Independent Expert Review Panel (IERP)
Human Health Risk Assessment for
Flin Flon, Manitoba and Creighton, Saskatchewan

Volume II

June 23-24, 2009
Winnipeg, CA

Peer Consultation Organized by:
Toxicology Excellence for Risk Assessment
(http://www.tera.org/peer/)

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Appendix A

Independent Expert Review Panel (IERP)
Human Health Risk Assessment for Flin Flon, Manitoba and Creighton, Saskatchewan

June 23-24, 2009

Panel Biographical Sketches and Conflict of Interest

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Conflict of Interest

An essential part of an independent expert review is the identification of conflicts of interest and biases that would disqualify a candidate, as well as identification and disclosure of situations which may appear to be a conflict or bias. *TERA* was selected by the TAC to independently organize and conduct this expert panel review and is solely responsible for the selection of the panel. Prior to selecting *TERA* to conduct this expert review, the TAC reviewed the proposals which included information regarding *TERA* past and current work necessary to evaluate *TERA* independence. *TERA* has experience in risk assessment and toxicity of a number of the chemicals of concern and this work has been done for a variety of public and private sponsors, but none of it is or was directly related to the Flin Flon and Creighton HHRA. *TERA* has not participated in the development or preparation of the human health assessment that is the subject of this meeting. *TERA* is not contracted to do any other work for HMBS and has no financial stake in the outcome of this review. As outlined in the contract between *TERA* and HBMS, *TERA* has independently selected the panel and organized this review. HBMS has had no influence on the selection of the IERP panel or implementation of the process.

The purpose for evaluating conflict of interest is to ensure that the public and others can have confidence that the peer reviewers do not have financial or other interests that would interfere with their ability to carry out their duties objectively. *TERA* asked each promising candidate to report on his or her financial and other relationships with HBMS and Intrinsik. In addition, *TERA* asked candidates to identify relationships with members of the TAC, so that we could insure that the panel members have not been indirectly involved with the HHRA through work for the TAC organizations.

The evaluation of real and perceived bias or conflict of interest is an important consideration in panel selection. *TERA* follows the U.S. National Academy of Sciences (NAS) guidance on selection of panel members to create panels that have a balance of scientific viewpoints on the issues to be discussed. As a result, the expert panels have a broad and diverse range of knowledge, experience, and perspective, including diversity of scientific expertise and affiliation. Panel members serve as *individuals*, representing their own personal scientific opinions. They do not serve as representatives of their companies, agencies, funding organizations, or other entities with which they are associated. Their opinions should not be construed to represent the opinions of their employers or those with whom they are affiliated.

Prior to selection, the candidates completed a questionnaire, which *TERA* used to determine whether their activities, financial holdings, or affiliations could pose a real or perceived conflict of interest or bias. The completed questionnaires were reviewed by *TERA* staff and discussed further with panel candidates as needed. (See www.tera.org/peer/COI.html for *TERA* conflict of interest and bias policy and procedures for panelist selection.)

TERA has determined that the selected IERP member have no conflicts of interest and are able to objectively participate in this peer consultation. None of the panel members has a financial or other interest that would interfere with his or her abilities to objectively participate on the panel.

None of the panel members is employed by HBMS or Intrinsik. Nor do the panel members have any financial interests in HBMS or the outcome of the review or assessment. None of the panel members was involved in the preparation of the human health risk assessment.

This panel of experts collectively has extensive experience in the key areas necessary to review the Flin Flon Human Health Risk Assessment, including multi-pathway risk assessment; environmental fate, toxicology and epidemiology; biomonitoring studies; exposure assessment and pathways modeling; bioavailability and bioaccessibility of metals from soils; sampling and analysis for metals in relevant media; evaluating human health hazards of soils and dust; derivation of Soil Trigger Concentrations (STC) and soil preliminary remediation goals (PRG); and uncertainty and sensitivity analyses. Panel members are very familiar with Canadian and U.S. guidance and methodologies for multimedia risk assessments including Health Canada Contaminated Sites Program, U.S. EPA Superfund Program, and Ontario Ministry of the Environment guidelines for contaminated sites.

A brief biographical sketch of each panel member is provided below. To promote transparency, a short statement describing situations which might appear to present a conflict of interest or bias are included, as appropriate.

Biographical Sketches of Panel Members

Ronald Brecher, Ph.D., C.Chem., QPRA, DABT
GlobalTox and University of Waterloo

Dr. Ronald Brecher is a Principal at GlobalTox International Consultants Inc. in Guelph, Ontario and an Adjunct Professor at the University of Waterloo. He earned his Ph.D. in Medicinal Biochemistry from the University of Sussex and a B.Sc. (Hon.) in Biochemistry from Carleton University. Dr. Brecher has over 20 years of experience as a senior consultant in toxicology, with an emphasis on assessing and communicating human health impacts of chemicals found in the environment and consumer products. His technical duties include assessment of human health impacts of toxic chemical exposures; design and implementation of full scale hazard, exposure and risk assessments for toxic chemicals in the workplace, drinking water, air and other environmental media; computer modelling of exposure; and, risk assessment, characterization and communication in public forums. He has served on governmental expert committees in both Canada and the U.S. and provides expert peer review of risk assessments prepared by others. Dr. Brecher has been actively involved in a scientific communications role in a number of high-profile risk assessment projects in high-concern, low-trust situations for clients including Department of Defence, Noranda Ltd., Health Canada, and local and provincial agencies. Dr. Brecher, in partnership with Frontline Corporate Communications has developed and conducted risk communication training for various groups. Dr. Brecher has served on several expert panels, including the American Council on Science and Health Blue Ribbon Panel on the Use of Phthalates in Medical Devices and Toys (2000), Health Canada's Expert Advisory Panel on Diethylhexyl Phthalate in Medical Devices (2001), and Ontario's Inter-ministry Expert Advisory Committee on N-Nitrosodimethylamine in Drinking Water (1990). In 2004, he was appointed to Ontario's Advisory Council on Drinking Water Quality and Testing Standards.

