toxic form –arsenic often enters the body in the form of sugar-like molecules, which get excreted from the body and never becomes an issue. Arsenic in other forms can be very toxic. Many assessments, in particular scoping and screening level risk assessments, do not differentiate between toxic and non-toxic arsenic.

PRESENTATION: Holistic Integrated Risk Assessments– Ken Froese, Ph.D., SLR Consulting

The remainder of the afternoon involved a presentation by Dr. Ken Froese regarding a holistic approach to risk assessment. Dr. Froese emphasized that Risk assessments are conducted within an intrinsically-linked socio-economic, environmental system; a series of components with relationships among them. In a risk assessment, it is important to understand these relationships. Drawing on the expertise in a variety of disciplines is critical to the overall sustainability of the system.
A copy of this presentation is provided in Appendix D.

DISCUSSION: QUESTIONS AND ANSWERS

Participant Question: How do you normalize between the metrics?

Answer: We would draw expertise of colleagues – standardized decision-making tools can distinguish between the qualitative values.

Participant Question: What about cumulative impact risk assessment?

Answer: This is challenging – cumulative project risk assessments have been done using a holistic approach. It is important to look at other nearby projects. It requires more input from the communities. We need to be reminded that cumulative risk assessment is important (e.g. the straw that broke the camel's back – it wasn't just a single event).

Participant Question: What is the purpose behind the spider diagrams? Provide other examples of holistic approach being used.

Answer: The spider diagram is a diagnostic tool – it is developed through work with colleagues and subsequent discussion and validation with the communities. The tool was developed to assist with community-based environmental decision-making.

It is a good idea to do a health impact assessment (HIA) along with an environmental impact assessment (EIA) as they are fundamentally linked. There is good HIA guidance through Health Canada.

Participant Question: This is already being done to a certain extent in the real world, at least in Ontario. There, the government has set up call centres where people can contribute.

Answer: It is necessary in Alberta where land use discussions are occurring. Proponents are best served by earning a social licence.

Participant Comment: There is a project in Alaska where there were lots of disciplines involved, boards were not involved – eventually there were outcomes. The participant had never really thought about the health impact assessment and Traditional Knowledge, but that is really what it was all about.

Closing Remarks

Patty thanked everyone who came and participated, as this was a great opportunity to gather expertise and gain clarification on risk assessment. The information session ended with a closing prayer.

APPENDIX A – WORKSHOP AGENDA

Agenda – Day 1

An Introduction to Risk Assessment

Date: December 6th and 7th, 2011 Time: 9:00 a.m. to 4:00 p.m.
Location: Yellowknife: Explorer Hotel, Katimavik C

Day 1: What is Risk Assessment?	
Time	**Topic**
9:00–9:45 a.m.	Opening prayer. Logistics and introduction.
9:45–10:15 a.m.	Introduction to Risk Assessment *Ken Froese, PhD - Senior Risk Assessment Specialist, SLR Consulting (Canada) Ltd.*
10:15–10:30 a.m.	**Break**
10:30–12:00 p.m.	Human Health Risk Assessment, continued Questions and Answers (Q and A) *Ken Froese, PhD - Senior Risk Assessment Specialist, SLR Consulting (Canada) Ltd.*
12:00–1:00 p.m.	**Lunch (on your own)**
1:00–2:30 p.m.	Ecological Risk Assessment, followed by Q and A *Ken Froese, PhD - Senior Risk Assessment Specialist, SLR Consulting (Canada) Ltd.*
2:30–2:45 p.m.	**Break**
2:45–4:00 p.m.	Community Involvement in Risk Assessment: A Case Study on the Swan Hills Waste Treatment Centre in Northern Alberta *Edna Willier, Environment Co-ordinator with the Lesser Slave Lake Indian Regional Council Environment Program, followed by Q and A*

Agenda – Day 2

An Introduction to Risk Assessment

Date: **December 6th and 7th, 2011** **Time:** **9:00 a.m. to 4:00 p.m.**
Location: **Yellowknife: Explorer Hotel, Katimavik C**

Day 2: Risk Assessment in Action	
Time	**Topic**
9:00–9:15 a.m.	Opening Comments and Overview of Day 1
9:15–10:45 a.m.	Case Studies of Risk Assessment in Action – A series of presentations on real-life applications of risk assessment (not necessarily in this order): - Environment Canada: Risk Assessment at Northern Contaminated Sites - Diavik Diamond Mines, Inc: Risk-Based Closure Criteria - Rescan: Risk Assessments at the Ekati Mine - Miramar Northern Ltd: Risk Assessment at Con Mine - Aboriginal Affairs and Northern Development Canada/Senes Consultants: Risk Assessment at Giant Mine
10:45–11:00 a.m.	**Break**
11:00–12:00 p.m.	Discussion Panel - Our presenters will form a panel and take questions from the audience
12:00–1:00 p.m.	**Lunch (on your own)**
1:00–1:30 p.m.	Discussion Panel, continued
1:30–1:45 p.m.	Exercise
1:45–2:45 p.m.	Holistic Integrated Risk Assessments, followed by Q and A *Ken Froese, PhD - Senior Risk Assessment Specialist, SLR Consulting (Canada) Ltd*
2:45–3:00 p.m.	**Break**
3:00–4:00 p.m.	Open Discussion and Networking Closing Prayer

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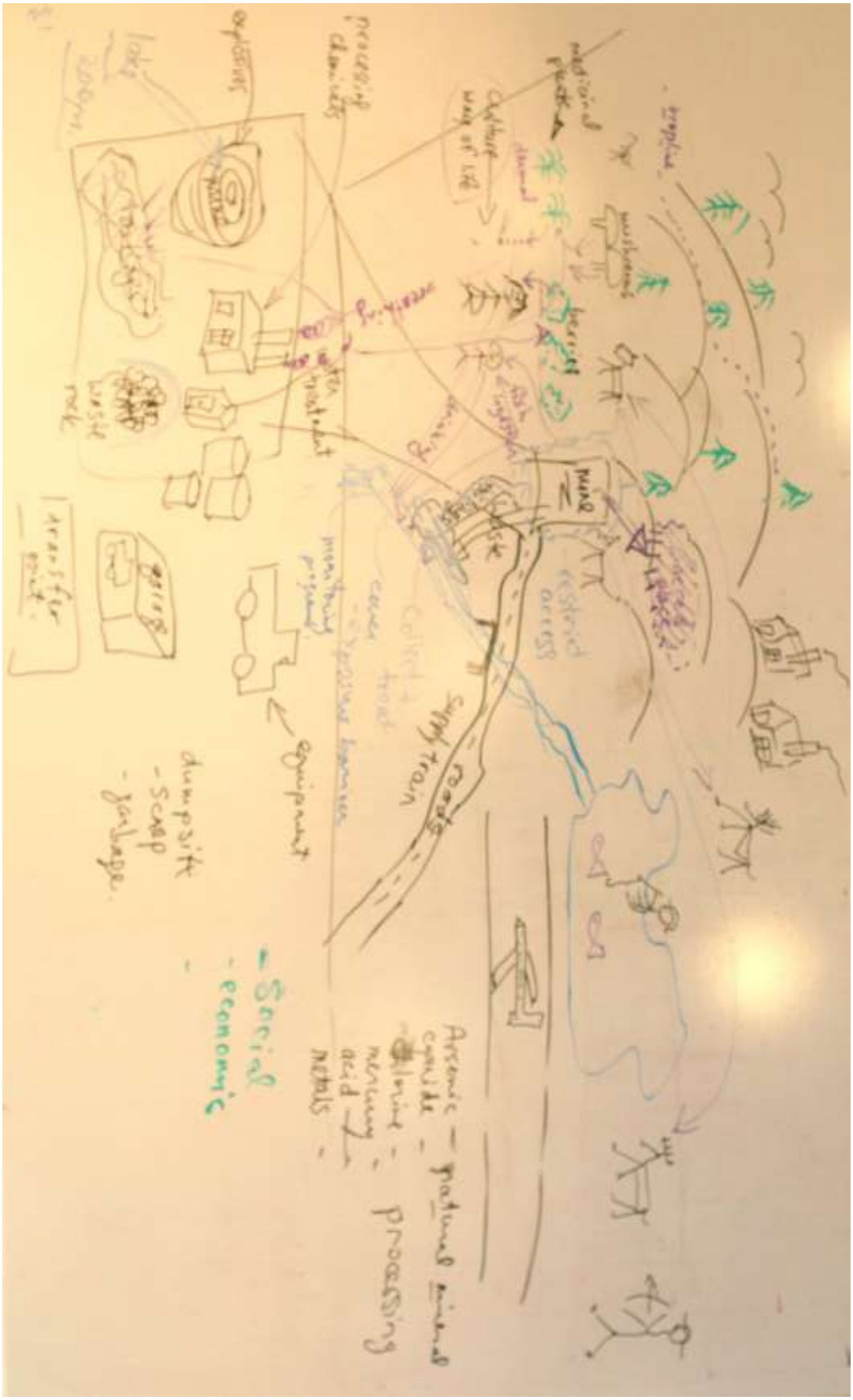
APPENDIX C – PHOTO: PROBLEM FORMULATION GROUP EXERCISE


Supply roads
Equipment
dumpsite
- scrap
- garbage
Social
- economic
Arsenic
- natural minerals
- processing
acid
metals

APPENDIX D – POWERPOINT PRESENTATIONS

Introduction to Risk Assessment

Ken Froese, Ph.D.

Content

- Definitions of Risk
  - Everyday examples
- Morning: Human Health Risk Assessment
- Afternoon: Ecological Risk Assessment
- Tomorrow: Holistic environmental assessment

Introduction

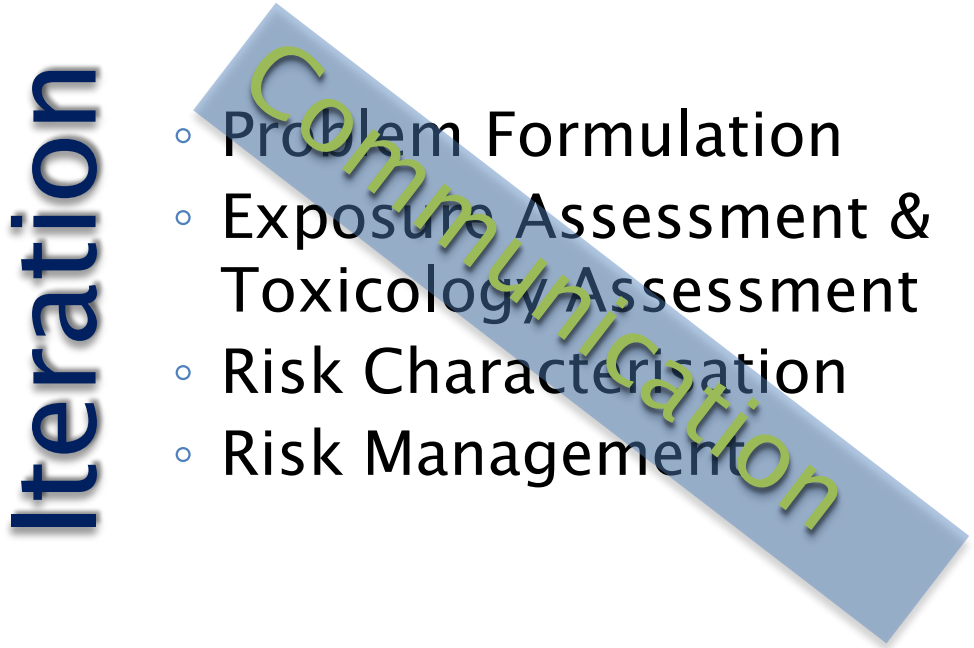
- What is Risk?
- Some definitions and concepts
- Every day examples – interactive!
  - Getting out of bed
  - Driving to work

Risk Assessment

- Contaminant or chemical risk assessment
- Health Canada guidance documents
  - http://www.hc-sc.gc.ca/ewh-semt/pubs/contamsite/index-eng.php
  - Contact HC for most recent documents and released drafts!
- CCME guidance documents
  - http://www.ccme.ca/publications/list_publications.html

Risk Assessment

- The RISK FRAMEWORK



Risk Assessment

- There are different levels of risk assessment
  - Scoping
  - Screening
  - Detailed or site-specific
- It is very important to define which one we are doing, and when and why we step to the next level.
  - "**risk it away**" is a product of miscommunication on this aspect of risk assessment

Problem Formulation

- What is the concern? Why are we doing an RA?
- Do we understand the problem(s) we need to address?
- Does everyone understand the same problem?

- Interactive… We are going to draw a picture

Problem Formulation

- What is the **setting**?
- What **receptors** might be present?
- What are the **hazards**?
- How could receptors be exposed to the hazards – **pathways** of exposure?

- Receptors – listed and endangered species; valued species; sentinel species; surrogates
- Hazards – aka chemicals in the Health Can and CCME risk assessments
  - Compare site concentrations to published screening values to make list of compounds of concern (CoC).

Problem Formulation

- Draw the picture!
  - Discuss and communicate
- Re-draw the picture!
  - Discuss and communicate with more stakeholders
- Re-re-draw the picture!
  - until everyone has a common mental model

Problem Formulation

- Have we defined the problem(s) we need to address?
- Does everyone understand the same problem?

Exposure Assessment

- How much are we exposed?
- How do we measure this?
  - Chemical concentrations in air, soil, water, sediment, plants, animals
  - Calculate or measure how much air we **breathe**, water we **drink**, food we **eat**, soil and sediment we accidentally eat, how often our **skin contacts** soil or water, …
- Use 'surrogates'
  - Organism or food that is similar
  - Receptor that is similar
- Use models
  - Mathematical computer calculations to **estimate** data if we don't have direct data

Exposure Assessment

- Northern and aboriginal communities
  - Country foods
  - Cultural practices
- Health Canada
  - Supplemental guidance on HHRA for Country Foods (Oct 2010)

Toxicity Assessment

- "All things are poisons. It depends only on the dose." Paracelsus ca. 1520 (paraphrased)
- How can chemicals affect us, and in what amounts?
- Who determines this?
  - Biologists, chemists, pharamacologists, medical prof, epidemiologists, etc...
- How do they determine this?
  - Direct studies (workplace), history, surrogate studies (rats, mice, pigs), etc...

Toxicity Assessment

- Establish Toxic Reference Values (TRV)
  - Also called Reference Dose (RfD)
- Main difference between HHRA and EcoRA is here
  - TRV for HHRA – differences for carcinogenic / non-carcinogenic.
    - Non-carcinogen – use "safety factors" of 3- to 1000-fold.
    - Carcinogen – no safety factors, assume health effect from 1 molecule exposure and increasing from there
  - TRV for Eco – now being based on EC_{20}

Risk Characterisation

- Simple description: calculate the ratio between amount of chemical exposed and the TRV
  - Defined as Risk Ratio or Hazard Quotient
- If the ratio is >1, *take a closer look. This does not automatically mean an unacceptable risk is inevitable!*

Uncertainties

- E.g. Country foods and amounts; appropriate surrogates; safety factors on TRVs
- How can these affect our risk characterisation?
  - Typically result in over-estimations
- We can reduce uncertainties, but not eliminate them

Risk Management

- Reduce (or eliminate) exposure – this is the main method of risk management for contaminated sites.
  - Examples – remove or cover contaminated soil; treat contaminated water; choice of foods or location of food & water source; reduce consumption
- Reduce effects; reduce severity of consequences

- We manage risks all the time in our lives…

Is our wild food healthy?

Lesser Slave Lake Indian Regional Council (LSLIRC) Traditional Environmental Monitoring and Risk Communication Project

LSLIRC is looking at wild foods to see if they are still healthy for our people. We want to put our land users in control of the information they need to make good decisions about the wild foods we eat.

TEMRCP Goal

- We are working in a rolling study. Community members, elders, researchers and health workers have identified goals, done training, and measured contaminants in wild foods with a focus on moose meat

Dioxins & Dioxin-like PCBs in Moose

- TEMRCP has sampled through early 2007 to present in the TEMRCP
- We also have moose samples analysis from 2004-2007
- Preliminary data presentation …