Dr. Brecher was selected for the panel for his expertise in risk communication, multimedia and site assessments, toxicology, bioavailability/bioaccessibility, sampling and analysis of metals in various media, evaluation of human health hazards from soils and dust, calculation of soil clean up goals, uncertainty and sensitivity analysis, and familiarity with Canadian and U.S. risk assessment methods that are used in this HHRA.

Disclosure: Dr. Brecher works for GlobalTox International Consultants, Inc, which has consulted with the document authors (Intrinsik) on past and current projects. Dr. Brecher has assisted Intrinsik on similar projects that evaluated historic metal impacts in soil, including serving as an independent scientific advisor for the Sudbury Soils Study. None of GlobalTox's work has involved Flin Flon/Creighton or HBMS. This relationship is being disclosed to promote transparency. *TERA* has determined that the relationship with Intrinsik is not a source of bias or conflict of interest because it does not involve the subject risk assessment and is a very small portion of GlobalTox total sales. The relationship should not impair Dr. Brecher's scientific objectivity as a panel member.

Michael L. Dourson, Ph.D., DABT, FATS
Toxicology Excellence for Risk Assessment (TERA)

Dr. Michael Dourson is the President of Toxicology Excellence for Risk Assessment (*TERA*), a nonprofit corporation dedicated to the best use of toxicity data in risk assessment. Before founding *TERA* in 1995, Dr. Dourson held leadership roles in the U.S. Environmental Protection Agency as chair of EPA's Reference Dose (RfD) Work Group, as a charter member of the EPA's Risk Assessment Forum and as chief of the group that helped create the Integrated Risk Information System (IRIS). Dr. Dourson received his Ph.D. in Toxicology from the University of Cincinnati. Dr. Dourson has served on or chaired numerous expert panels, including peer review panels for EPA IRIS assessments, EPA's Risk Assessment Forum, *TERA* International Toxicity Estimates for Risk (*ITER*) independent peer reviews and consultations, FDA's Science Board Subcommittee on Toxicology, the NSF International's Health Advisory Board, and SOT's harmonization of cancer and non-cancer risk assessment. Dr. Dourson has organized numerous symposia on a variety of topics, including: risk communication; chromium; information resources for toxicology and environmental health; risk assessment of essential trace elements; risk characterization; EPA's IRIS; uncertainty in risk assessment techniques; statistical and dose response models in risk assessment; benchmark dose methodology; basics of risk assessment; improvements in quantitative noncancer risk assessment; and neurotoxicity risk assessment. Dr. Dourson is a Diplomate of the American Board of Toxicology and a Fellow of the Academy of Toxicological Sciences. In 2003, Dr. Dourson was awarded the Arnold J. Lehman award for major contributions that improve the scientific basis of risk assessment by the Society of Toxicology (SOT). He has been elected to multiple officer positions in the American Board of Toxicology, SOT, and the Society for Risk Analysis. He is also a media resource specialist in risk assessment for the SOT, member of the editorial board of three journals, and vice chair of the NSF International Health Advisory Board. Dr. Dourson has chaired dozens of expert panels reviewing risk assessments, including the Sudbury Soils Study human health and ecological risk assessment IERPs.

Dr. Dourson was selected for this panel for his expertise in dose-response assessment, metals toxicology, multimedia risk assessment, and familiarity with various agency risk assessment methodologies. In addition, Dr. Dourson has extensive experience effectively chairing panels of expert scientists in review of risk assessments.

Disclosure: Dr. Dourson is the President of *TERA*, which is under contract with HBMS to independently organize and conduct this peer review. See discussion above.

Susan Griffin, Ph.D., DABT
U.S. Environmental Protection Agency

Dr. Susan Griffin has a doctorate in Veterinary Pharmacology and Toxicology and a B.S. in genetics from the University of California at Davis. She is board certified by the American Board of Toxicology. She has worked for the U.S. Environmental Protection Agency for over 20 years in the Toxic Substances Control Act (TSCA), Resource Conservation and Recovery Act (RCRA) and Superfund programs. She is currently the Senior Toxicologist in EPA's Region 8 Superfund program where she has extensive experience in assessing exposure and risk from mining and smelting sites in the Western U.S.. She has been responsible for the preparation of several hundred human health baseline risk assessments, including the design and collection of site-specific environmental and biological data to more accurately characterize risk. She has also been involved in the design and conduct of bioavailability studies in juvenile swine to determine the bioavailability of lead and arsenic from soil contaminated by mining and smelting activities. Currently she is working on a collaborative research project to develop and validate a faster and less expensive *in vitro* benchtop method for assessing the bioavailability of arsenic from soil. Dr. Griffin has also worked with the U.S. Agency for International Development in Romania to instruct environmental agencies and citizen groups in assessing lead exposures and risks from smelters. In 2000, she was asked to consult with the Chilean Ministry of Mines on arsenic exposures and health effects at the Chuquicamata Mine. In addition, she is actively involved in writing and developing national Superfund guidance documents, such as the Probabilistic Risk Assessment Guidance for Superfund, the Superfund Guidance for Inhalation Risk Assessment, the Guidance Manual for the Integrated Exposure Biokinetic Uptake Model. She also reviews chemical toxicity values for EPA's Integrated Risk Information System (IRIS) database as an IRIS consensus reviewer. Dr. Griffin served as an expert on the Sudbury Soils Study human health risk assessment IERP.

Dr. Griffin was selected for this panel for her extensive experience in multimedia and site assessments (particularly of mining and smelting sites), toxicology of metals, bioavailability, sampling and analysis of metals in various media, evaluation of human health hazards from soils and dust, calculation of soil clean up goals and extensive knowledge of the U.S. EPA risk assessment methods that are used in this HHRA.

Disclosure: None. Dr. Griffin is participating in this review on her own time and outside of her duties with her employer, the U.S. Environmental Protection Agency.

Sean Hays, M.S.
Summit Toxicology

Mr. Sean Hays is the President and founder of Summit Toxicology, a toxicology and risk assessment consulting firm. Mr. Hays received his B.S. in Biomedical Engineering from Texas A&M University, a M.S. in Physiology from the University of Vermont, and a M.S. in Chemical Engineering from Colorado State University. Mr. Hays specializes in conducting exposure assessments, developing pharmacokinetic and physiologically based pharmacokinetic (PBPK) models, deriving acceptable exposure limits, and in developing methods for interpreting biomonitoring data in a health risk context. Mr. Hays has developed PBPK models for a wide range of chemicals and metals, including volatile organic solvents, lead, dioxin, chromium, benzo[a]pyrene, and glycol ethers. He has specialized in developing models for pregnancy and the developing child. He has experience in performing pharmacokinetic modeling of lead in humans and in using the US EPA IEUBK model to assess potential health risks for a wide range of potential exposure scenarios and to set site-specific clean-up goals for numerous lead impacted properties, to model the potential for elevated blood lead levels among children exposed to elevated levels of lead in school drinking water supplies, and for modeling the likely changes in blood lead levels among astronauts who experience rapid and substantial bone loss while on extended space travel. Mr. Hays has performed detailed analyses to evaluate the scientific differences between the various lead pharmacokinetic models and to evaluate in which risk assessment scenarios each lead model is scientifically valid for predicting changes in blood lead levels. Mr. Hays has served on numerous advisory panels including the All Ages Lead Model Review Panel (U.S. EPA Scientific Advisory Board [SAB)]); the panel Clean Air Scientific Advisory Committee (CASAC) review of the U.S. EPA National Ambient Air Quality Standard (NAAQS) for Lead; and the peer review panel for U.S. EPA's Acrylamide Assessment. He has served as the President of the Biological Modeling Section of the Society of Toxicology.

Mr. Hays was selected for the IERP for his expertise in multi-pathway risk assessment, toxicology and epidemiology, exposure assessment, lead pharmacokinetics, biomonitoring equivalents, and uncertainty and sensitivity analysis.

Disclosure: None**.**

Norm Healey, B.Sc., DABT
Azimuth Group

Mr. Norm Healey is with the Azimuth Consulting Group in Sidney, British Columbia. He has more than 10 years experience as a risk assessor and toxicologist, both as a practitioner and as a regulator. Most recently, the focus of his work has been on various human health projects including the development of Canadian Soil Quality Guidelines, derivation of toxicological reference values, and development of Health Canada risk assessment policy and guidance documents. Mr. Healey has a B.Sc. in Environmental Science from Royal Roads University. Prior to joining Azimuth in 2009, he was a risk assessment and toxicology specialist with Health Canada and an environmental officer with the Canadian Coast Guard. Mr. Healey has directed or peer reviewed several multi-media human health risk assessments of lead. He was the principal author of Health Canada's 2008 draft toxicological evaluation of lead and in 2008 directed an evaluation and international panel review of the O'Flaherty and US EPA IEUBK models of lead exposure, uptake and toxicokinetics. Mr. Healey is currently a co-investigator of an epidemiological study to assess chronic lead exposure among Canadians by measuring lead in whole blood, serum and bone. He was also a scientific advisor to the Canadian House Dust Study, where he derived the schedule of lead values in house dust that would require the researchers to warn participants of potential lead exposure risks from dust in their homes. Mr. Healey has authored or co-authored over 15 papers or conference presentations on risk assessment and health effects of lead and has been an invited speaker on the topic at international scientific conferences. He represented Health Canada at the World Health Organization's Working Group on Lead and Children's Health and chaired Health Canada's Vapour Intrusion Working Group.

Mr. Healey was selected for the panel for his expertise in multimedia and site assessments; toxicology of metals (particularly lead); bioavailability/bioaccessibility; sampling and analysis of metals in water, soil, and dust; evaluation of human health hazards from soils and dust; calculation of soil clean up goals; and, extensive knowledge of Health Canada contaminated sites risk assessment methods.

Disclosure: None.

Anthony L. Knafla, M.SC., DABT
Equilibrium Environmental Inc.

Mr. Knafla is the President of Equilibrium Environmental Inc., in Calgary, Alberta. He has worked as a toxicologist and risk assessor in Canada for 16 years. He is a Diplomate of the American Board of Toxicology, obtained a B.Sc. in biochemistry from the University of Calgary and a M.Sc. in Medical Sciences (Toxicology) from the Faculty of Medicine. Mr. Knafla has developed toxicological profiles and methods for deriving soil quality guidelines that have been applied at provincial and federal levels for substances including lead, arsenic, perfluorooctanoic acid, PAHs, mercury, salts, and hydrocarbons. He has developed state of the science reports for application under the Canadian Environmental Protection Act. Mr. Knafla has also been responsible for scientific advisory roles in public hearings and consultation to the Alberta Energy and Utilities Board, Alberta Environment, the Canadian Council for Ministers of the Environment, Environment Canada, and Health Canada.

Mr. Knafla was selected for the panel for his expertise in multi-pathway human health risk assessments; biochemical sciences, toxicology of arsenic, lead, cadmium, selenium and mercury; biomonitoring studies; fate and transport models, sampling and analysis of metals in air, soil, and dust; evaluation of human health hazards from soils and dust; calculation of soil clean up goals; uncertainty and sensitivity analysis; and extensive knowledge of Health Canada contaminated sites risk assessment methods.