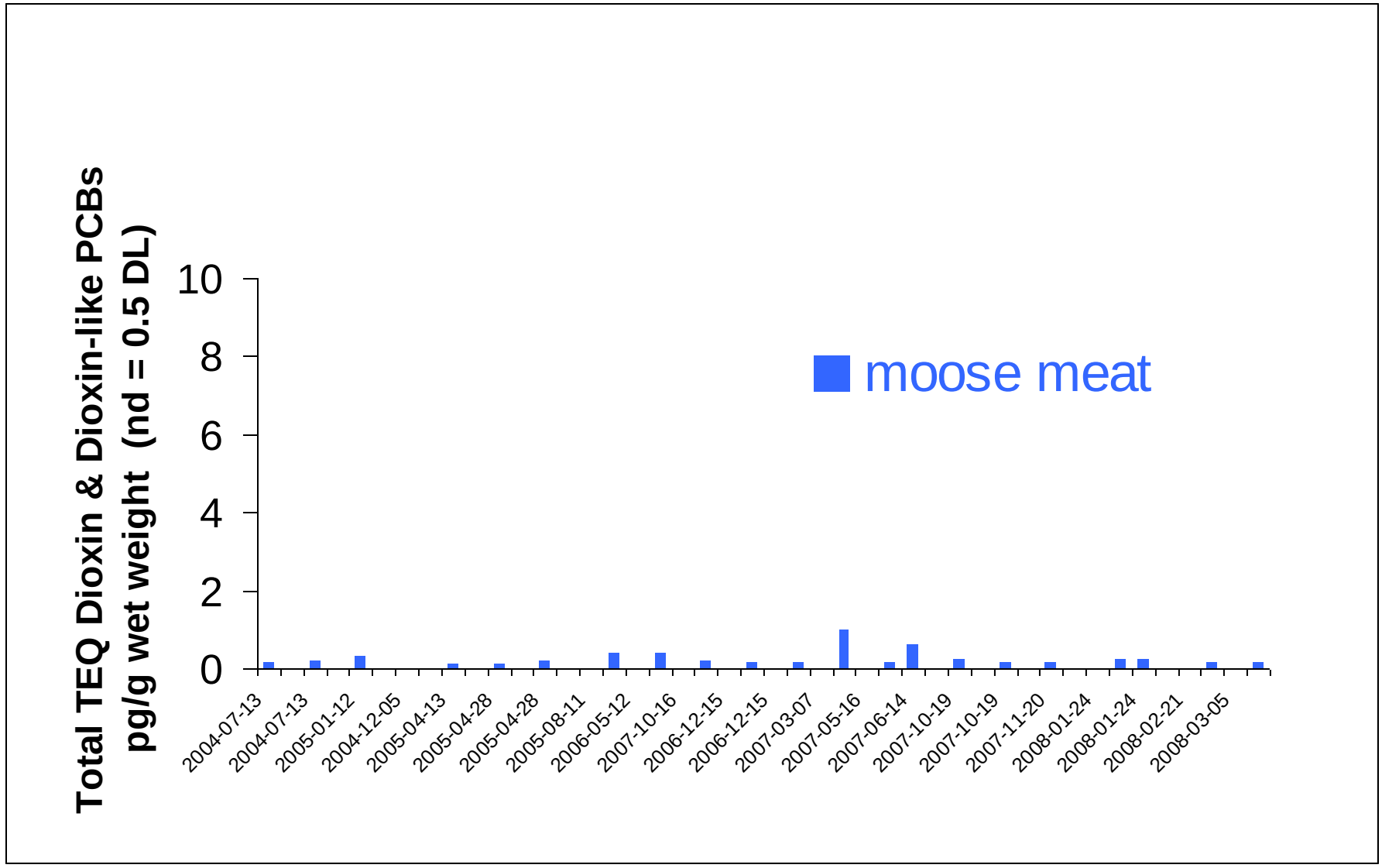
Two Futures…

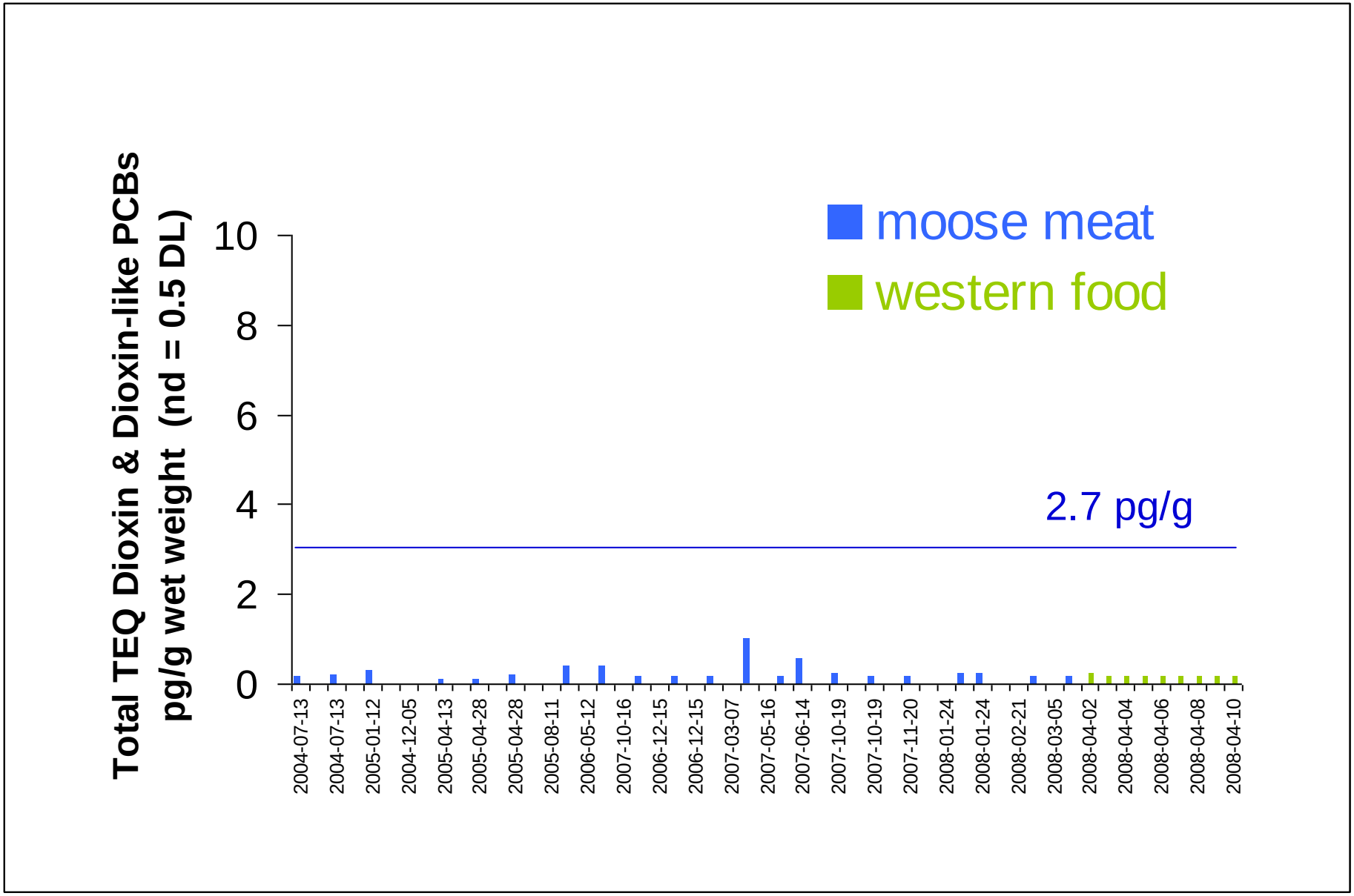
Dioxins and PCBs are above levels

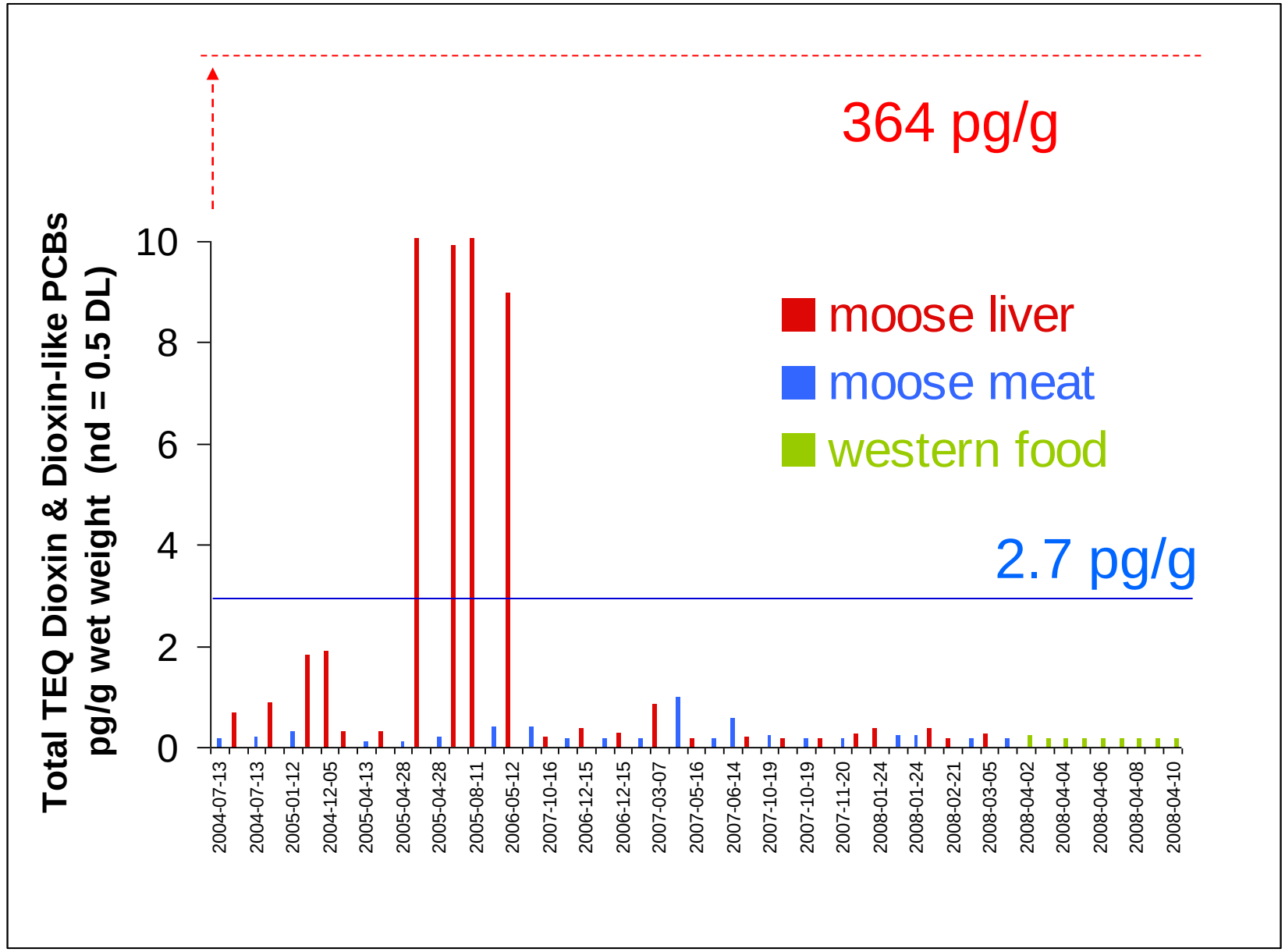
- Support country food ban
- Hunt for country food farther away
- Stock food kitchens and freezers
- Educate people about risks

Dioxins and PCBs are below levels

- Support country food harvesting
- Support elders and at risk people through education
- Develop country food educational materials
- Continue harvesting studies


Total TEQ Dioxin & Dioxin-like PCBs
pg/g wet weight (nd = 0.5 DL)
10
8
6
4
2
0
moose meat
2004-07-13
2004-07-13
2005-01-12
2004-12-05
2005-04-13
2005-04-28
2005-04-28
2005-08-11
2006-05-12
2007-10-16
2006-12-15
2006-12-15
2007-03-07
2007-05-16
2007-06-14
2007-10-19
2007-10-19
2007-11-20
2008-01-24
2008-01-24
2008-02-21
2008-03-05


Total TEQ Dioxin & Dioxin-like PCBs
pg/g wet weight (nd = 0.5 DL)
10
8
6
4
2
0
moose meat
western food
2.7 pg/g
2004-07-13
2004-07-13
2005-01-12
2004-12-05
2005-04-13
2005-04-28
2005-04-28
2005-08-11
2006-05-12
2007-10-16
2006-12-15
2006-12-15
2007-03-07
2007-05-16
2007-06-14
2007-10-19
2007-10-19
2007-11-20
2008-01-24
2008-01-24
2008-02-21
2008-03-05
2008-04-02
2008-04-04
2008-04-06
2008-04-08
2008-04-10

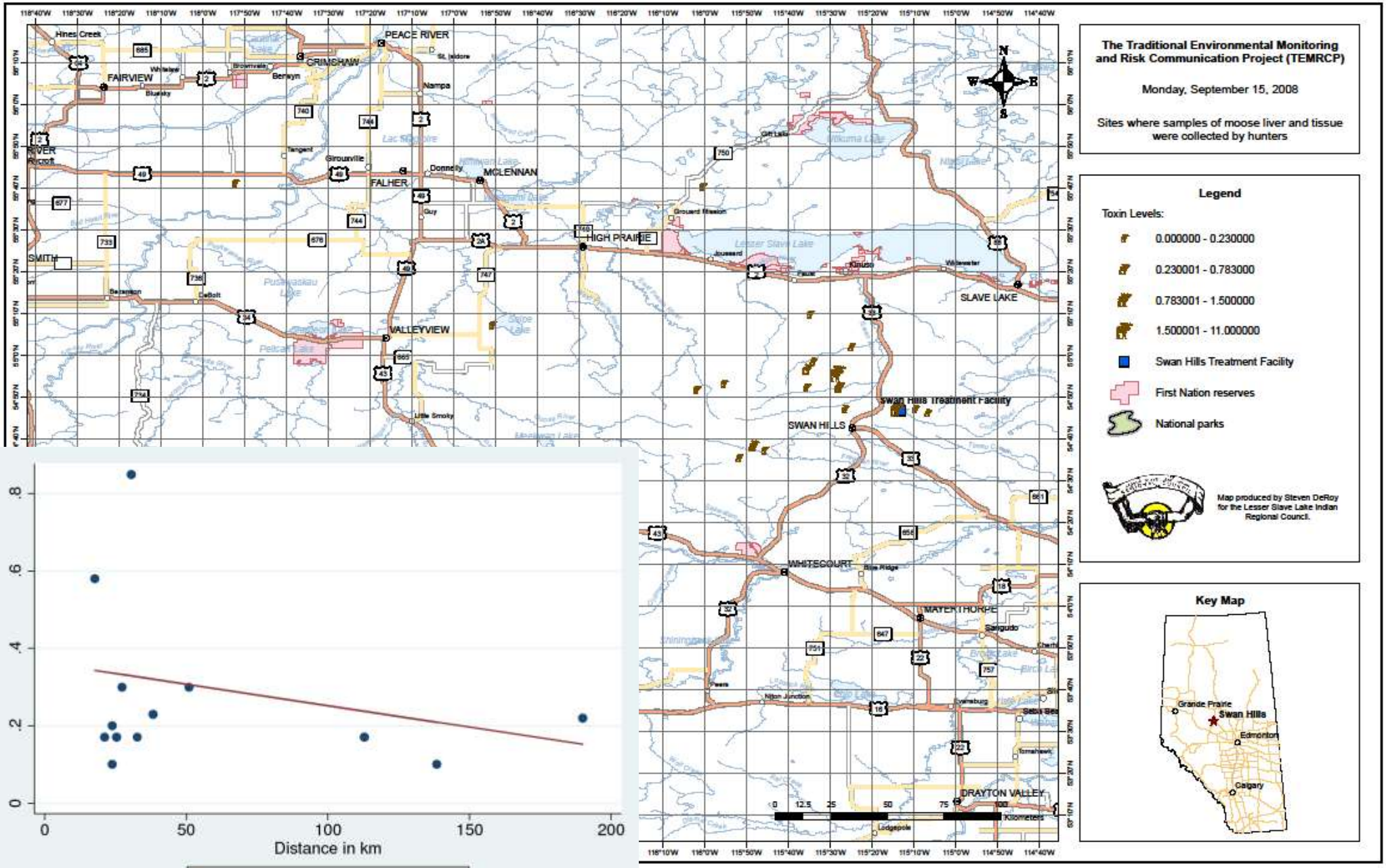

364 pg/g
moose liver
moose meat
western food
2.7 pg/g
Total TEQ Dioxin & Dioxin-like PCBs
pg/g wet weight (nd = 0.5 DL)
0
2
4
6
8
10
2004-07-13
2004-07-13
2005-01-12
2004-12-05
2005-04-13
2005-04-28
2005-04-28
2005-08-11
2006-05-12
2007-10-16
2006-12-15
2006-12-15
2007-03-07
2007-05-16
2007-06-14
2007-10-19
2007-10-19
2007-11-20
2008-01-24
2008-01-24
2008-02-21
2008-03-05
2008-04-02
2008-04-04
2008-04-06
2008-04-08
2008-04-10

Issues

- exposure standards & consumption rates

- Non-detects
- 0?
- 0.5?
- DL?
- another valid statistical approach

- Exposure trends with time
- Sampling integrity of historical data
- Exposure trends with geography
- Variability & Confidence Intervals
- Duplicate Analysis
- Background monitoring program


The Traditional Environmental Monitoring and Risk Communication Project (TEMRCP)
Monday, September 15, 2008
Sites where samples of moose liver and tissue were collected by hunters
Legend
Toxin Levels:
0.000000 - 0.230000
0.230001 - 0.783000
0.783001 - 1.500000
1.500001 - 11.000000
Swan Hills Treatment Facility
First Nation reserves
National parks
Map produced by Steven DeRoy for the Lesser Slave Lake Indian Regional Council.
Key Map
Grande Prairie
Swan Hills
Edmonton
Calgary
PEACE RIVER
CRIMSHAW
FAIRVIEW
Nampa
FALHER
MCLENNAN
HIGH PRAIRIE
SLAVE LAKE
VALLEYVIEW
SMITH
SWAN HILLS
Swan Hills Treatment Facility
WHITECOURT
MAYERTHORPE
DRAYTON VALLEY
Distance in km
tddpcbh
Fitted values

Health Risk?

Risk Assessment

- Exposure Assessment
- Modeling
- Toxicity & Standards
- Risk Assessment
- Health Impact?

Risk Perception

- Fear
- Altered Lifestyle
- Altered diet
- Erosion of culture
- Stress in individual, family & community
- Health Impact!

TEMRCP Risk Communication

- Introductory poster
- Fact sheets for CHRs
- Community meetings
- Toxic Round-Up organized through the LSLIRC with support from Alberta Environment and schools in Joussard, Kinuso, and Driftpile
- Medicine Wheel poster

Capacity Building

- Lesser Slave Lake
- Health Care Workers
- Hunters
- Youth & families
- LSLIRC Leadership
- TEMRCP team

Is our wild food healthy?

"We know our wild food is more contaminated than it used to be. We also know it is still better for us than just about anything we can buy from the grocery store."

Wild Food Is Important To Our Health

LESSER SLAVE LAKE INDIAN REGIONAL COUNCIL (LSLIRC)
TRADITIONAL ENVIRONMENTAL MONITORING
AND RISK COMMUNICATION PROJECT

Traditional food helps us to maintain balance when our health is under pressure.

PROJECT COORDINATOR: EDNA WILLIER,
ENVIRONMENTAL COORDINATOR, LSLIRC,
1(800) 252-7893 ENVIRO@SLIRC.AB.CA

Thank you

Traditional Environmental Monitoring and Risk Communication Project *TEMRCP*

Our research team includes hunters, elders, and community members, and has support from: Driftpile, Sucker Creek, Kapawe'no, Swan River First Nations and the Sawridge Band. Grande Chief Rose Laboucan is the Project Leader and Edna Willier is Project Coordinator. Doris Courtreille & Linda Girroux are Community Health Representatives

Our team also includes independent scientists:

Dr. John Dennis *HHRA & PI*
Dr Ginger Gibson *Communication*
Dr. Ken Froese *PCB Dioxin specialist advisor*
Dr. Gordon Fick *UofC, statistical analysis*
David Thompson *funding, legal & project continuity*
Carolyn Whittaker *community capacity building*

Funders

- **Earth Tech**
- **National First Nations Environmental Contaminant Program (NFNECP) Health Canada**
- **Alberta Lottery**

When Should You Do Ecological Risk Assessment?
and
What Can Ecological Risk Assessment Do for You?

Amy Sparks and Jody Klassen
Environment Canada, Contaminated Sites

When Should an Ecological Risk Assessment be completed on a site?

- Types of Situations
  - Significant ecological concerns
  - Unacceptable data gaps
  - Special site characteristics

Significant Ecological Concerns

- "SARA Species"
- Critical or sensitive habitat
- Organisms that are not representative of the data on which the criteria values are based

Unacceptable Data Gaps

- National/territorial criteria do not exist for a contaminant
- Cause of effects seen on site
- Harm from remediation
- Unidentified receptors, pathways

Special Site Characteristics

- Site-specific factors suggest that generic criteria don't apply
- Significant public concern over the site
- High background concentrations of contaminants
- Cost of remediation to generic criteria levels is prohibitive

What Can an Ecological Risk Assessment Do for You?

- Identify and focus on chemicals of highest concern
- Address public concerns
- Minimize costs

Identify and Focus on Chemicals of Highest Concern

- Assess risks from chemicals of concern and determine which are most important
- Use for complex sites where it isn't immediately clear which chemicals have the highest risk to the environment

Address Public Concerns

- At sites of high public interest/concern a risk assessment can sometimes be used to inform the public

Minimize Costs

- No budget is unlimited, remediation efforts must be controlled
- Identifies areas of highest risk in order to address them first
- Further efforts focused on areas of lower risk up to the budgetary limit

What are the Outcomes for An Ecological Risk Assessment

- Determine risk on site to receptors
- Communicate ecological risks on site to stakeholders
- Understand a realistic picture of what is happening at the site
- Determine need for remediation or risk management

Outcomes cont.

- Develop site specific remediation objectives
- Focus risk management efforts
- Identify priorities or set goals for protection at a site
- Identify data gaps

Methods to Develop Numeric Remediation Objectives

	CCME Tier 1	CCME Tier 2	CCME Tier 3
Methodology	Generic Guidelines	Modified Guidelines	Risk Assessments
Site-Specificity of Objective	Generic	Somewhat site-specific	Very site-specific
Site Conditions, Pathways and Receptors	Similar to guideline protocols	Differ slightly from guideline protocols	Differ greatly from guideline protocols or are unique/sensitive
Time, Effort and Money	Low	Moderate	High

Thank You

Questions?

Amy Sparks amy.sparks@ec.gc.ca
Jody Klassen jody.klassen@ec.gc.ca; 780-951-8942

Giant Mine Remediation Risk Assessment

Presented By:

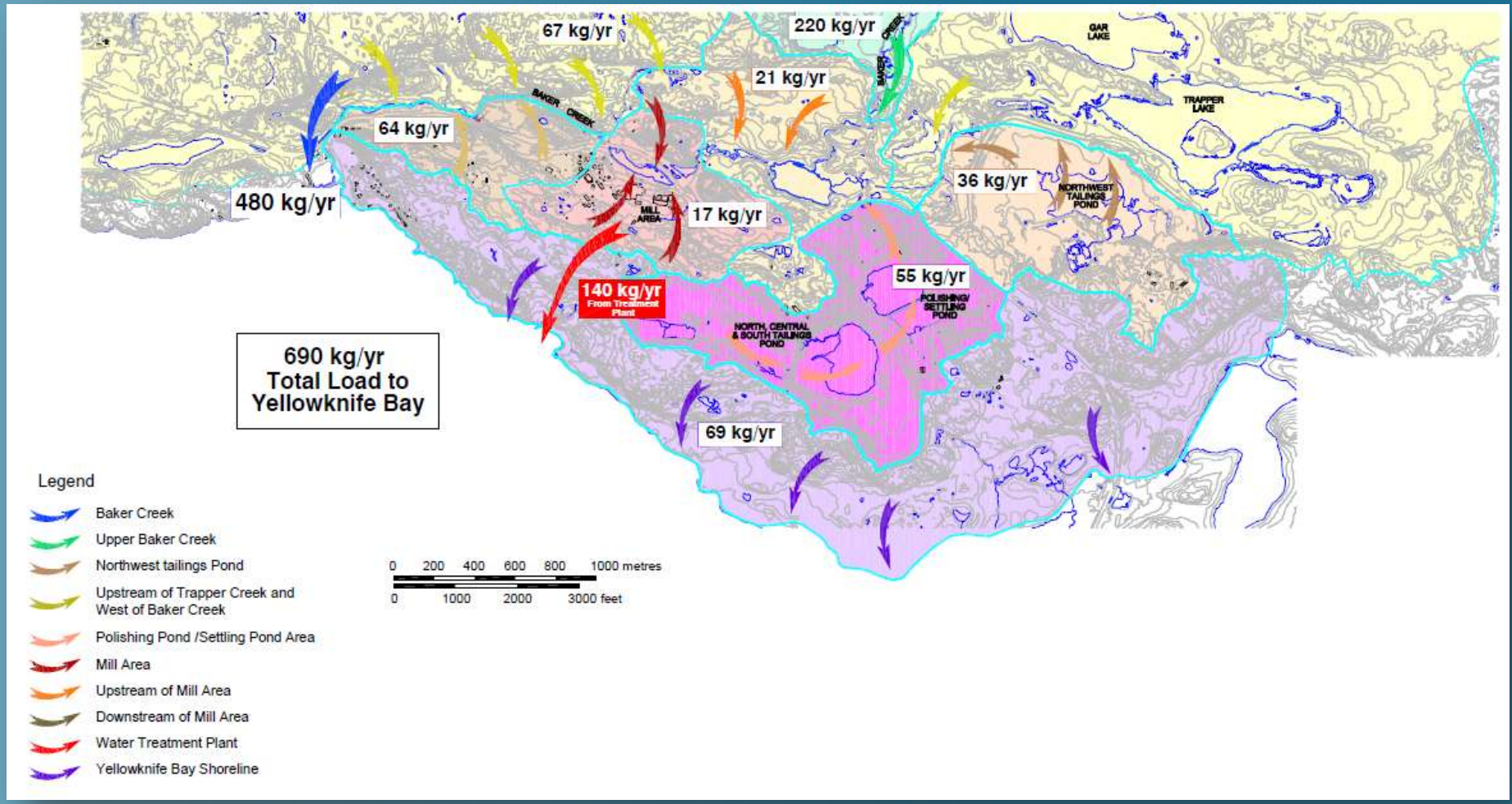
Bruce Halbert

December 2011

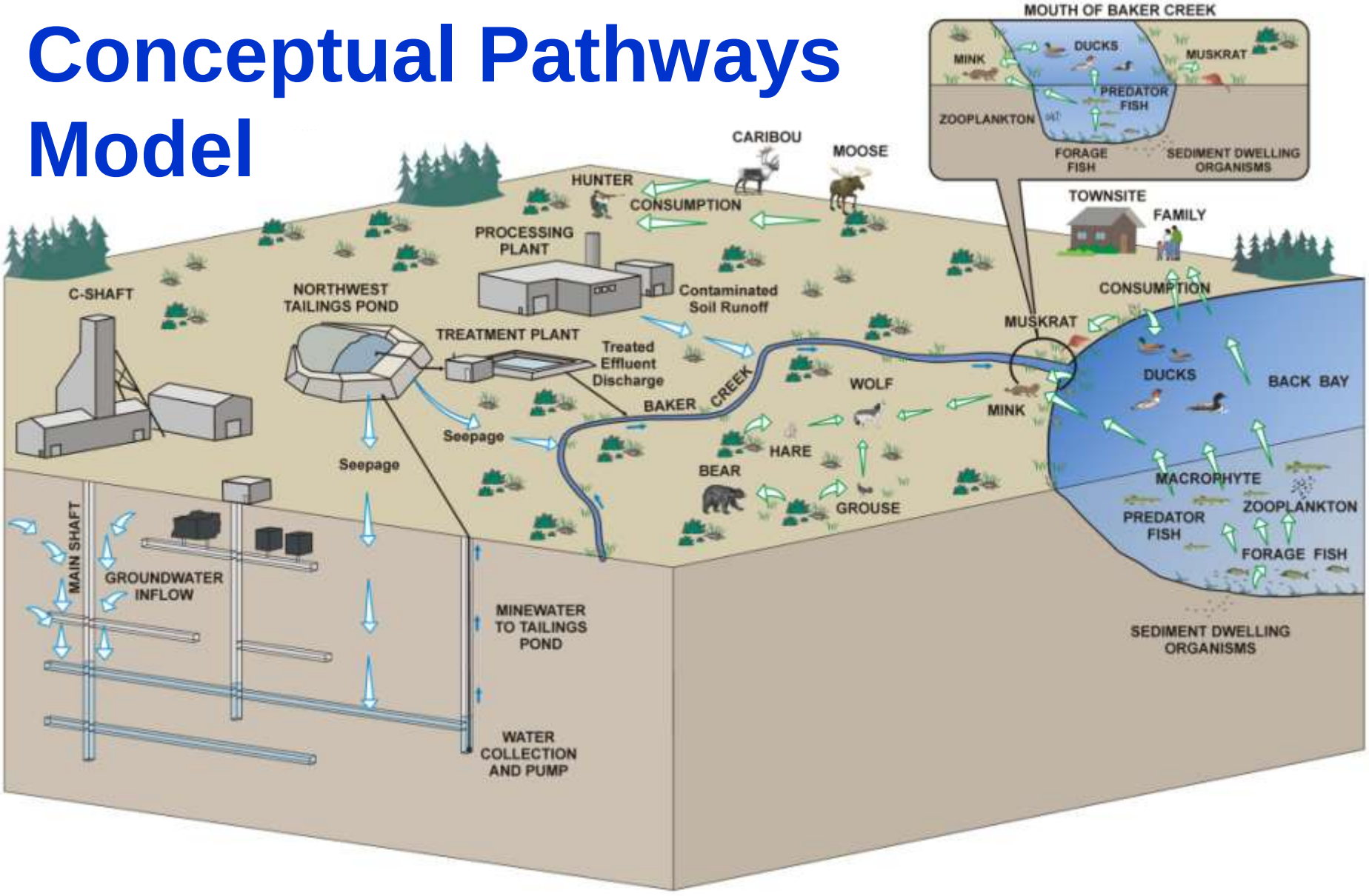
Risk Assessment Process at the Giant Mine

- Risk assessment is an iterative process
  - Several risk assessments conducted
- Original risk assessment determined that "unacceptable" risks were associated with the "do nothing" scenario
- Second risk assessment established the loadings of arsenic to Baker Creek and Back Bay that would result in "acceptable" risks
- Third risk assessment evaluated the residual risks post-remediation

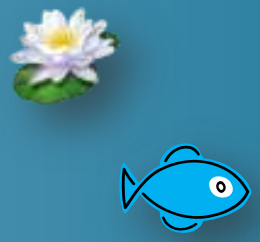
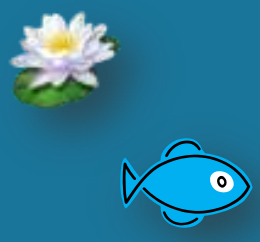
Post Remediation Arsenic Loads



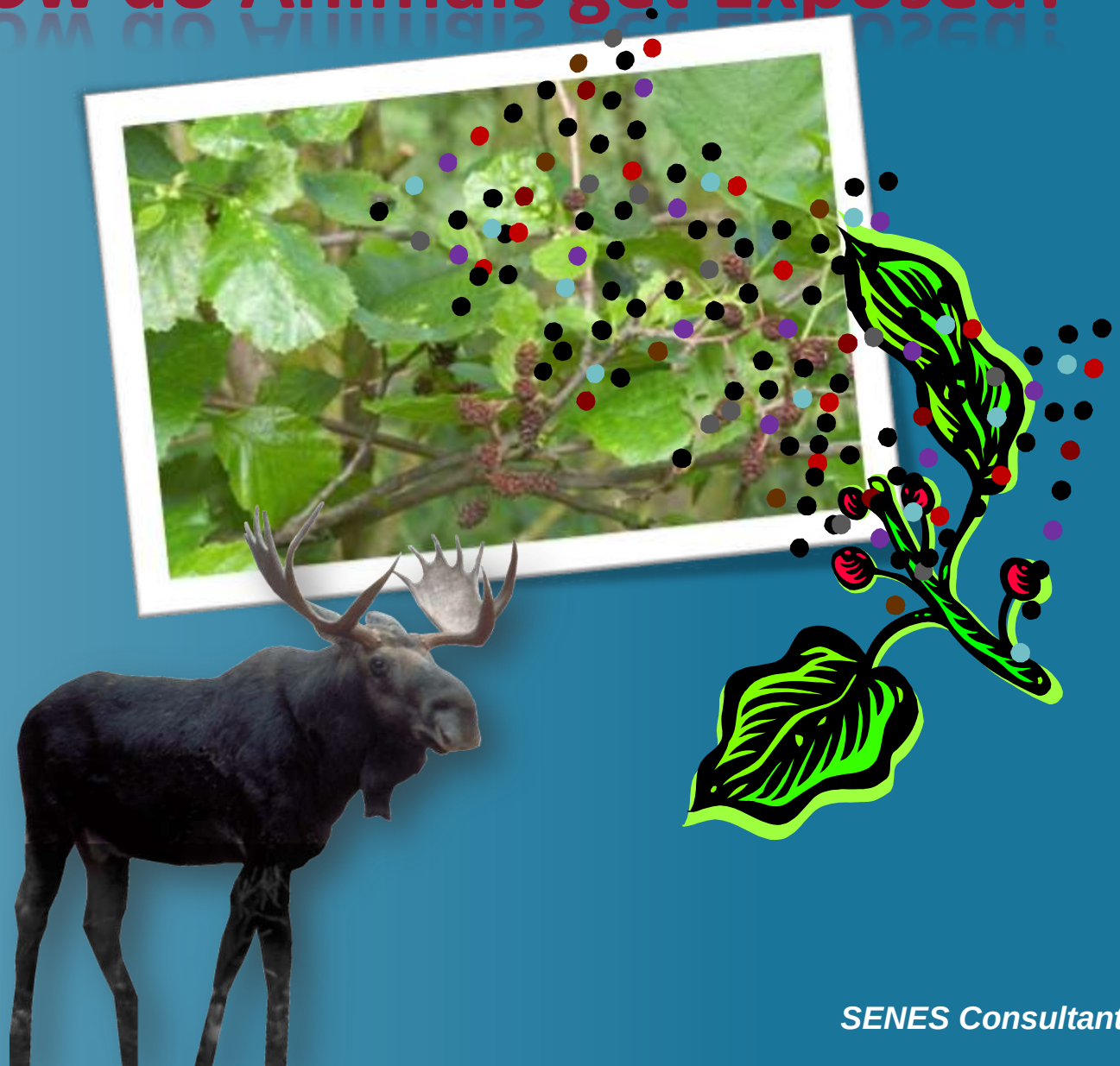
Conceptual Pathways Model



How Safe is it for Aquatic Plants and Fish?

Baker Creek	Back Bay	Yellowknife Bay	
		North	South
			

How do Animals get Exposed?



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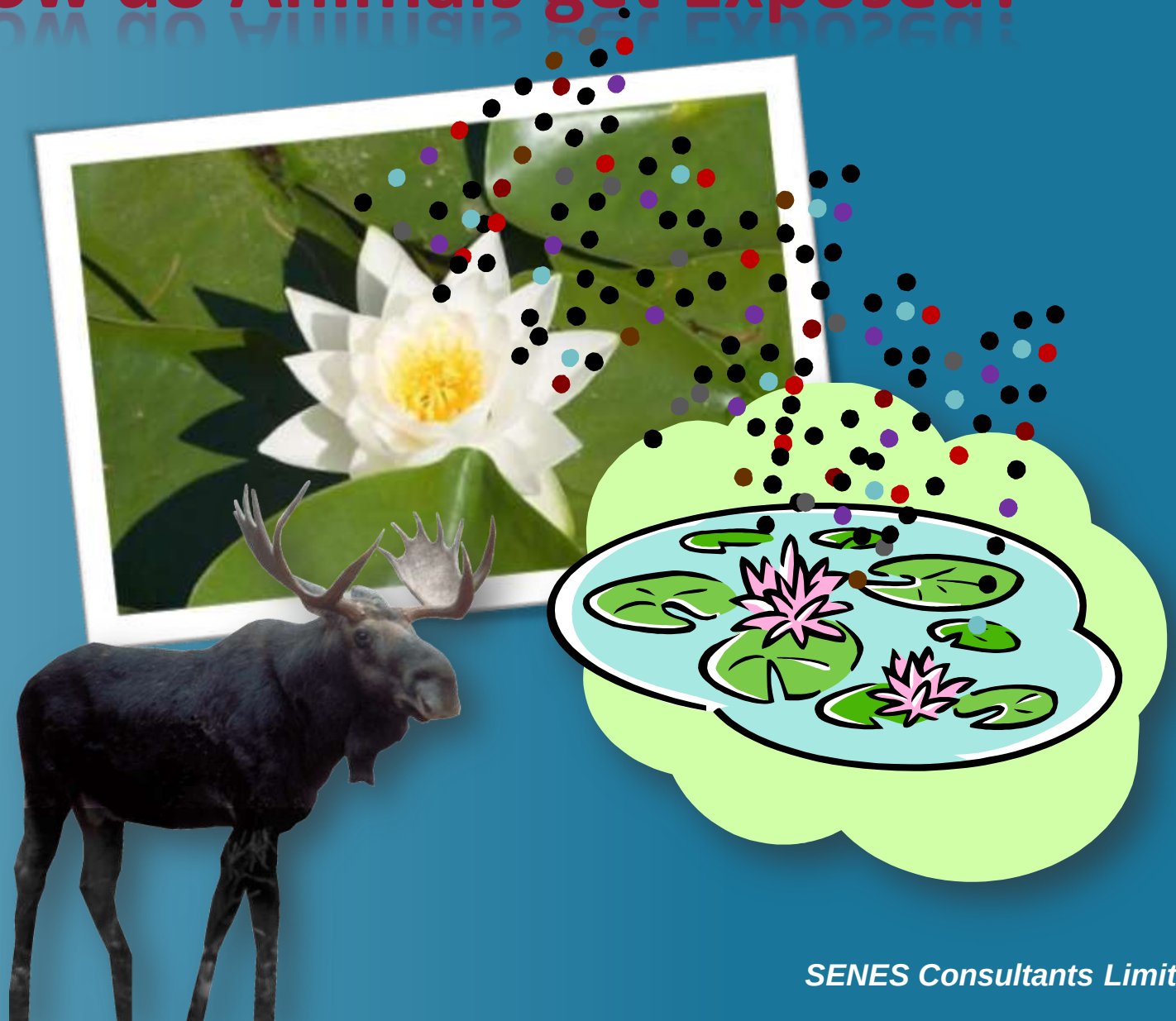
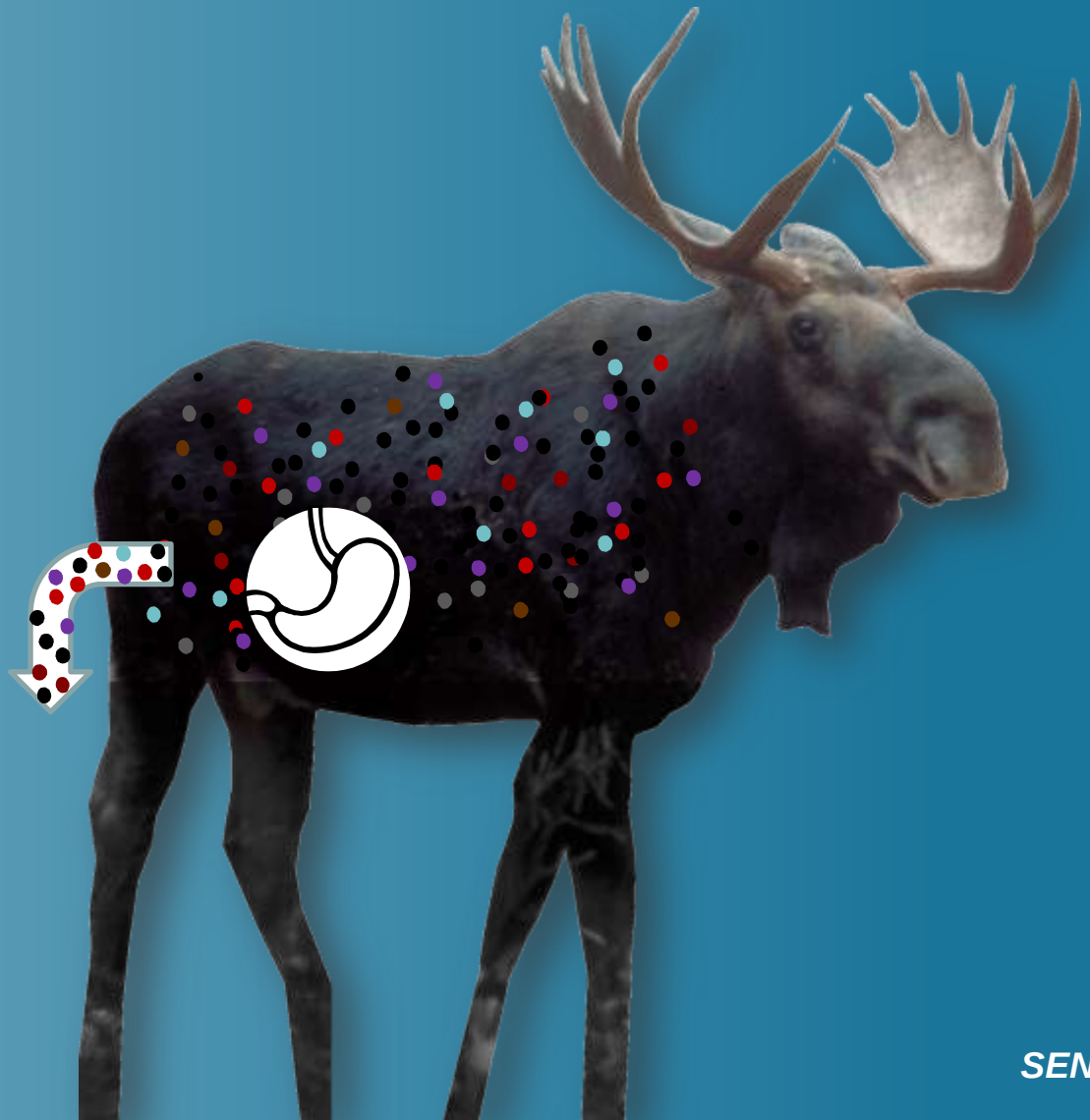


How do Animals get Exposed?