Disclosure: Mr. Knafla was an employee of Cantox (now Intrinsik) from 1992-1996 but has no current financial relationship with Intrinsik. This information is being shared to promote transparency. *TERA* has determined that Mr. Knafla's previous employment by Cantox is not a conflict of interest because it was over ten years ago and should not impair Mr. Knafla's scientific objectivity as a panel member.

Rebecca L. Tominack, M.D., FAACT, FACMT
Missouri Regional Poison Center and Saint Louis University School of Medicine

Dr. Rebecca Tominack is a medical toxicologist and serves as the Assistant Medical Director of the Missouri Regional Poison Center. She is also an Adjunct Professor of Medicine, Division of Toxicology, Department of Pediatrics and Clinical Assistant Professor of Pediatrics, Division of Toxicology, of the Saint Louis University School of Medicine. Dr. Tominack earned her M.D. from the University of Maryland, School of Medicine, and a B.S. in Pharmacy from the University of Maryland, School of Pharmacy. She received postdoctoral training in Internal Medicine, Virology, and Clinical Pharmacology and Toxicology. Previous positions include Program Director, Occupational Medicine Residency, Saint Louis University School of Medicine (concurrent with Poison Center directorship; residency program closed by SLU) and Director, Health Promotion and Work-family Balance and Medical Toxicology for the Monsanto Company. Dr. Tominack is experienced in evaluating and treating humans exposed to metals including mercury and lead. She teaches courses on human toxicology, risk assessment, and environmental toxicology in the Saint Louis University School of Public Health and toxicology at the Medical School. Dr. Tominack is board certified in Internal Medicine and in Medical Toxicology. She is a Fellow of the American Academy of Clinical Toxicology and a Fellow of the American College of Medical Toxicology. She serves on the editorial Board of the Journal of Toxicology Clinical Toxicology. Dr. Tominack has consulted to U.S. federal and state government agencies, as well as the International Program of Chemical Safety of the World Health Organization. She has served on expert committees on medical management for chemical exposures, assessments of lead contamination, and global pesticide poisoning.

Dr. Tominack was selected for the panel for her expertise in medical toxicology, pediatrics, public health issues, toxicology and epidemiology, and biomonitoring.

Disclosure: None

Joyce S. Tsuji, Ph.D., DABT, FATS
Exponent

Dr. Joyce Tsuji is a Principal in Exponent's Health Sciences practice in Bellevue, Washington. Dr. Tsuji received a B.S. in biological sciences from Stanford University with honors and distinction, Phi Beta Kappa, and a Ph.D. focused in physiology and ecology from the Department of Zoology, University of Washington. She is a Diplomate of the American Board of Toxicology, a Fellow of the Academy of Toxicological Sciences, and has over 20 years of experience in toxicology and risk assessment on projects in the United States, Canada, South America, Africa, Australia, and Asia for industry, as well as for the U.S. EPA, the U.S. Department of Justice, the Australian EPA, and state and local municipalities and agencies. Particular areas of interest include exposure assessment and toxicology of a variety of chemicals including those from industrial releases and in consumer products and nanomaterials. Dr. Tsuji has specialized experience with mining and smelting sites and the toxicology, bioavailability, and exposure to metals such as arsenic, lead, cadmium, mercury, manganese, chromium, and zinc. She has conducted and reviewed human health and ecological risk assessments of mining and smelting sites, and has designed and directed exposure studies involving health education, environmental sampling, and biomonitoring of populations potentially exposed to metals in soil, water, and the food chain. Dr. Tsuji has served on expert committees for the National Research Council, including serving as a peer reviewer for the report on the Coeur d'Alene Basin mining site and risk assessment. She has also served on committees for the U.S. EPA, U.S. Army, and the State of Washington (including the Area Wide Soil Contamination group of experts convened by the State of Washington to evaluate arsenic and lead in soil). Dr. Tsuji served as an expert on the Sudbury Soils Study IERP for the human health and ecological risk assessments. Dr. Tsuji has served as an expert witness on several legal cases involving metals and mines and has published a number of papers on risk assessment issues, including arsenic and lead in soils and mercury in air.

Dr. Tsuji was selected for the panel because of her expertise in toxicology of metals, bioavailability/bioaccessibility, biomonitoring studies, environmental fate, multimedia risk assessment (particularly of mining and smelting sites), sampling and analysis of metals in various media, evaluation of human health hazards from soils and dusts, calculation of soil clean up goals, and familiarity with U.S. EPA and Ontario MOE risk assessment methods.

Disclosure: Dr. Tsuji and her employer Exponent have conducted risk assessments and developed community exposure intervention and monitoring programs on behalf of mining companies, government agencies, and other private clients. None of this work has been for HBMS, or any project related to this HHRA. Other professionals at Exponent have been involved in the past in litigation cases with multiple defendants (e.g., 30+) in which HBMS was a defendant. This case did not involve a mining or smelting site, Exponent was not hired by HBMS and Dr. Tsuji was not involved in this project. These activities are being disclosed to promote transparency. *TERA* has determined that these situations are not a conflict of interest because they do not involve the Flin Flon/Creighton risk assessment, and Dr. Tsuji was not involved in the legal case that involved HBMS. *TERA* also concluded that these activities will not impair Dr. Tsuji's scientific objectivity as a panel member.