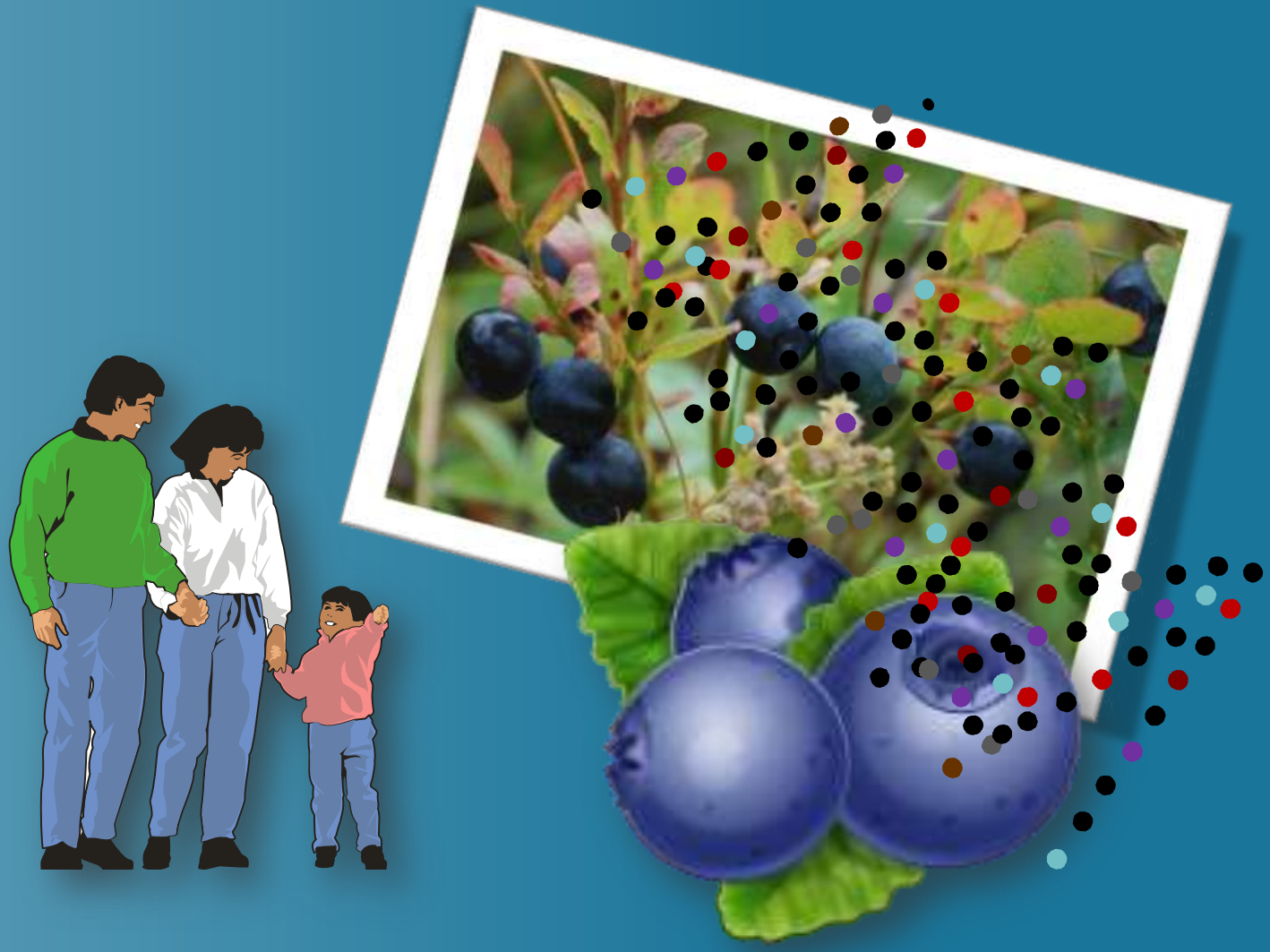


What Other Things are Considered?

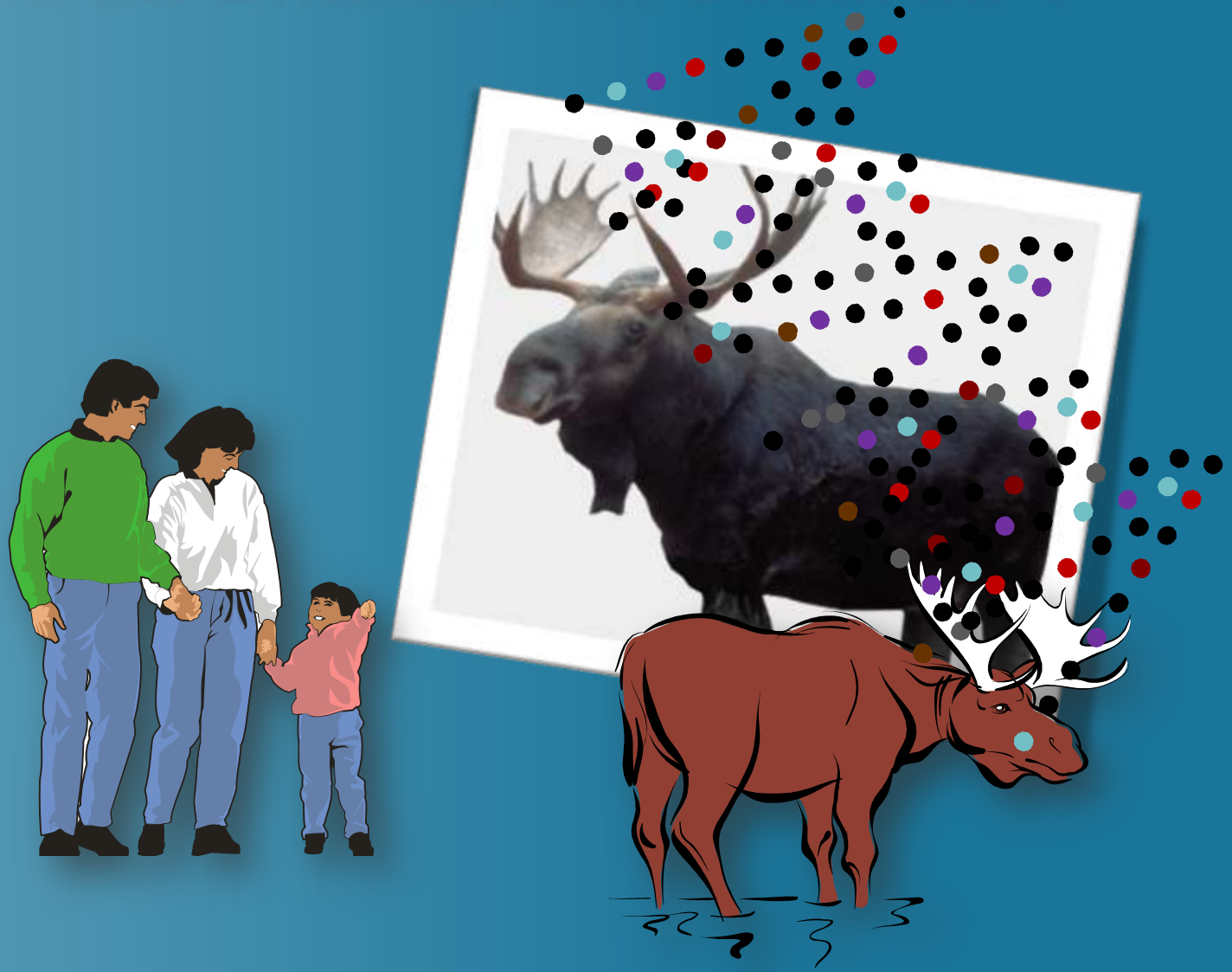
- What birds and animals are present?
- Is it a small animal or a big animal?
- How far does the animal travel for food?
- Are they always present? Do they migrate?
- Is the animal a protected species?
- Do some animals eat the same things?

How Safe is it for Ecological Receptors

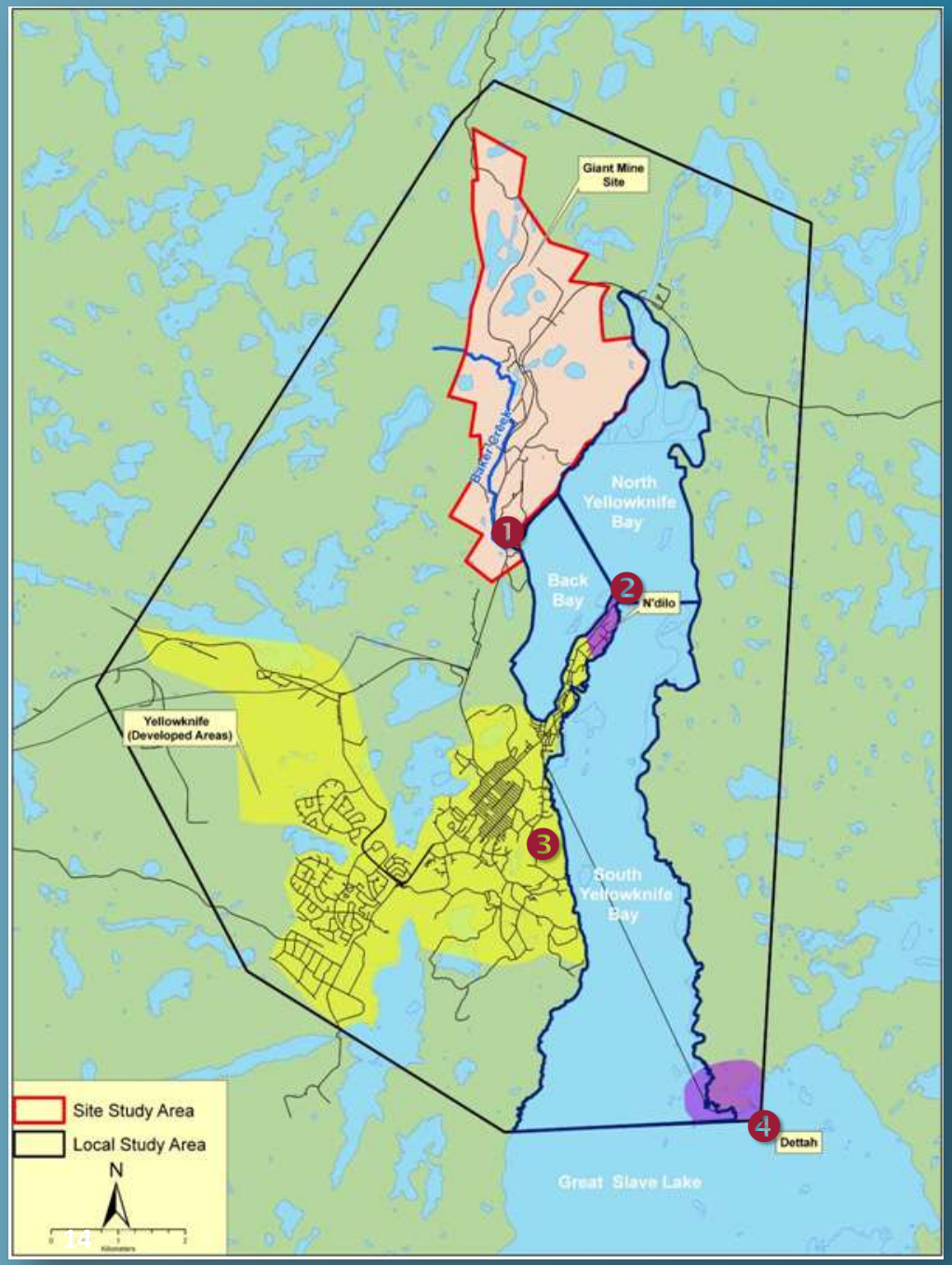
How do Humans get Exposed ?



How do Humans get Exposed ?



How do Humans get Exposed ?



Where Were Humans Evaluated?

Receptor Locations

1. Former Giant Mine Townsite
2. Latham Island
3. City of Yellowknife
4. Dettah Community

SENES Consultants Limited

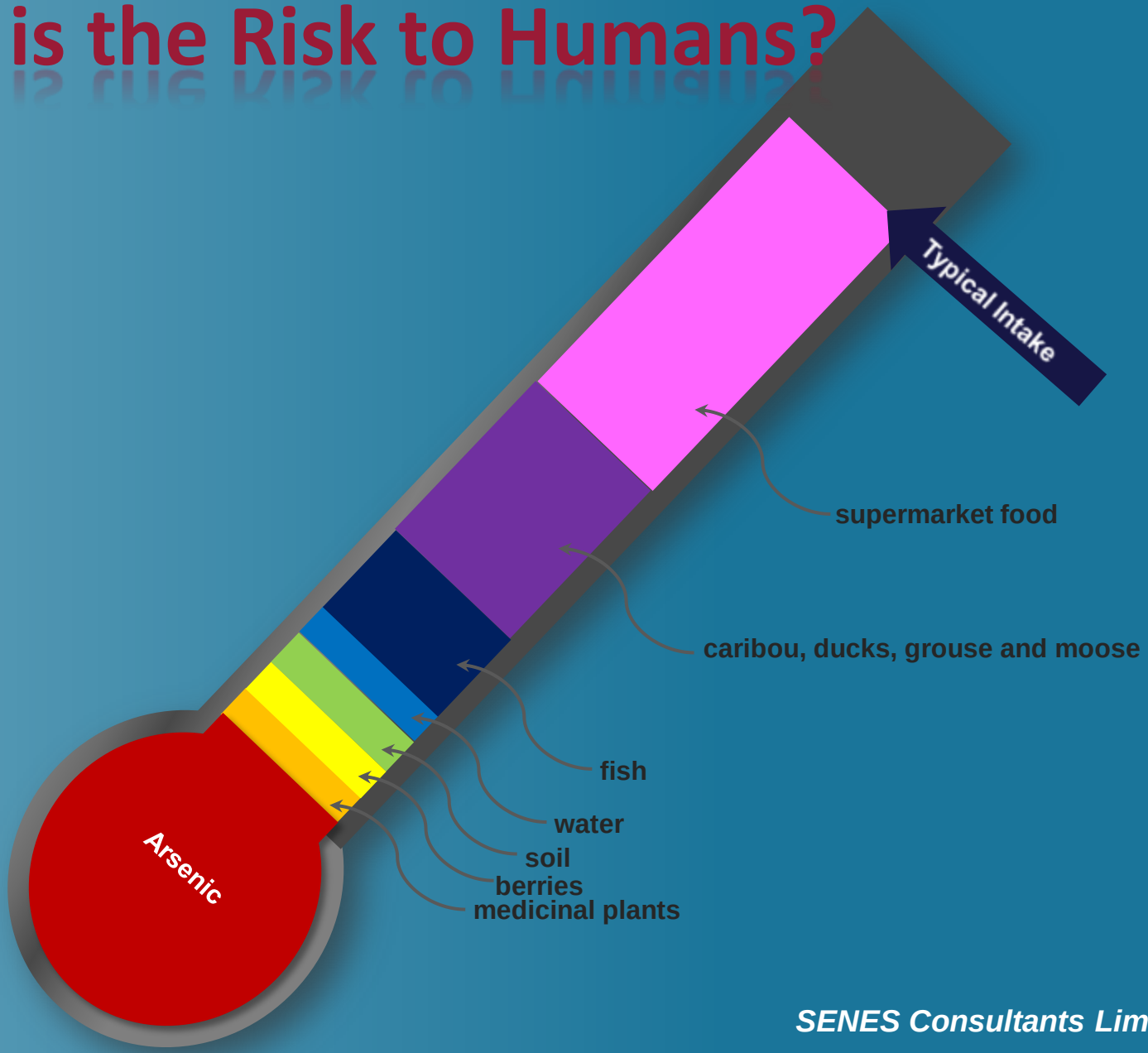
What Other Things are Considered?

- How long are you in an area?
- What are you doing when in the area?
- Where do you get your food?
- Where do you collect medicinal plants?
- What do you eat?
- How much do you eat?

Is the Water Safe to Drink?

Baker Creek	Back Bay	North Yellowknife Bay	South Yellowknife Bay
			

What is the Risk to Humans?



Questions ?

Rio Tinto

Risk Assessment Workshop

December 6-7, 2011

Rio Tinto

Purpose

- Provide a working example of how risk assessment can be used in the development of closure criteria.

Closure Criteria - Definition

- Closure criteria are developed for each closure objective for approval by the Board that issued the water licence.
- They are used to determine if selected closure activities meet the closure objectives for each project component.
- Closure criteria can be site-specific or adopted from territorial/federal standards and can be narrative statements or numerical values.
- Closure criteria must be meaningful, measurable, and achievable over time to ensure successful reclamation of project components.
- Closure criteria may also have a temporal aspect to consider (e.g., testing will be done for two, five, ten years).

(**Source**: Land and Water Board DRAFT Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories. August 11, 2011)

An example

- Closure **goal :** Land and water that is physically and chemically stable and safe for people, wildlife and aquatic life.
- PKC specific closure **objective:** No adverse affects on people or wildlife.
- Closure **activities**:
  - Place rock covers over beaches
  - Remove free water, treat and discharge
- Closure **criteria**:
  - Wildlife: site-specific risk-based criteria met
  - Human: CCME or site-specific risk-based criteria met
- Closure **monitoring**: Post-closure sampling of runoff/seepage/vegetation/dust deposition at representative locations where human/wildlife consumption of water/vegetation/dust is likely.