Appendix B

Independent Expert Review Panel (IERP)
Human Health Risk Assessment for Flin Flon, Manitoba and Creighton, Saskatchewan

June 23-24, 2009

Overview of HBMS Peer Consultation Process, List of Attendees, Agenda, and Presenter Biographical Sketches

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Overview of the HBMS Peer Consultation Process

Background

This meeting of an independent expert review panel (IERP) has been organized by Toxicology Excellence for Risk Assessment (*TERA).* *TERA* is an independent non-profit organization with a mission to protect public health through the best use of toxicity and exposure information in the development of human health risk assessments. *TERA* has organized and conducted peer review and consultation meetings for private and public sponsors since 1996 (see www.tera.org/peer for information about the program and reports from meetings).

TERA has convened this panel to review the draft human health risk assessment (HHRA) of Flin Flon, Manitoba, and Creighton, Saskatchewan. The draft HHRA was prepared by Intrinsik Environmental Sciences Inc. to address the potential human health risks associated with exposure to smelter-related metals in soils and other environmental media in the Flin Flon and Creighton area. A Technical Advisory Committee (TAC) with representatives from national and provincial agencies is providing technical guidance to Intrinsik. The TAC is made up of members from HBMS, Manitoba Conservation; Manitoba Health; Manitoba Science, Technology, Energy and Mines (STEM); Manitoba Water Stewardship; Saskatchewan Environment; Saskatchewan Health; and, Health Canada. Hudson Bay Mining and Smelting (HBMS) provided funding for the HHRA and the IERP review.

This meeting is not open to the general public and the assessment results are not yet final; therefore, the panel and observers are asked to keep the assessment and panel discussions confidential and not discuss them with others, including the media.

Independent Expert Review Panel

The independent peer review panel includes eight scientists who have expertise in the key disciplines and areas of concern. Each panelist is a well-respected scientist in his or her field. Collectively, the panel has expertise in multi-pathway risk assessment; environmental fate, human toxicology and epidemiology; biomonitoring studies; exposure assessment and pathways modeling; bioavailability and bioaccessibility of metals from soils; sampling and analysis for metals in diverse media; evaluating human health hazards of soils and dust; derivation of Soil Trigger Concentrations (STC) and soil preliminary remediation goals (PRG); and uncertainty and sensitivity analyses. Panel members are very familiar with Canadian and U.S. guidance and methodologies for multimedia risk assessments including Health Canada Contaminated Sites Program, U.S. EPA Superfund Program, and Ontario Ministry of the Environment guidelines for contaminated sites. *TERA* was solely responsible for the selection of the panel members.

Each panel member has disclosed information pertinent to evaluating potential conflicts of interest and biases related to the HHRA and its sponsor. *TERA* carefully evaluated this

information when selecting panel members. Short biographical sketches and disclosure statements for panel members are provided (see page 8).

Review Package and Charge to Peer Reviewers

The panel was sent the HHRA and review materials approximately six weeks prior to the meeting to ensure adequate time to carefully review the document and prepare for the meeting discussions. *TERA* developed a "charge to peer reviewers" document that outlines the key questions and scientific issues that need to be discussed by the panel in order to evaluate the quality and completeness of the risk assessment. Panel members provided preliminary comments several weeks prior to the meeting for the authors to consider in preparation for the meeting. As these comments were preliminary and panelists may change their opinion upon further review and discussion, they will not be distributed further or made part of the official meeting record.

Meeting Procedures

The meeting has been organized to make the best use of the time available to hear and discuss the opinions of the panelists regarding the charge questions and the human health risk assessment. The meeting will begin with brief panel introductions and a discussion of conflict of interest and bias issues. The discussion will then address the four broad areas of the assessment: problem formulation and sampling, exposure assessment, hazard assessment, and risk characterization. To start each discussion section, the authors of the assessment document will make a short presentation. These presentations will highlight the salient points and focus on important issues. There will be a brief period for panel member clarifying questions and then the panel will discuss the relevant charge questions.

Observers

Members of the Technical Advisory Committee have been invited to observe the panel meeting process. As the purpose of the IERP meeting is to have the expert panel discuss the assessment and reach conclusions on the science and the quality, the discussions will be limited to the panel members. To insure the panel's independence, observers are asked to refrain from initiating discussions about the assessment or related issues with the panel members. Please see the observer handout in your folder.

Meeting Report

TERA will draft a meeting report that briefly summarizes the panel's discussions and recommendations. The meeting report will serve as a record of the peer review and will assist the authors in making revisions to the assessment. The report will be reviewed by the panel members for accuracy before it is finalized.

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List of Attendees

Panel Members

Dr. Ronald W. Brecher
GlobalTox International Consultants

Dr. Michael Dourson
Toxicology Excellence for Risk Assessment (*TERA*)

Dr. Susan Griffin
U.S. Environmental Protection Agency

Mr. Sean M. Hays
Summit Toxicology

Mr. Norm Healey
Azimuth Consulting Group Inc.

Mr. Anthony L. Knafla
Equilibrium Environmental Inc.

Dr. Rebecca Tominack
Missouri Regional Poison Center

Dr. Joyce Tsuji
Exponent

Observers

Dave Bezak
Manitoba Conservation

George Bihun
Saskatchewan Ministry of Environment

Ian Cooper
Hudson Bay Mining and Smelting

Dr. Lawrence Elliott
Manitoba Health and Healthy Living

Alan Hair
Hudson Bay Mining and Smelting

Ines Hiraoka
Manitoba Conservation

Dr. James Irvine
Saskatchewan Ministry of Health

Kevin Jacobs
Manitoba Water Stewardship

Geoff Jones
Manitoba Conservation

Dean Kasur
Manitoba Conservation

Tom Lindsey
Community Advisory Committee Observer

Sheldon McLeod
TAC Facilitator

Jacqueline Patterson
Toxicology Excellence for Risk Assessment (*TERA*)