Site-specific risk-based closure criteria

- Site-specific because the exposure pathways and wildlife receptor characteristics are for the Diavik area.
- Risk-based as they are calculated using the principles of risk assessment. Considers routes of exposure combined with relative toxicity of parameters of concern.
- Derived criteria are conservative exposure concentrations that would not pose an adverse risk to receptors. Meaning that they tend to over estimate the potential for health effect to wildlife.
- Exposure routes are biased to “reasonable maximum” exposure.
- They are initially screening criteria. If predicted or measured exposure concentrations exceed criteria then a detailed risk assessment may be undertaken using more realistic exposure scenarios to assess the risk.
- Closure criteria can evolve with more detailed assessment and/or new information

Example Wildlife Receptor Selection

Receptor	Rationale for Selection
Caribou:	* Mine site is located within an established caribou migration corridor
	* may spend up to 2 months per year on East Island
	* exposed to chemicals in the terrestrial food chain (soil, dust, water and plants)
	* a highly valued species in the area (hunting, conservation)
Northern Red-backed Vole:	* organism with high potential for exposure due to small home range and small body size (surrogate for other rodents)
	* common year-round resident in the area and may be a year-round resident on East Island
	* important as a food source for predators (e.g., red fox, raptors)
Red Fox:	* common year-round resident in the area (surrogate for other predators)
	* predator of voles and other small rodents, hare and ptarmigan which may inhabit the area
	* exposed to chemicals in the terrestrial food chain (soil, dust, water and prey)
	* valued species in the area (hunting/trapping)
Ptarmigan:	* common seasonal resident for six months of the year, and occasionally a year-round resident in the area (surrogate for other terrestrial avian species)
	* exposed to chemicals in the terrestrial food chain (soil, dust, water and plants)
	* valued species in the area (hunting)

Typical Site Specific Information

Parameter	Caribou[a]	Northern Red-backed Vole[a]	Red Fox	Ptarmigan[a]
Body Weight (kg)	90	0.02	4.5[bcd]	0.6
Longevity	4.5 years (max. 13 years)	9 months	12 years[d]	4 years
Dietary Preferences	100% vegetation	100% vegetation	100% mammals/birds[b]	100% vegetation
Food Ingestion Rates (kg dry weight/day)	2.7	0.0066	0.34[b] (wet wt) 0.1 (dry wt)	0.065
Water Ingestion Rates (L/day)	1.1	0.017	0.4[b]	0.025
Soil/Dust Ingestion Rates (kg dry weight/day)	0.11	0.00016	0.0028[e]	0.006
Lung Ventilation Rates (m^3/day)	24	0.042	2[b]	0.44

Parameter	Caribou[a]	Northern Red-backed Vole[a]	Red Fox	Ptarmigan[a]
Duration of Exposure	2 months (60 days)	year round (365 days)	year round (365 days)	year round (365 days)
Key Habitats	Heath tundra, sedge meadows	Bouldery heath tundra	All habitat types during hunting, eskers for denning [a]	Heath tundra, tall shrub, bouldery tundra
Locations of Exposure: remaining natural habitat on east island	Residual heath tundra, sedge meadows, unvegetated areas like country rock storage	Residual bouldery heath tundra	All habitat types during hunting, eskers for denning [a]	Residual heath tundra, tall shrub, bouldery tundra

a Information compiled by Penner and Associates (Penner and Associates Ltd., 1998).
b EPA, 1993.
c Soper, 1973.
d Towers, 1980.
e Beyer et al., 1994.

Typical Toxicological Information

Chemicals	Test Species	Test[1] Species NOAEL (mg/kg-BW/day)	Toxicological Endpoint and Exposure Duration	Test Species Body Weight (kg)	Wildlife[2] Species Body Weight (kg)	Estimated[3] Chronic Wildlife NOAEL (mg/kg-BW/day)	References
Red Fox							
Arsenic	laboratory mice	0.126	reproduction; 3 generations (>1 year)	0.03	4.5	0.04	Perry et al. 1983.
Barium	laboratory rat	5.1	growth, hypertension; 16 months	0.435	4.5	2.8	Schroeder and Mitchener 1971
Beryllium	laboratory rat	0.7	longevity, weight loss	0.35	4.5	0.3	Schroeder and Mitchener 1975
Cadmium	laboratory rat	1.0	reproduction; 6 weeks during mating and gestati	0.303	4.5	0.5	Sutou et al. 1980b
Chromium (III)	laboratory rat	2737.0	reproduction; longevity; 2 years	0.35	4.5	1445.4	Ivankovic and Preussmann 1975
Cobalt	cattle	0.25	maximum tolerable level	318	4.5	0.7	NAS 1980.
Copper	mink	11.7	reproduction; 357 days during critical lifestage	1	4.5	8.0	Aulerich et al. 1982
Lead	laboratory rat	8.0	reproduction; 3 generations (>1 year)	0.35	4.5	4.2	Azar et al. 1973
Manganese	laboratory rat	88.0	reproduction; 244 days during critical lifestage	0.35	4.5	46.5	Laskey et al. 1982
Mercury	mink	1.0	reproduction; 6 months during critical lifestage	1	4.5	0.7	Aulerich et al. 1974
Molybdenum	laboratory mice	0.26	reproduction; 3 generations (>1 year)	0.03	4.5	0.1	Schroeder and Mitchener 1971
Nickel	laboratory rat	40.00	reproduction; 3 generations (>1 year)	0.35	4.5	21.1	Ambrose et al. 1976
Selenium	laboratory rat	0.20	reproduction; 2 generations (1 year)	0.35	4.5	0.1	Rosenfield and Beath 1954
Strontium	laboratory rat	263.00	body weight and bone changes	0.35	4.5	138.9	Skornya 1981
Uranium	laboratory mice	3.1	reproduction; during gestation, delivery and lacta	0.028	4.5	0.9	Paternain et al. 1989.
Vanadium	laboratory rat	0.21	reproduction; during gestation, delivery and lacta	0.26	4.5	0.10	Domingo et al. 1986.
Zinc	laboratory rat	160	reproduction; days 1-16 of gestation	0.35	4.5	84.5	Schlicker and Cox 1968

Typical Calculations

Water: $RBCC\ (mg/L) = \frac{0.2 * bw * NOAEL}{IR_w * EFR}$

Prey: $RBCC\ (mg/kg) = \frac{0.2 * bw * NOAEL}{IR_{pr} * EFR}$

Plant: $RBCC\ (mg/kg) = \frac{0.2 * bw * NOAEL}{IR_{pl} * EFR}$

Soil: $RBCC\ (mg/kg) = \frac{0.2 * bw * NOAEL}{IR_s * EFR}$

Dust: $RBCC\ (\mu g/m^3) = \frac{0.2 * bw * NOAEL * BAoral * CF}{LV * EFR * BAinhal}$

RBRC	= risk-based closure criteria (in units specified)
bw	= body weight (kg)
NOAEL	= No-Observable-Adverse-Effect Level (mg/kg/d)
IR	= ingestion rate (L/d) (kg dry weight/d)
LV	= lung ventilation rate (m^3/d)
EFR	= exposure frequency ratio; fraction of time spent on East Island (e.g., 20/365 d)
CF	= conversion factor (1000 µg/mg)
BAoral	= oral bioavailability; fraction of chemical absorbed via ingestion (chemical-specific)
BAinhal	= inhalation bioavailability; fraction of chemical absorbed via inhalation (chemical-specific)

Rio Tinto

Example Results

Chemicals	Risk-Based Closure Criteria for Plants (mg/kg dry weight)	Risk-Based Closure Criteria for Prey (mg/kg dry weight)	Risk-Based Closure Criteria for Dust (ug/m^3)	Risk-Based Closure Criteria for Soil (mg/kg dry weight)	Risk-Based Closure Criteria for Water (mg/L)
Caribou					
Barium	170	n/a	2400	4000	130
Cadmium	8	n/a	370	200	20
Chromium (III)	28000	n/a	1000000	680000	68000
Cobalt	12	n/a	690	300	30
Copper	150	n/a	17000	3800	380
Lead	81	n/a	1300	2000	200
Molybdenum	1.6	n/a	180	40	4
Nickel	400	n/a	46000	10000	1000
Uranium	17	n/a	1900	410	41
Vanadium	2	n/a	230	50	5
Zinc	1600	n/a	180000	40000	4000
Red Fox					
Arsenic	n/a	0.4	n/a	n/a	n/a
Barium	n/a	80	500	2800	6
Beryllium	n/a	3	n/a	n/a	n/a
Cadmium	n/a	5	90	160	1
Chromium (III)	n/a	13000	216750	460000	3250
Cobalt	n/a	6	158	225	2
Copper	n/a	72	3600	2600	18
Lead	n/a	38	270	1350	9
Manganese	n/a	420	n/a	n/a	n/a
Mercury	n/a	6	n/a	n/a	n/a
Molybdenum	n/a	0.6	32	23	0.2
Nickel	n/a	190	9450	6750	47
Selenium	n/a	0.9	n/a	n/a	n/a
Strontium	n/a	1250	n/a	n/a	n/a
Uranium	n/a	8	387	280	2
Vanadium	n/a	0.9	45	32	0.2
Zinc	n/a	760	38025	27000	190

Acknowledgement

References:

Mucklow, L and S. Swanson 1998. Technical Memorandum: Risk-Based Reference Concentrations for Protection of Wildlife. Prepared for Diavik Diamond Mines Inc by Golder Associates. June 18,1998

Penner and Associates Ltd. 1998. Wildlife parameters to support risk based assessment for the Diavik Diamond Project. January 1998.

Examples of Risk Assessments from EKATI

Marc Wen and Annette Muttray

Presented at:
An Introduction to Risk Assessment: Two-day Information Session and Discussion on Human Health and Ecological Risk Assessment in the Mining Industry

The Mackenzie Valley Land and Water Board, and the Wek'èezhìi Land and Water Board
Explorer Hotel, Yellowknife, December 6 and 7, 2011

Acknowledgements

- Eric Denholm, Helen Butler (BHP Billiton)
- Tonia Robb, Michael Stewart, Michael McGurk, Kelli Bergh (Rescan)
- James Elphick, Howard Bailey (Nautilus)
- Harvey Martens (HMA)
- Kim Pool (Aurora Wildlife Research)
- Can Dang (ALS Laboratory)

Overview

- Wildlife and human health risk assessment for closure planning (Long Lake Containment Facility example)

- Ecological risk assessment as a operational management tool (chloride example)

Wildlife and Human Health Risk Assessment
Long Lake Containment Facility (LLCF) at Closure

Long Lake Containment Facility (LLCF)

Long Lake Containment Facility
Cell A
Cell B
Cell C
Cell D
Cell E
Panda Pit
Bearclaw Lake
Beartooth Pit
North Panda Lake
Grizzly Lake
Koala North Pit
Koala Pit
CAMP
Panda Diversion Channel
Kodiak Lake
Leslie Lake
Outlet Dam
Nero Lake
Nema Lake
Fox Pit
Martine Lake
Paul Lake Bridge
Misery Road

Soil and Vegetation Information

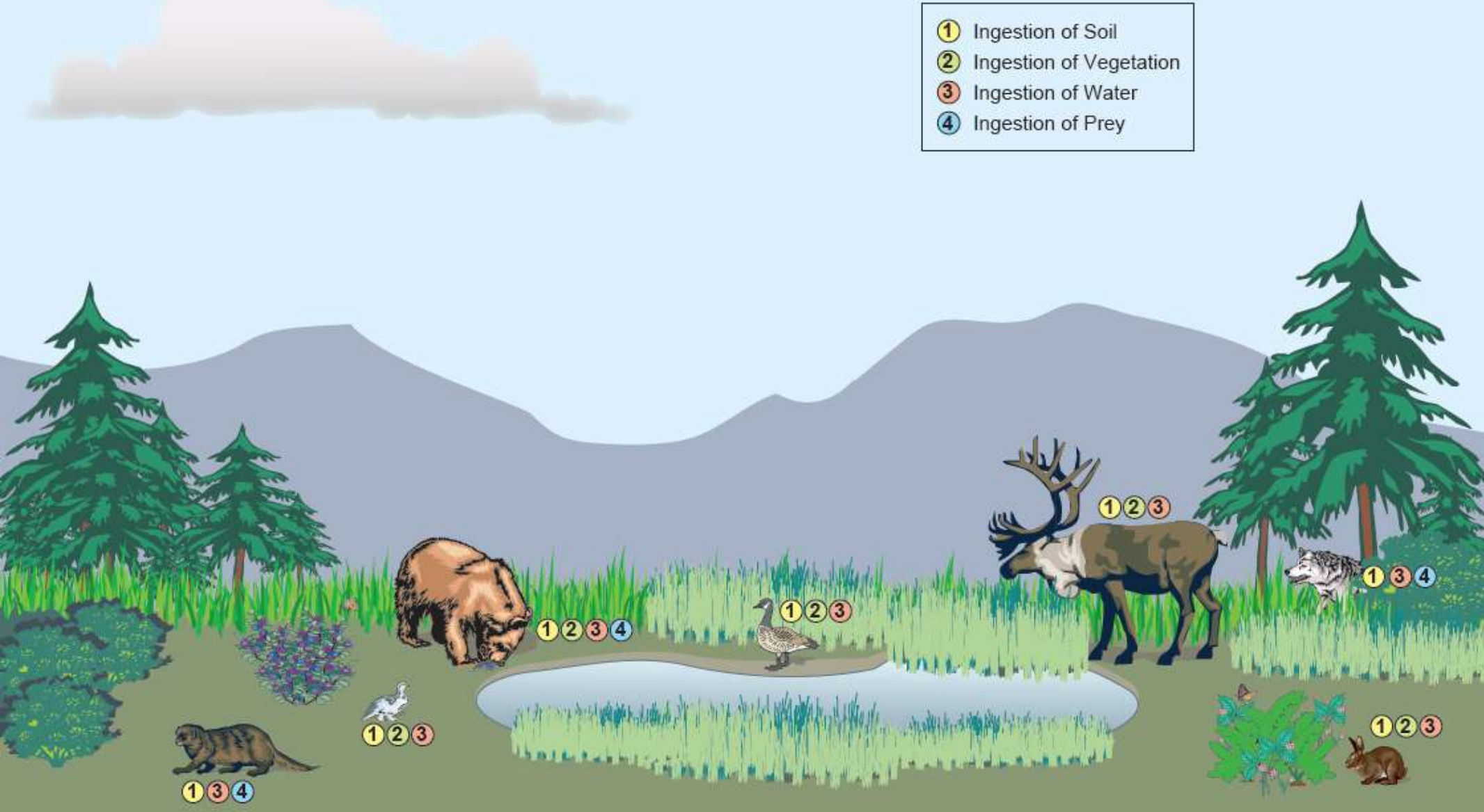
- Several metals elevated in soil and vegetation plots at LLCF compared to reference sites, and some exceed recommended maximum dietary intake by grazers
- However a number of aspects must be accounted for:
  - Direct comparison problematic (wet vs. dry weight)
  - Residence time of grazers in LLCF
  - Forage preferences
  - Different seasonal stages of plant growth
  - Bioaccumulation and biomagnification potential of trace metals low

Wildlife and Human Health RA of LLCF Closure

- *EKATI Diamond Mine: Wildlife and Human Health Risk Assessment*. Prepared for BHP Billiton Diamond Mines Inc. by Rescan Environmental Services Ltd., January 2006.

- Research question?
  - Evaluate reclamation option for closure of growing plants on processed kimberlite (PK) in the Long Lake Containment Facility (LLCF)
  - Under this option, will wildlife and humans face unacceptable health risks if exposed to metals from the LLCF area after closure of the facility?

Wildlife Risk Assessment Conceptual Model



Results of Wildlife Risk Assessment

- <u>The assessment was for closure concept for LLCF, not current operational LLCF</u>

- No unacceptable risks to receptors at the individual or population level from exposure to the metals evaluated except aluminum and magnesium
- Conservative assumptions
- Tier II risk assessment when key uncertainties can be addressed. A large scale pilot study was identified in the Closure Plan; will include bioavailability, actual dietary preferences (e.g. lichens), and spatial and temporal boundaries

Human Health Risk Assessment

- <u>The assessment was for closure concept for LLCF, not current operational LLCF</u>

- Indicates acceptable risks from the consumption of *Canada geese* and *caribou* for toddlers and adults for metals evaluated except nickel
- Concentrations in meat tissues may have been over-estimated

Uncertainties

- Metal bioavailability
- Actual dietary preferences
- Spatial and temporal boundaries
- Concentrations in meat

Management Plan to Address Uncertainties

- LLCF closure concept is reasonable, but requires additional study and detailed investigation
- Reclamation Research Plans – Pilot-scale LLCF reclamation study
  (Cell B of LLCF)
  - Will address some of the uncertainties

Ecological Risk Assessment for Chloride
To Guide Operational Activities

Chloride Ecological RA for Operations

- 2004 Tier I ERA (EVS), derived literature-based HC5 of 180 mg/L chloride
- Aquatic monitoring showed increase in chloride concentrations in LLCF and downstream, but still well below Tier I HC5 value
- Water quality predictions using a numerical model showed potential for increasing chloride under current mine plan
- 2006 Tier II ERA (unpublished work)

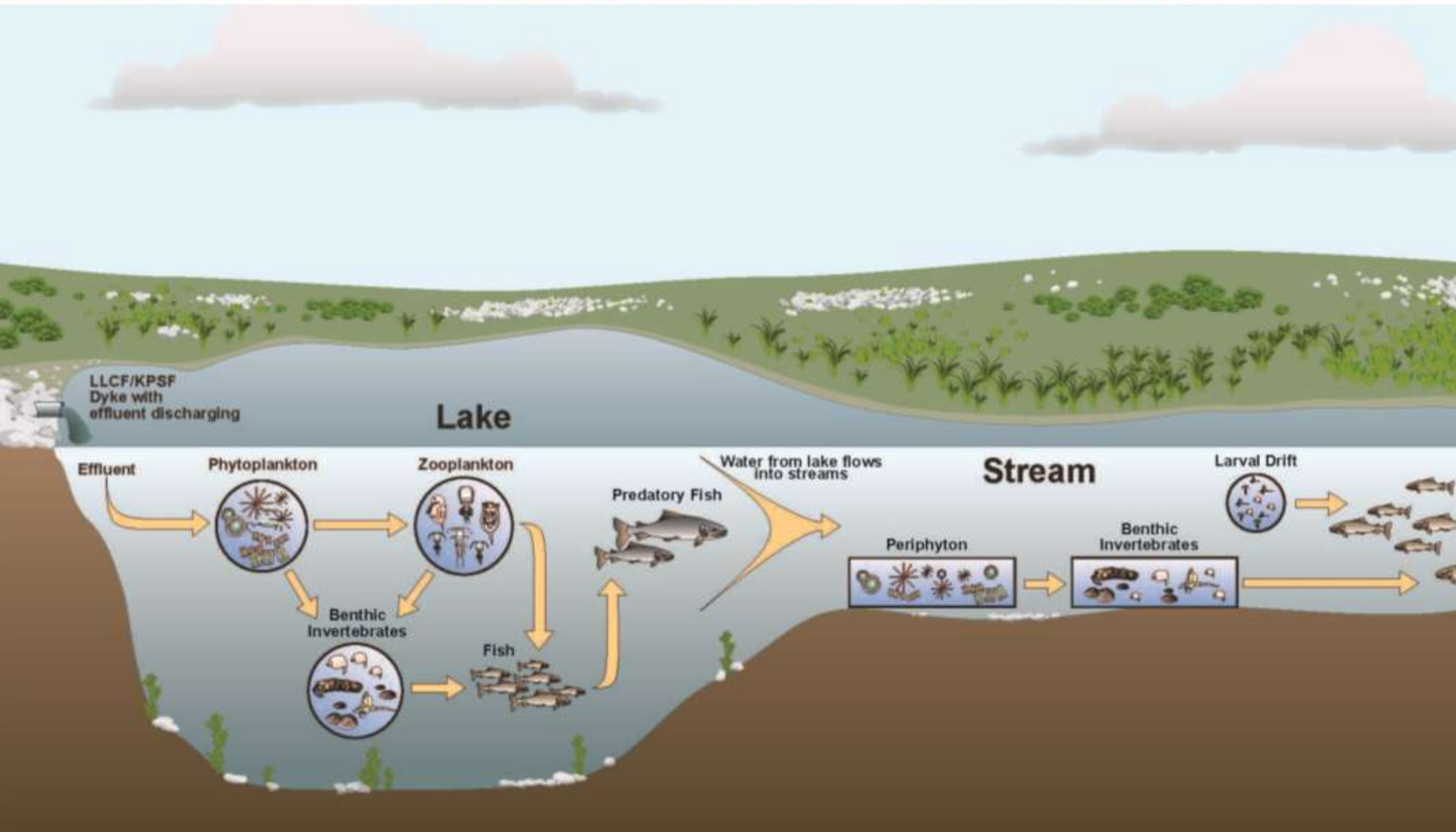
Objectives of Chloride Tier II ERA

1. Review current and predicted future chloride concentrations
2. Re-evaluate and, if appropriate, update Toxicity Reference Value (TRV) for chloride
3. Evaluate the potential for current and future aquatic ecological effects from chloride exposure

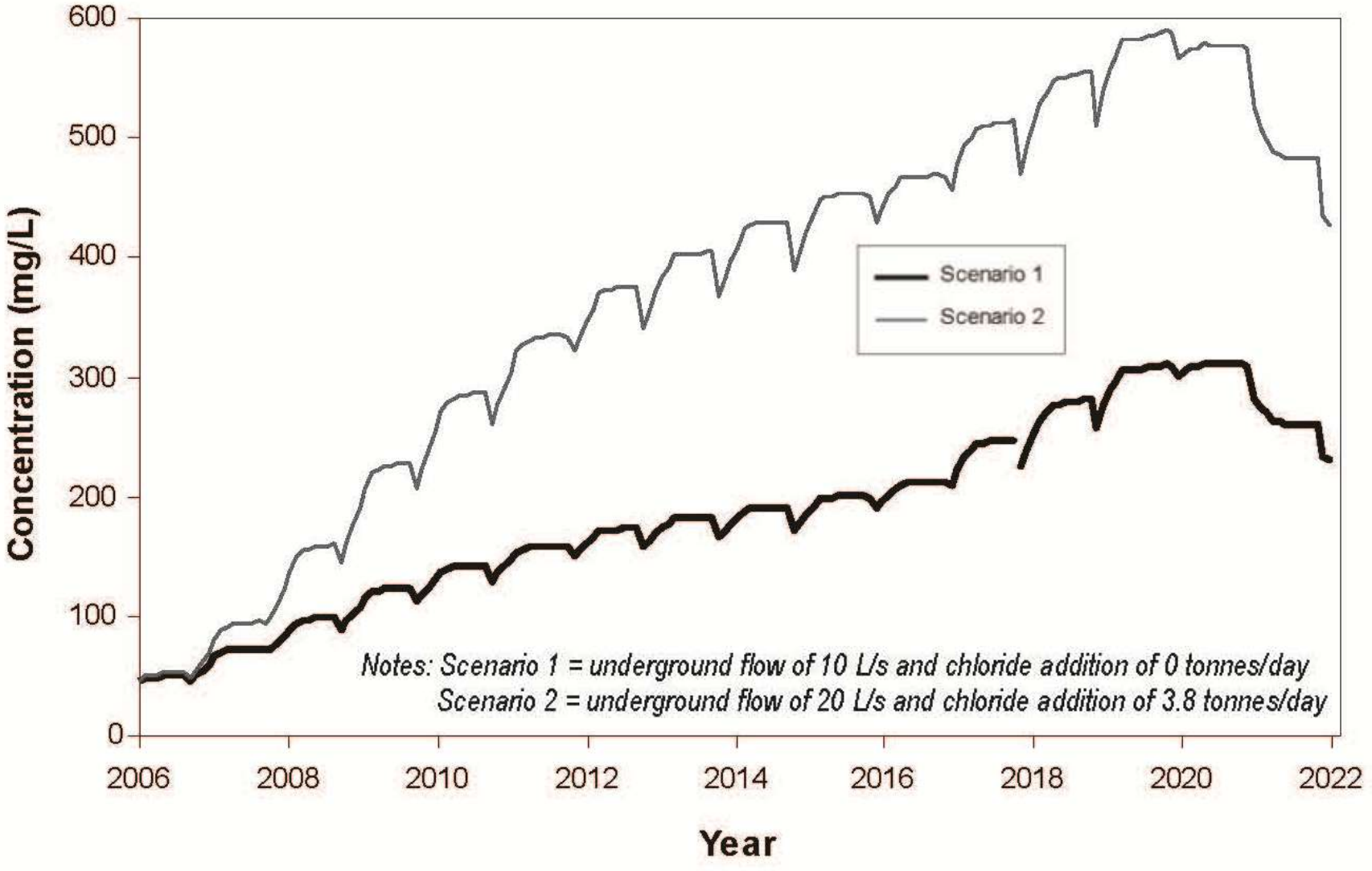
Approach to Chloride Tier II ERA

- Problem formulation
- Exposure assessment
  - Numerical load balance model
- Effects assessment
  - Toxicity testing of 9 species
- Risk characterization
- Uncertainty assessment
- Management Plan

Conceptual Model of EKATI Aquatic Ecosystem



Chloride Predictions under Various Scenarios (LLCF E)



Chloride Tier II ERA Approach

- 1988 US EPA criterion, 230 mg/L
- 2003 BC guidelines, 150 mg/L
- 2004 EKATI (EVS) Tier I ERA, 180 mg/L
- 2006 Tier II ERA, review/update TRV
  - Repeat tests on 3 genera and conduct new tests with 6 additional genera. Collectively these 9 genera included data for 2 fish, 2 cladoceran, 2 oligochate species, 1 rotifer, 1 dipteran, and 1 amphipod species for Acute to Chronic Ratios tests (ACRs)
  - Based on a Species Sensitivity Distribution (SSD) methodology

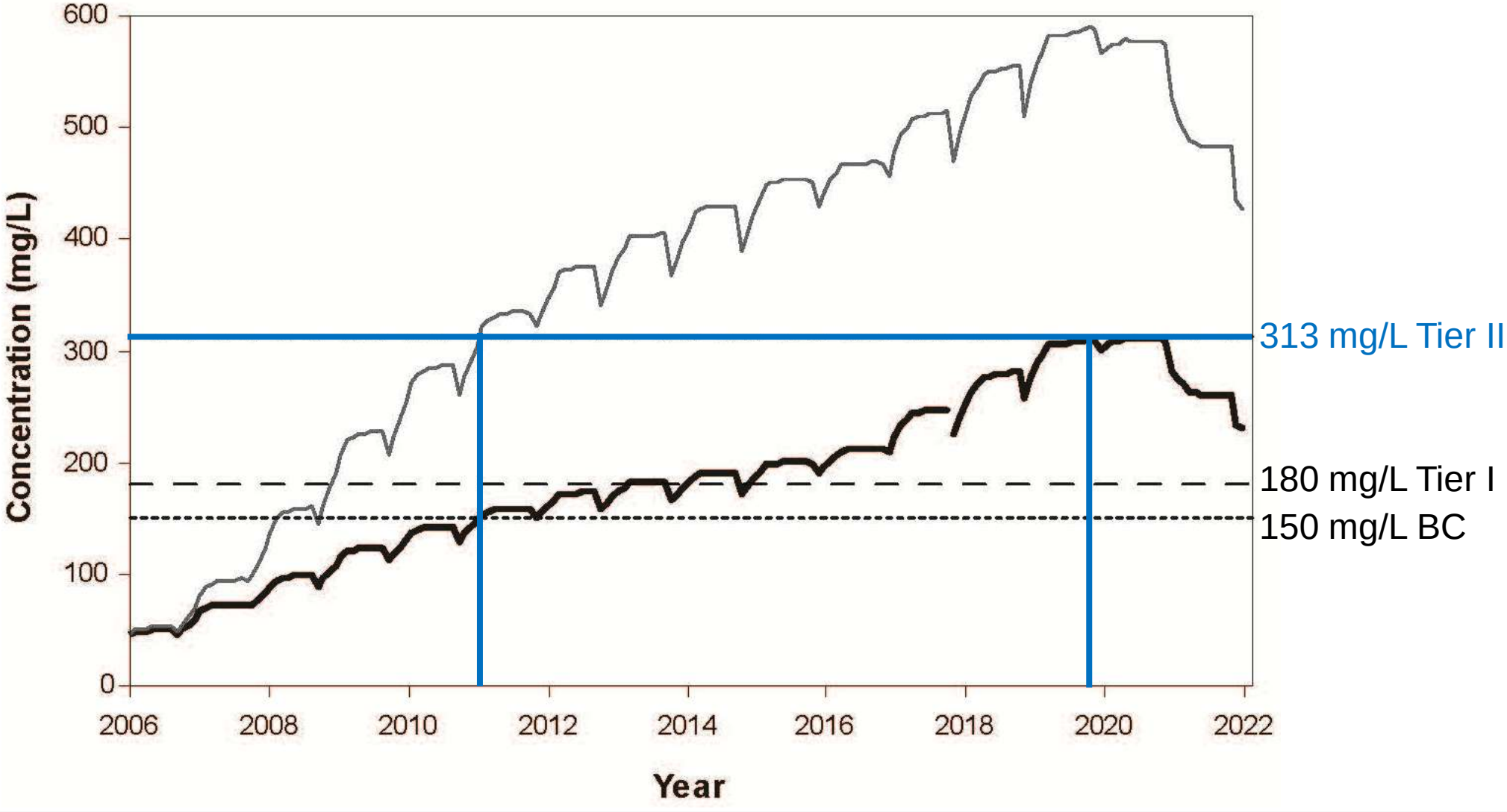
    1,648 mg/L acute HC5

    313 mg/L chronic HC5

Tier II ERA Results

- Risk characterization
  - Negligible current risks (2006) and potential adverse effects between 2011 and 2020

Chloride Tier II ERA Results



Chloride Tier II ERA Key Uncertainties

- Water quality numerical modelling predictions (underground water inflows, underground chloride concentrations)
- Ion balance (effects of hardness)

Management Plan to Address Uncertainties

- EKATI Underground Water Quality Assessment (2007)
- Updates to water quality numerical model
- Additional chloride toxicity testwork exploring hardness relationship:
  - Hardness-specific chloride WQO across hardness of 10 to 160 mg/L is WQO = [116.63 · ln(hardness)] – 204.09
  - Elphick, J.R.F, Bergh, K.D., and H.C. Bailey. 2010. Chronic toxicity of chloride to freshwater species: Effects of hardness and implications for water quality guidelines. *Environmental Toxicity and Chemistry* 30(1): 239-246

Mitigation Options

- Options analysis for mine water management (2007)
- Conceptual plan for mine water pond in Beartooth pit (2008)
- Engineering designs for use of Beartooth pit (2008-2009)
- Update and approval to Wastewater and Processed Kimberlite Management Plan (2009)
- Pumping to Beartooth initiated (2010)
  - Will significantly reduce chloride loads to the LLCF and downstream lakes

Summary and Conclusions

- Human Health and Ecological Risk Assessments have been used at EKATI. Two examples covered here:
  - Planning for closure (LLCF – wildlife and human health Risk Assessment)
  - Operational Planning (chloride management – ecological Risk Assessment)

- Not always published information, can be used internally for decision making (Risk Optimization)

Thank You

NEWMONT

RISK ASSESSMENT AT CON MINE

RON CONNELL

December 7, 2011

INTRODUCTION

HISTORY

- Con Mine ceased production in 2003
- A Multi-Stakeholder Working Group developed the Closure & Reclamation Plan over a period of 5 years
- Final Closure & Reclamation Plan approved in June 2007
- Reclamation is now approximately 80% complete
- Target is to finish reclamation by Fall of 2014
- To date, there have been No Major Incidents
- We attribute this to ongoing RISK ASSESSMENT

RISK ASSESSMENT?

NEWMONT TAKES RISK ASSESSMENT SERIOUSLY

- **Applied at all levels of all operations**

- **Takes many forms, but Primary focus is:**
  1. **Human Health and Safety**
  2. **Environment**
  3. **Loss Control**
  4. **Company Reputation**

RISK MANAGEMENT TRAINING

NEWMONT MANAGERS AT ALL LEVELS:

- Mandatory Safety Journey Workshop (1 Week)
- Mandatory Health, Safety, & Loss Prevention
  - 10 Modules to complete
  - Must Pass Test on each module
  - Then present each module to your staff
- Mandatory Monthly Safety Meeting (Recorded)
- Mandatory Daily Tailgate Meeting (All Crews)
- TIME OUT FOR SAFETY AT LEAST TWICE/YEAR
  - Worldwide operations shut down for 2 hours
  - Review company track record

PROJECT RISK ASSESSMENT

EVERY MAJOR PROJECT MUST UNDERGO

- **Formal Risk Assessment – Including:**
  1. **Human Health & Safety**
  2. **Environmental Impacts**
  3. **Aboriginal Components**
  4. **Community Sustainability**
  5. **Logistics (location, climate)**
  6. **Legal (Permits, Licensing)**
  7. **Financial**

RISK ASSESSMENT MATRIX

RISK ASSESSMENT MATRIX

Likelihood	Insign 1	2	3	Major 4	Catastrophic 5
5 (Certain)	11	16	20	23	25
4 (Likely)	7	12	17	21	24
3 (Possible)	4	8	13	18	22
2 (Unlikely)	2	5	9	14	19
1 (Rare)	1	3	6	10	15

Low (1 - 5) | Moderate (6 - 10) | High (11 - 17) | Extreme (18 - 25)

RISK ASSESSMENT PROBABILITY DEFINITIONS

Certain	Event is a common or frequent occurrence (daily)
Likely	Event is expected to, or has occurred under some conditions (monthly)
Possible	Event will probably occur, or has occurred, under some conditions (yearly)
Unlikely	Event could occur at some time, or has happened elsewhere (every 10 years or so)
Rare	Event is not expected to occur, but may under exceptional circumstances

RISK	CORRECTIVE ACTION & CONTROLS
Low	Consider controls.
Moderate	Preferable to set controls.
High	Controls must be set.
Extreme	Controls set immediately.

Consequence Definitions

Level	Safety	Environmental	External / Community Relations	Damage/Loss
Insignificant	First-aid treated injury	No or very low impact, Impact confined to small area	Isolated complaint, No media inquiry, No NGO interest, No Community reaction	> $1,000
Minor	Medical treatment, restricted work injury	Low impact, Rapid cleanup by site staff and/or contractors, Impact contained to operations area	Small number of sporadic complaints, Local media inquiries, Some NGO interest, Some Community interest	> $10,000
Moderate	Single lost time injury	Moderate impact, cleanup by site staff and/or contractors, Impact confined within property boundary	Serious rate of complaints / repeated complaints, Increased local media interest w/ signs of national interest, Increased NGO interest, Some Community concern	> $100,000
Major	Multiple lost-time injuries, Admission to intensive care or equivelent, Serious, chronic, long-term effects	Major impact, Considerable cleanup using site and external resources, Impact may extend beyond property boundary	Increasing rate of complaints / repeated complaints, Increased local / national media interest, Organized NGO interest, Organized Community concern and/or action	> $1,000,000
Catastrophic	Fatality or permanent disability	Severe impact, Local species destruction and likely long recovery period, extensive cleanup w/ external resources, Impact on regional scale	High level of concern or interest from local community, National and/or international media interest, Organized NGO action, Aggressive community action	> $10,000,000

TASK HAZARD ANALYSIS

EACH TASK OF ANY SIGNIFICANCE

- Undergoes a formal Task Hazard Analysis (THA)
- It is done by the people performing the work

- Can the work be done safely?
- Energy sources present? (Electrical, Heat, Air, Water)
- Special Equipment or Training (O/H Cranes, Asbestos)
- Personal Protective Equipment Requirements?
- Special considerations? (Weather, Remote Location)
- Environmental issues (HazMat, Dust, Flora, Fauna)
- Community Concerns (Noise, Dust, Traffic, Bystanders)
- Warnings in Place (Barriers, Guards, Public Notice)
- Special Interest Groups (Skiers, Snowmobilers)

OTHER RISK ASSESSMENTS - 1

HUMAN HEALTH RISK ASSESSMENT

- Yellowknife Arsenic Soil Remediation Committee
  - 5 year program from 1998 to 2002
  - Multi-stakeholder group
  - Developed guidelines for Yellowknife
  - Incorporated into Closure Plans (Con & Giant)

ROYAL MILITARY COLLEGE STUDIES

- Bioavailability of Arsenic in Yellowknife (2000)
- Arsenic Contamination of Terrestrial & Freshwater Environment in Yellowknife (2000)
- Characterization of Arsenic in Solid Phase Samples (2001)
- Human Health Risk from Consumption of Garden Vegetables in Yellowknife (2001)

OTHER RISK ASSESSMENTS - 2

- Environmental Evaluation of Con Mine - RMC 1999
- ARD and Geochemical Characterization of Con Mine – URS 2001
- Environmental Compliance Audit of Con Mine – URS 2003
- Kinetic Testing of Tailings and Water Quality Predictions for Con Mine – URS 2003
- Risk Assessment & Risk Management Plan for Flooding of Underground at Con Mine – URS 2004
- Review of Con Mine Tailing Geochemistry and Water Quality – Ecologica 2007
- Long Term Kinetic Testing of Tailings at Con Mine – Golder 2006 - 2008
- Demolition of Mill Complex at Con Mine – Health & Safety Issues – Golder 2008
- Human Health Risk Assessment of Rat Lake – Golder 2009

REGULATORY RISK ASSESSMENT

Regulatory Agencies Also Require Mandatory Risk Assessment:

FEDERAL

- **PCB Regulations**
- **Metal Mining Effluent Regulation (MMER)**
- **Environmental Effect Monitoring (EEM)**
- **Aboriginal Affairs and Northern Development**
- **Environment Canada**
- **Fisheries and Oceans Canada**

TERRITORIAL

- **MVLWB (Water Licenses)**
- **MVEIRB (Environmental Impact Assessment)**
- **Workers' Safety & Compensation Commission**
- **Department of Transportation**
- **Environment & Natural Resources**

THE BOTTOM LINE

THE MINE IS UNDER MANY WATCHFUL EYES!