Doina Priscu
Manitoba Science, Technology, Energy and Mines

Shala Ricklefs
Saskatchewan Ministry of Health

Dr. Susan Roberecki
Manitoba Health and Healthy Living

Adam Safruk
Intrinsik

Elliot Sigal
Intrinsik

Lindsey Smith
Health Canada

Alison Willis
Toxicology Excellence for Risk Assessment (*TERA*)

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Agenda

Fort Garry Hotel, Winnipeg, Manitoba

Tuesday, June 23, 2009

8:00 **Registration**

8:30 **Meeting Convenes**[1]
Welcome, Ms. Jacqueline Patterson, *TERA*
Panel Introductions and Conflict of Interest/Bias Disclosures, Panel
Meeting Process and Ground Rules, Dr. Michael Dourson, Chair

9:00 **Background**
Mr. Alan Hair, Hudson Bay Mining and Smelting

Clarifying Questions from the Panel

9:15 **Problem Formulation and Sampling**
Mr. Adam Safruk, Intrinsik

Clarifying Questions from the Panel
Discussion (Charge Questions 1-5)

11:00 **Exposure Assessment**
Mr. Adam Safruk, Intrinsik

Clarifying Questions from the Panel
Discussion (Charge Questions 6-12)

12:00` **Lunch**

1:00 **Complete Exposure Discussion**

3:00 **Hazard Assessment**
Mr. Elliot Sigal, Intrinsik

Clarifying Questions from the Panel
Discussion (Charge Questions 13-15)

5:30 **Meeting Adjourns for the Day**

7:00 **Panel Dinner**

[1] The Chair will call a break mid-morning and mid-afternoon.

Agenda

Fort Garry Hotel, Winnipeg, Manitoba

Wednesday, June 24, 2009

8:00 **Meeting Re-convenes**

Results, Risk Characterization, Uncertainties
Mr. Elliot Sigal, Intrinsik

Clarifying Questions from the Panel
Discussion (Charge Questions 16-22)

12:00` **Lunch**

1:00 **Complete Risk Characterization Discussion**

2:00 **Conclusions and Recommendations**
Mr. Elliot Sigal, Intrinsik

Clarifying Questions from the Panel
Discussion (Charge Questions 23-29)

4:00 **Meeting Adjourns**

Biographical Sketches of Presenters

Elliot A. Sigal
Executive Vice President, Intrinsik Environmental

Mr. Elliot Sigal is the Executive Vice President of Intrinsik Environmental Sciences, Inc. (formerly Cantox Environmental Inc). Mr. Sigal graduated with an Honours B.Sc. in Toxicology from the University of Toronto in 1988. Since joining Intrinsik (Cantox) in 1989, he has gained over 20 years of experience in human health and ecological risk assessment, and toxicology. Mr. Sigal is responsible for supervising over 15 employees in our Mississauga office, as well as managing both small (a few thousand dollars) and large projects (over a million dollars).

Mr. Sigal has extensive experience in all aspects of toxicology and risk assessment with specific expertise in computer exposure modeling for human and ecological receptors. He has been responsible for leading risk assessment teams in determination of potential for exposure of and risk to receptors associated with complex contaminated sites, military base closures, underground storage tanks, incinerator emissions, landfill sites and industrial processes. Mr. Sigal has been involved in the use of toxicological principles to facilitate the risk assessment process, such as the development of a health-based method for the evaluation of total petroleum hydrocarbons (TPH), and provision of a benchmark comparison of remediation alternatives, in order to determine economically feasible and scientifically sound solutions to risk management problems. Mr. Sigal was also integrally involved in development and implementation of deterministic (point estimate) and probabilistic (stochastic) exposure and hazard assessment modeling techniques.

Mr. Sigal has conducted interpretive reviews of toxicology and mechanistic databases for a variety of chemicals including metals (arsenic, lead, nickel), chlorinated organics (vinyl chloride, PCBs, dioxins and furans), volatile organic compounds (benzene, toluene), combustion gases (NO_X, SO_X), and PAHs (, benzo[a]pyrene). Mr. Sigal has conducted peer reviews on many risk assessments in jurisdictions across Canada and the U.S., and has conducted reviews of risk assessments on behalf of the Ontario Ministry of the Environment.

Adam Safruk
Environmental Scientist, Intrinsik Environmental

Mr. Adam Safruk is an Environmental Scientist with Intrinsik Environmental Sciences, Inc. (formerly Cantox Environmental Inc). Mr. Safruk completed his MES in Toxicology and Risk Assessment at York University/ University of Toronto in 2003, and his Honours B.Sc. in Fish and Wildlife Biology from the University of Guelph in 1999. His academic training has provided him with experience in environmental toxicology, fugacity modelling, aquatic toxicology, risk assessment, risk management, and environmental law/public policy.

Mr. Safruk specializes in human and ecological exposure modelling and has conducted deterministic and probabilistic risk assessments for projects in Canada and Egypt. He is also involved in fate and transport modelling, risk characterization, development of risk management criteria, and report preparation. His work at Intrinsik Environmental Sciences Inc. has also focused on the fate and toxicity of chemicals in the aquatic environment as they impact both human and ecological receptors. Mr. Safruk has also prepared sections of a sediment sampling guidance document for Ontario Ministry of the Environment.

Mr. Safruk has worked on numerous projects including evaluation of impacts of on-site contamination to aquatic receptors in an urban stream, human and ecological exposure modelling, risk characterization and risk management for chlorinated organics, PAHs, PCBs and metals in soil, groundwater and surface water, and fate and transport modelling, human and ecological exposure modelling, and risk characterization for PCBs and Petroleum Hydrocarbons in soil. Mr. Safruk has conducted critical reviews of scientific literature for expert advice to Health Canada on the human health toxicology of Trichloroethylene and Perchlorate, along with various other literature reviews.