THROUGH THE EFFORTS OF:

- **NEWMONT MINING CORPORATION**
- **THE REGULATORY AGENCIES**
- **THE CITY OF YELLOWKNIFE**
- **ABORIGINAL GROUPS & ORGANIZATIONS**
- **ENVIRONMENTAL & NON-GOVERNMENT AGENCIES**
- **AND PRIVATE "CONCERNED CITIZENS"**

VERY LITTLE IS LEFT TO CHANCE!

Holistic Risk Assessment

Ken Froese, Ph.D.

Holistic Assessment

- A common (Western science) way of looking at things and attempting to solve problems is to divide into smaller bits and pieces.
- Often results in a “silo” approach – each part of the problem is separated from everything else.
- We lose the relationships and understanding of the nature of those relationships between the parts.

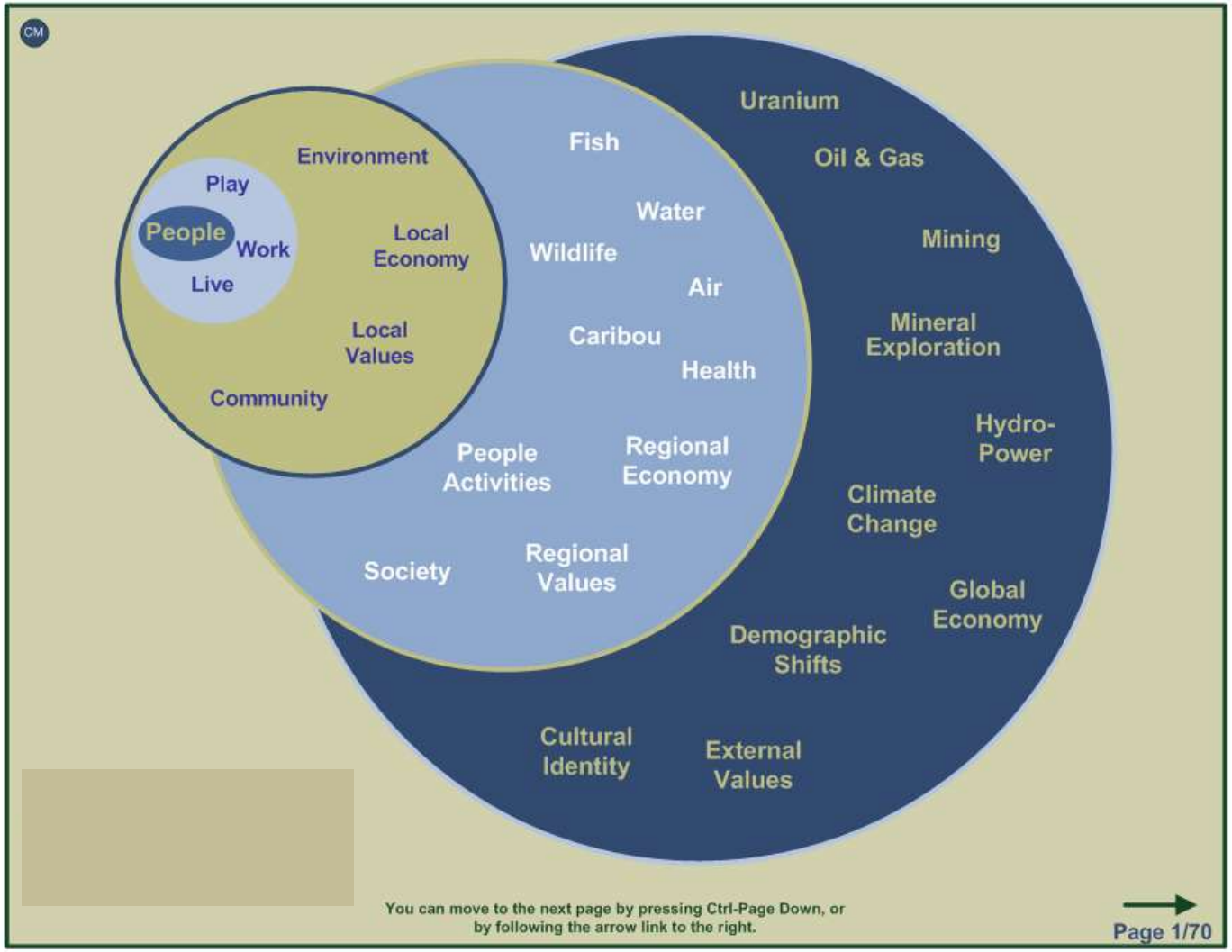
Holistic Assessment

- Why should we care about a different perspective?
- Definition of 'health'
  - WHO: Health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity.
- The current approach to HHRA does not address the broader issues that affect health
  - Understand values (e.g. Ties to the land) to be able to ask the right questions and gather data to address these questions.

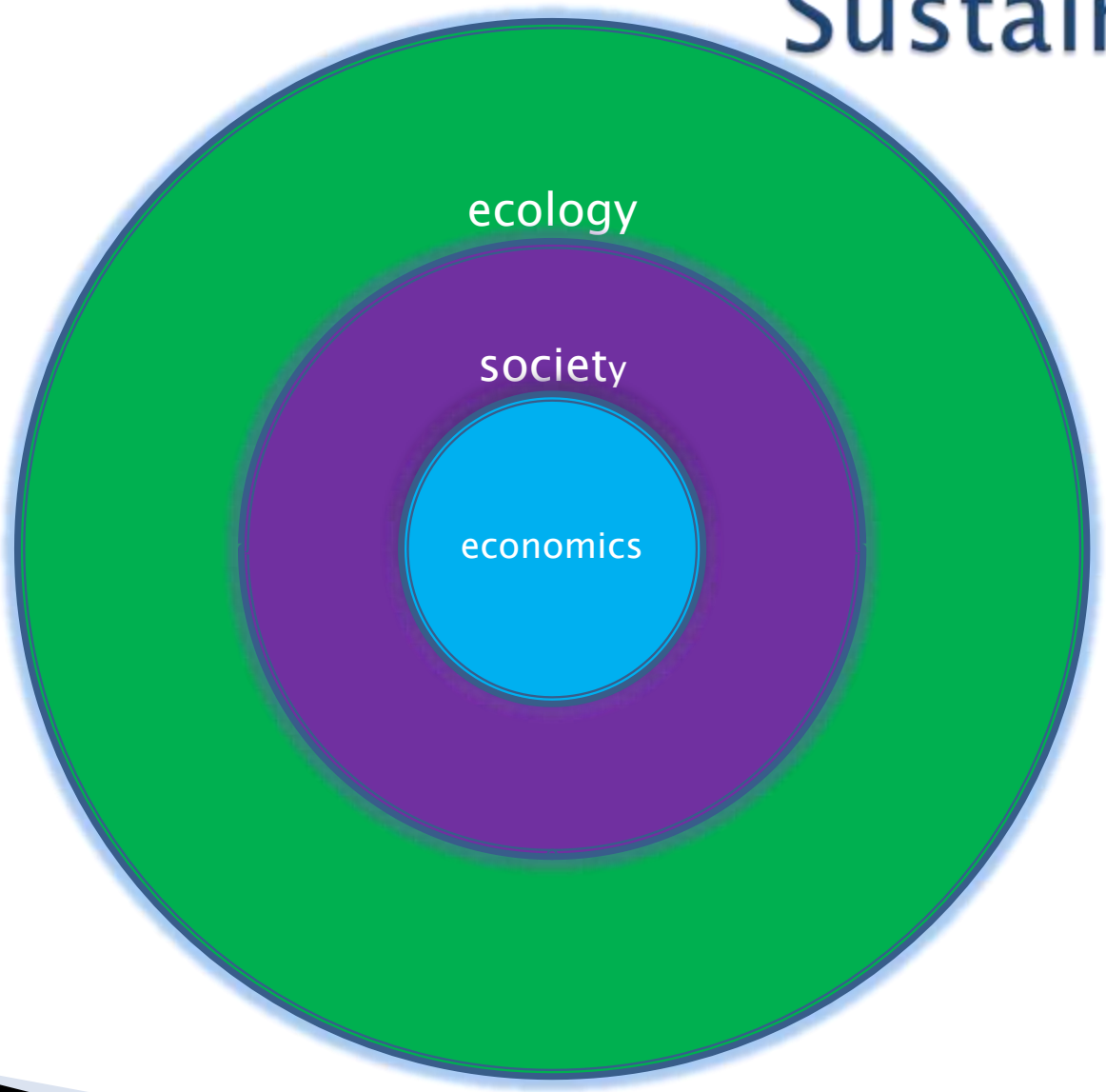
SLR

IDEAS

Influence Diagrams for Environmental Assessment of Sustainability

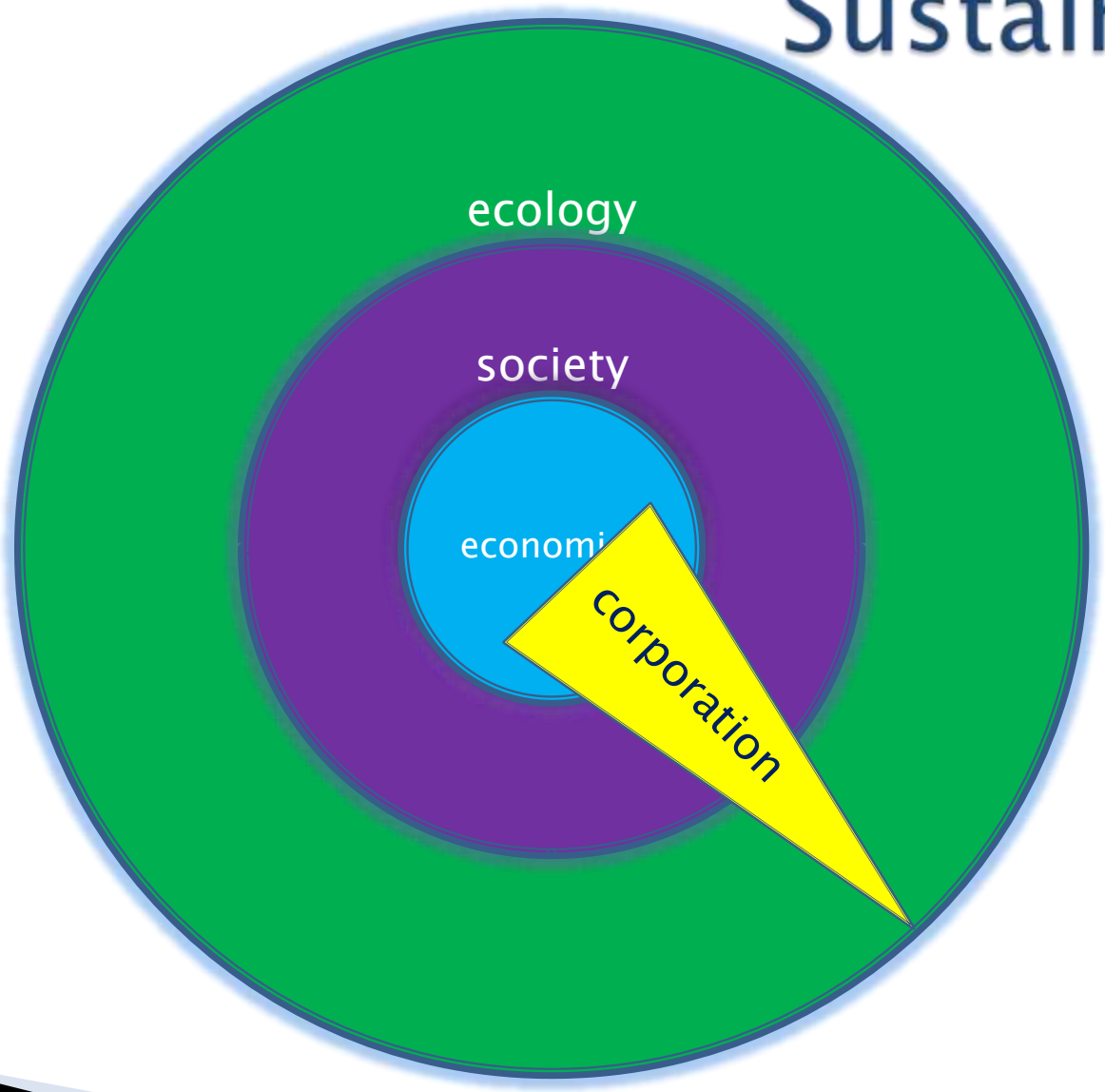


Sustainability

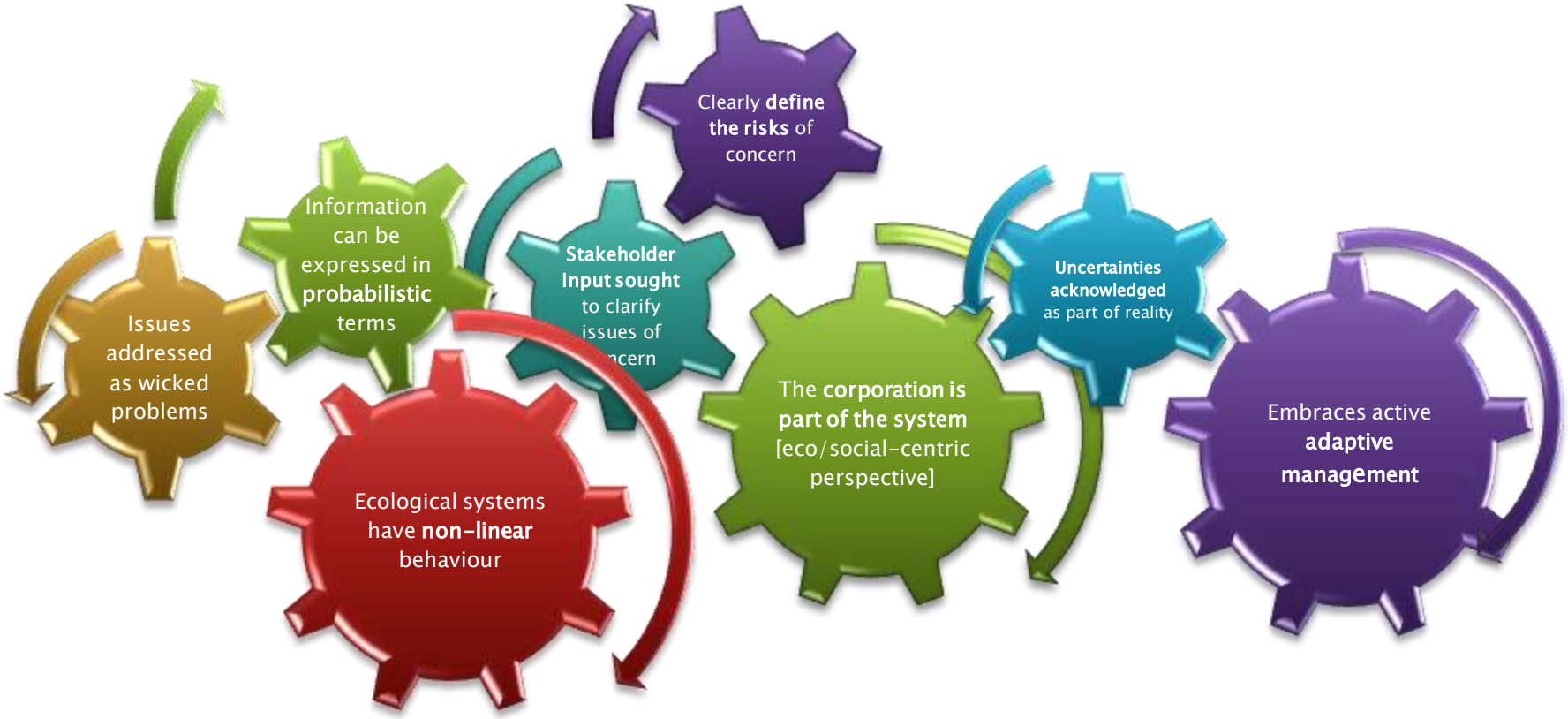


Adapted from Jody Roberts, Ph.D.,
Chemical Heritage Foundation (2010)