Appendix C

Independent Expert Review Panel (IERP)
Human Health Risk Assessment for Flin Flon, Manitoba and Creighton, Saskatchewan

June 23-24, 2009

Presenter Slides

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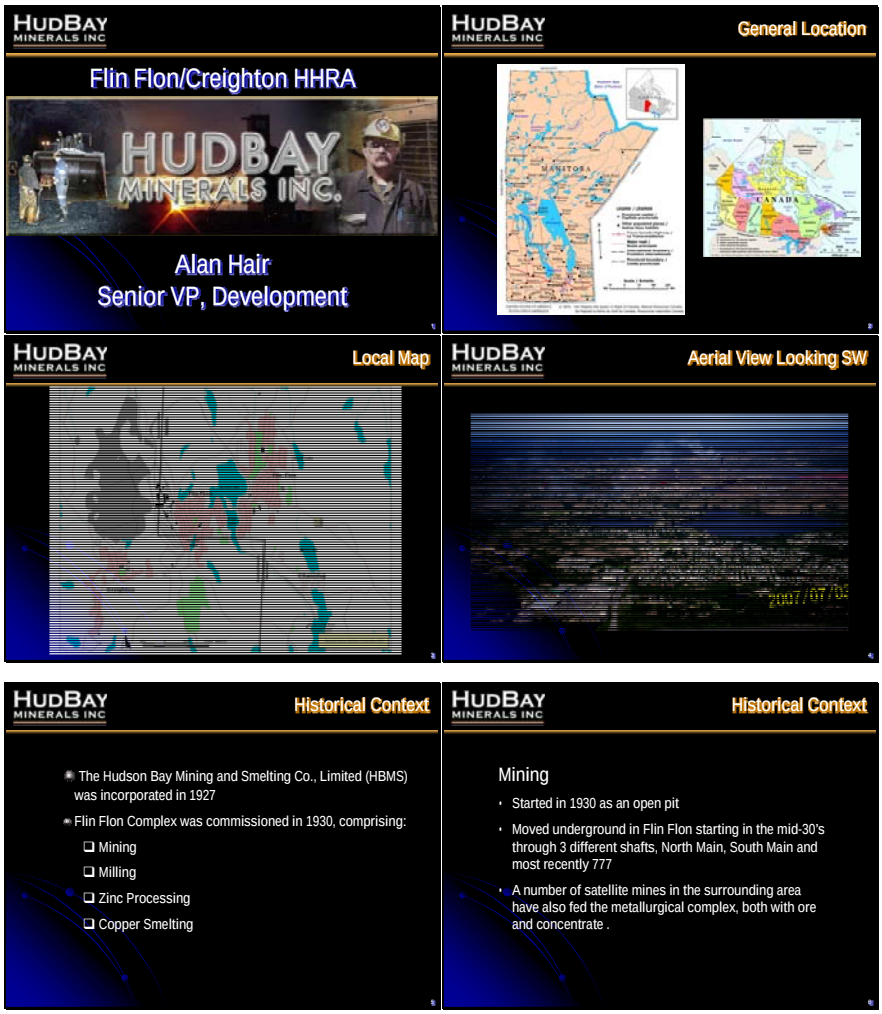
Presenter Slides

Presentation 1 - Mr. Alan Hair



HUDBAY MINERALS INC

Historical Context

Milling

- Conventional Ore Concentrator
- Crushing/Grinding/Flotation
- Produces both copper and zinc concentrates for downstream treatment on site
- Waste tailings stream stored in tailings management area adjacent to complex

HUDBAY MINERALS INC

Historical Context

Zinc Plant

- Started in 1930 as conventional Roast/Leach/Electrowin
- Significant process upgrades over the years

Copper Smelter

- Started in 1930 as roaster, reverberatory furnace and Pierce-Smith converter operation
- Flowsheet fundamentally unchanged
- Scheduled to cease operation by July 2010

HUDBAY MINERALS INC

Emissions

- Original metallurgical plants had only rudimentary gas cleaning equipment
- Emissions in the early years have been estimated to be an order of magnitude greater than today.
- Plant emissions were through two separate stacks:
  - 150' stack for zinc roaster emissions
  - 250' stack for copper roaster, reverb and converters

HUDBAY MINERALS INC

1930's Complex Looking North

HUDBAY MINERALS INC

1950's Complex Looking West

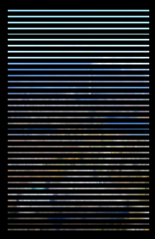
HUDBAY MINERALS INC

Emission Step Changes

- Process changes to Smelter in the 1950's saw improvements to pollution abatement with the commissioning of a large Dracco Baghouse.
- Next significant change was in the early 1970's with the commissioning of a new 825' high stack.
- In 1993 the new zinc pressure leach facility was brought into operation effectively eliminating atmospheric emissions from the zinc plant.