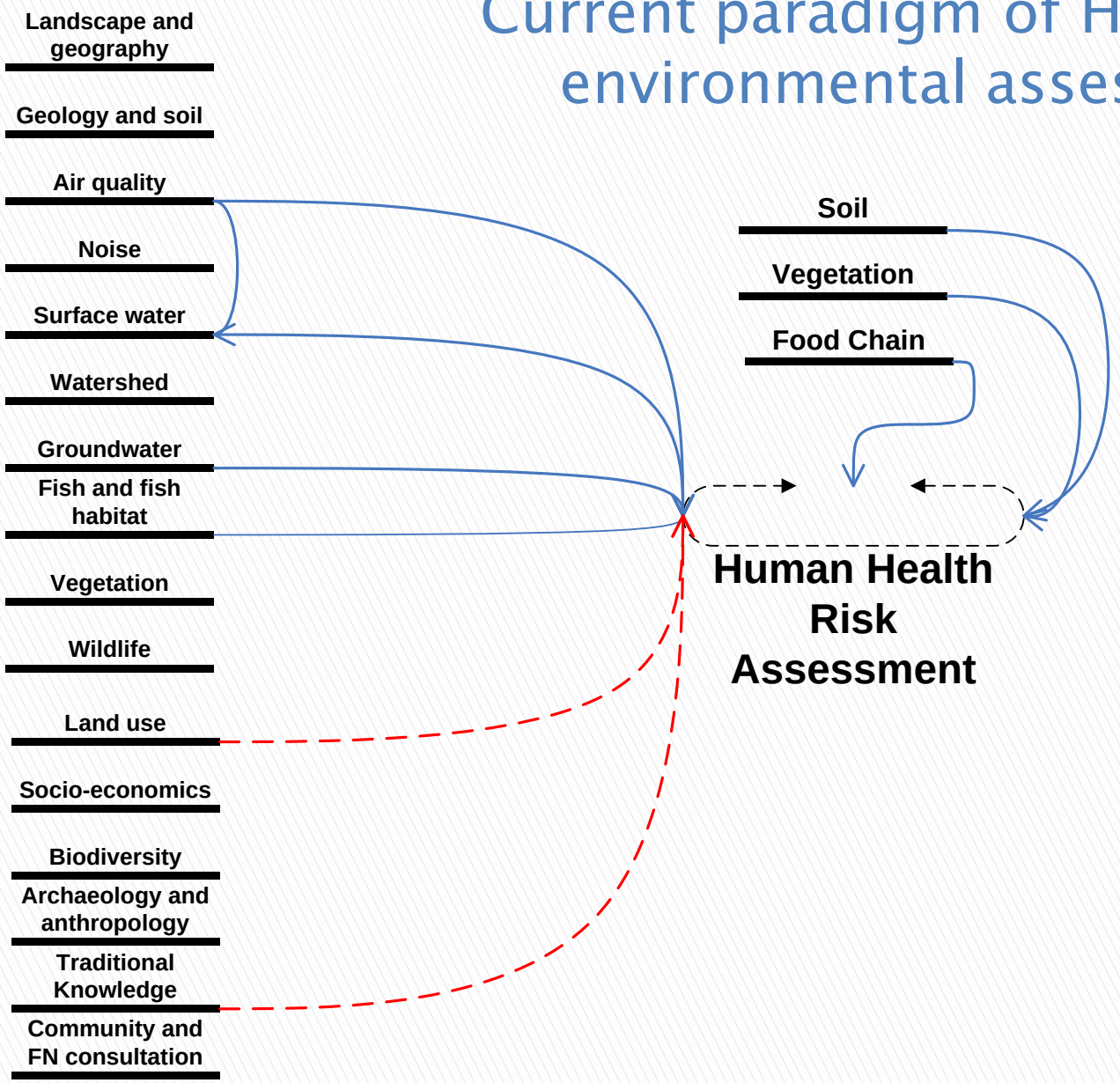
Sustainability



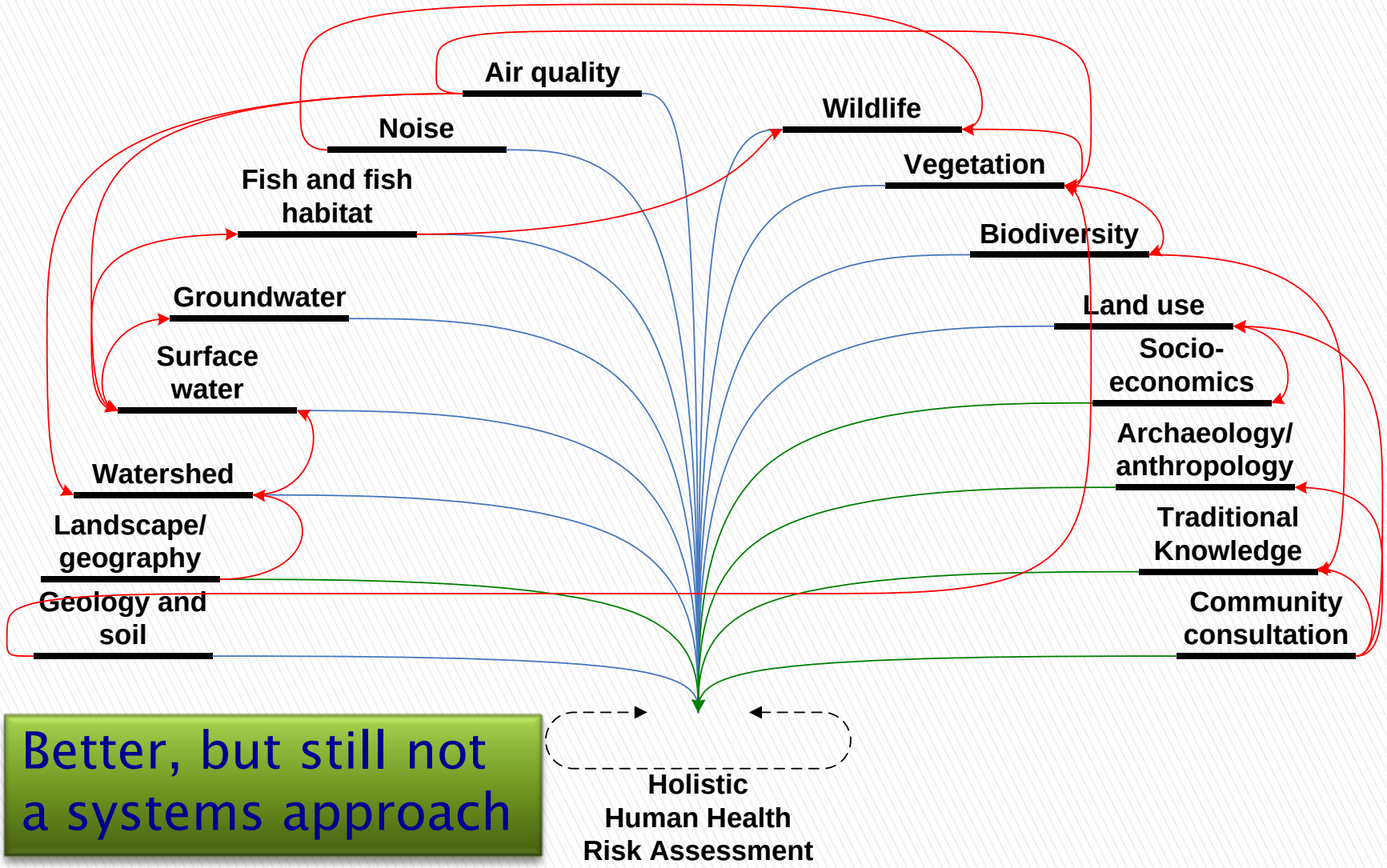
Holistic Environmental input to ERM



Current paradigm of HHRA in environmental assessment

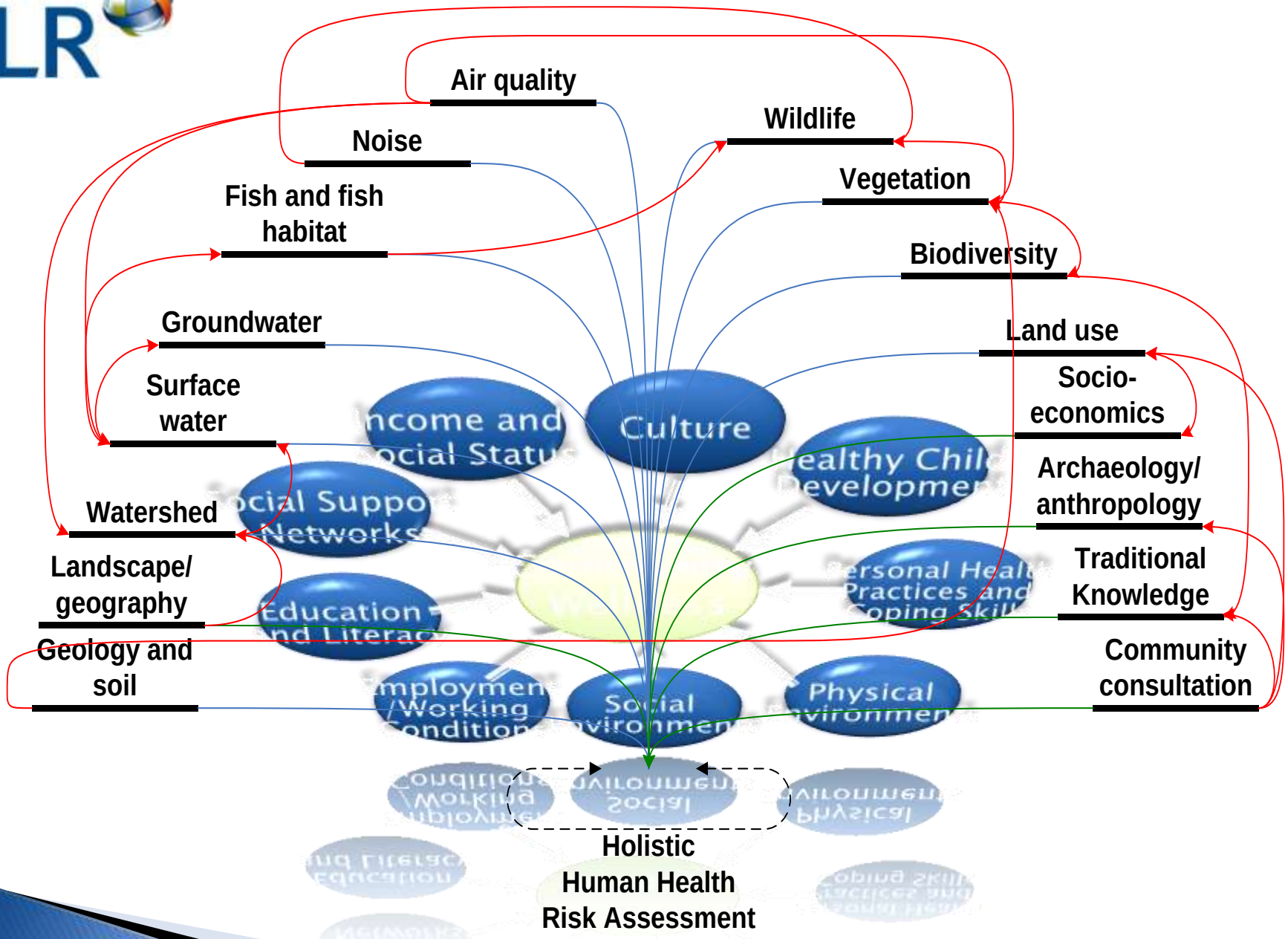


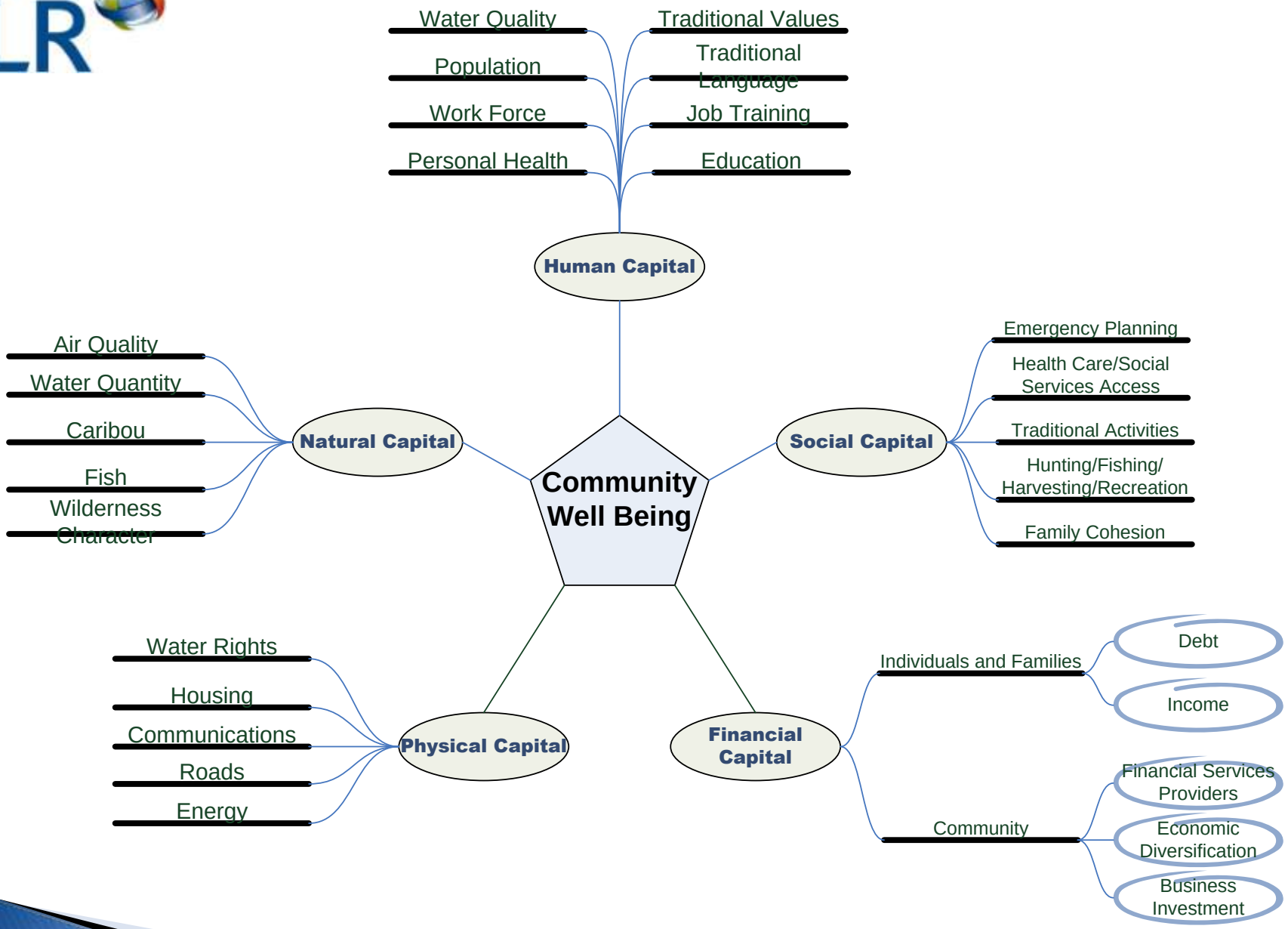
Holistic / Transdisciplinary paradigm of HHRA in environmental assessment.



Better, but still not a systems approach

Determinants of Health


Air quality
Noise
Fish and fish habitat
Groundwater
Surface water
Watershed
Landscape/ geography
Geology and soil
Wildlife
Vegetation
Biodiversity
Land use
Socio-economics
Archaeology/ anthropology
Traditional Knowledge
Community consultation
Culture
Physical
Holistic
Human Health
Risk Assessment

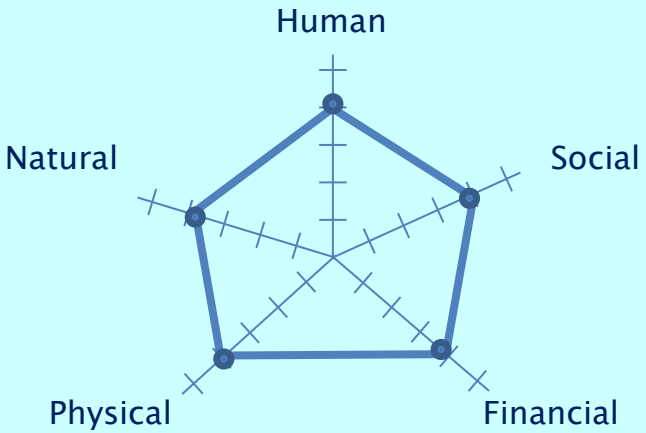

Water Quality
Population
Work Force
Personal Health
Traditional Values
Traditional Language
Job Training
Education
Human Capital
Air Quality
Water Quantity
Caribou
Fish
Wilderness Character
Natural Capital
Community Well Being
Social Capital
Emergency Planning
Health Care/Social Services Access
Traditional Activities
Hunting/Fishing/ Harvesting/Recreation
Family Cohesion
Water Rights
Housing
Communications
Roads
Energy
Physical Capital
Financial Capital
Individuals and Families
Debt
Income
Community
Financial Services Providers
Economic Diversification
Business Investment

Risk management

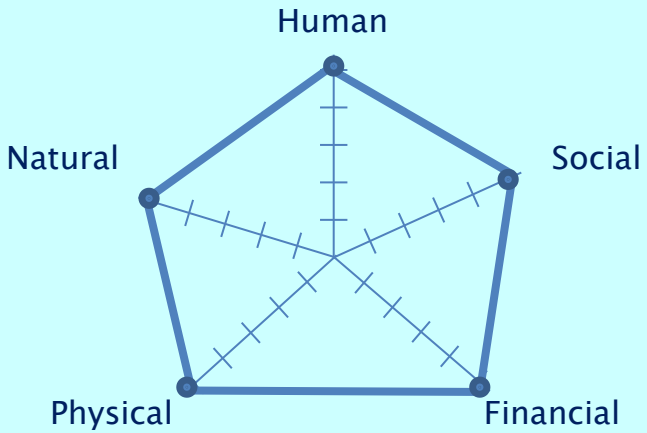
- Holistic perspective carries through to risk management
  - Reducing risks from one perspective may have adverse effects elsewhere
  - Example – digging up contaminated soil and trucking it to a landfill moves the issue to another region and introduces risks from transport...
    - See driving risks...

IDEAS

Sustainability [spider-web diagrams]



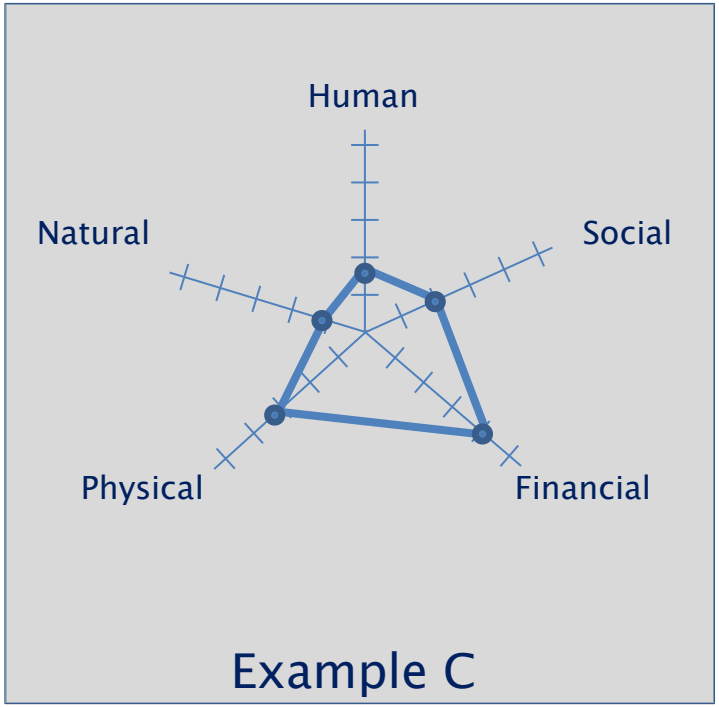
Example A



Example B

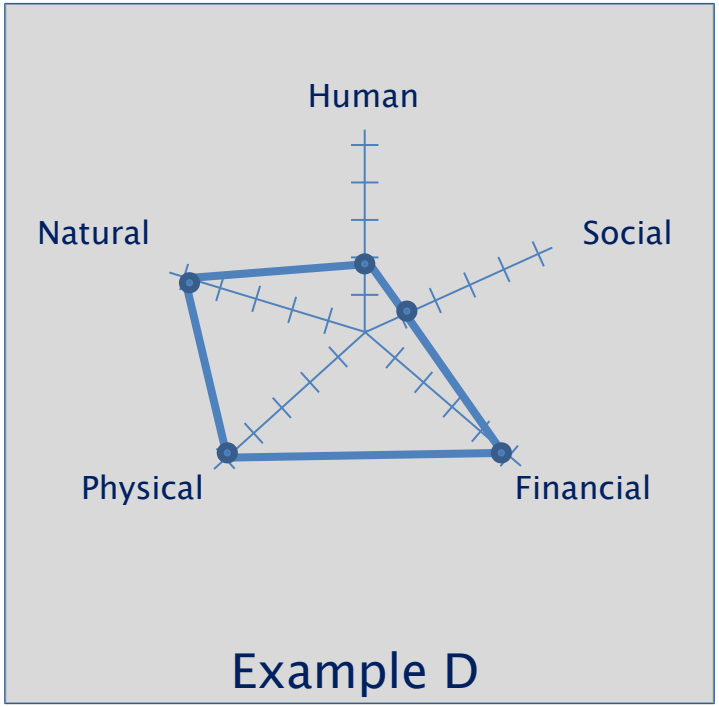
IDEAS

Sustainability [spider-web diagrams]



Example C

Requires investments in natural, human, and social capital



Example D

Requires investments in human and social capital

IDEAS

Sustainability Scenarios