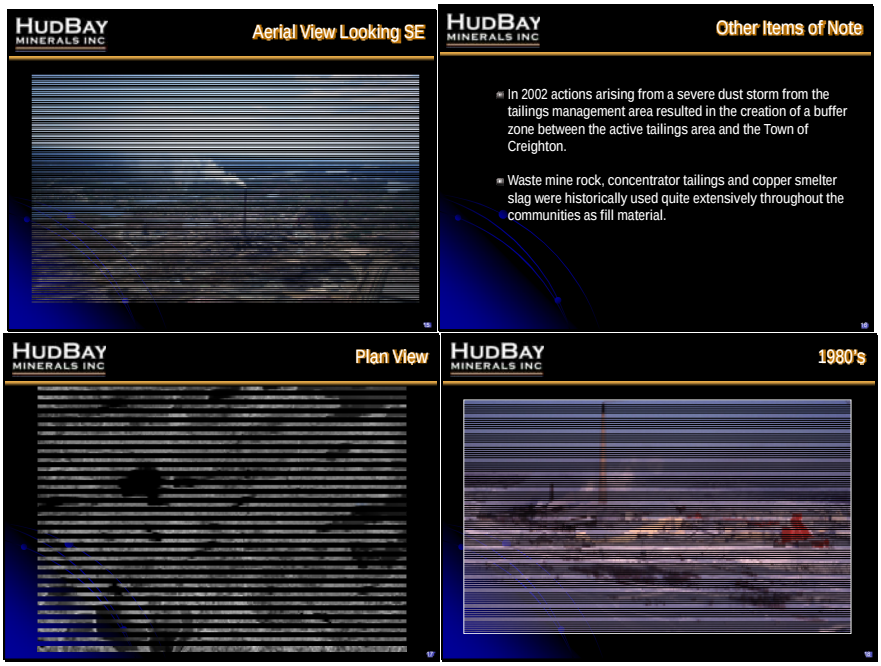
HUDBAY MINERALS INC

825' Stack

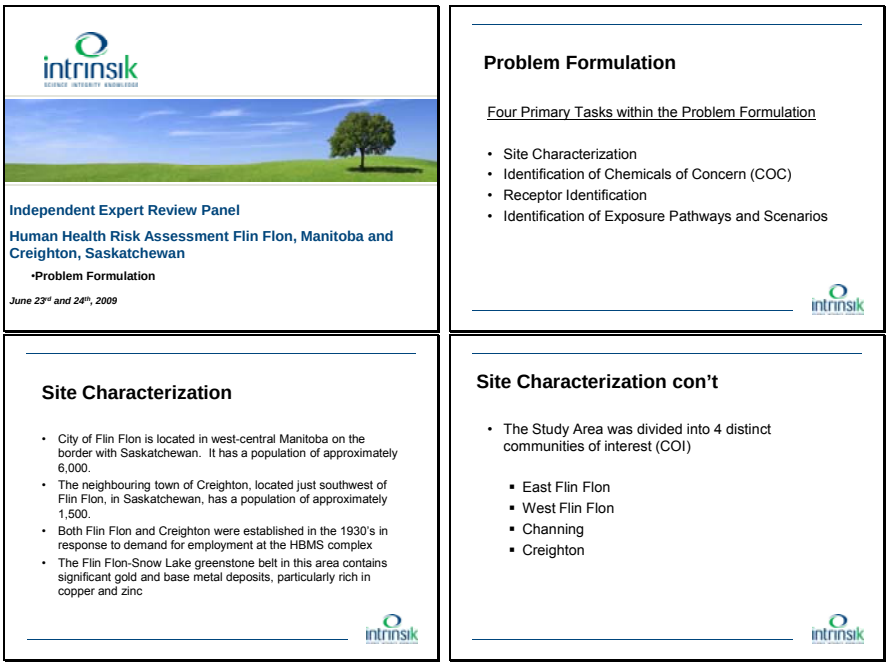


HUDBAY MINERALS INC

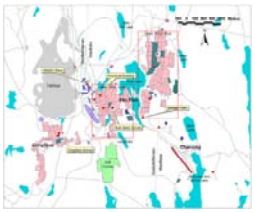
Aerial View Looking NE



Presentation 2 - Mr. Adam Safruk



Communities of Interest



Site Characterization con't

- Numerous studies over the past 20 years have indicated the presence of elevated levels of metals in soils surrounding the HBMS complex
- A strong positive inter-correlation has been noted by several sources indicating that these metals share a common point of origin
- Manitoba Conservation has completed 4 significant soil-related studies:
  - Soil and blueberry study in 2000
  - Forest soil study with sampling in 1998,1999 and 2003
  - Home garden produce study in 2002
  - Surface soil study in 2006

Site Characterization con't

- Manitoba Conservation surface soil study (2006)
  - 93 sites in Flin Flon; 13 sites in Creighton (each site had 3 samples)
  - Samples were collected from the top 2.5 cm and were a composite of 20 cores
  - Publicly accessible lands such as parks, schoolyards, boulevards, vacant lots, undeveloped areas, etc.
  - Results indicated that concentrations of 12 chemicals were elevated relative to a reference site
  - Six chemicals exceeded health-based Federal guidelines
    - Arsenic, cadmium, copper, lead, mercury, and selenium
  - Initiated the start of the HHRA

Site Characterization con't

- The literature review and data gap analysis identified the need for additional data collection which was completed in 2008
  - Residential soil
  - Drinking water
  - Supplementary air
  - Indoor dust
  - Bioaccessibility (outdoor soil)
  - Fish, surface water, sediment
  - Blueberries
  - Snow
  - Local food consumption survey

Site Characterization con't

- An initial step of the HHRA was the completion of a residential soil sampling study in fall 2007 completed by Jacques Whitford
  - 107 samples in West Flin Flon; 141 samples in East Flin Flon; 68 in Creighton; 18 in Channing
  - Samples were a composite of a minimum of 10 cores
  - Samples were collected from homes on a volunteer basis

Identification of Chemicals of Concern (COC)

- Identified based on concentrations in soil
- Current air monitoring completed by Manitoba Conservation evaluates risks associated with direct emissions
- COC identification process included:
  - Comparison of maximum concentrations to human health-based soil guidelines
  - Consideration of the percentage of samples in excess of guideline
  - Consideration of regional background concentrations
  - Known association with smelter emissions
- Selection of maximum soil concentrations considered data from the Manitoba Conservation Study (2007) and the Residential Soil Study (2008)

Identification of COC con't

- Initial comparison indicated the maximum concentration of 11 elements exceeded the selected guideline
- Three of these elements (chromium, thallium, and zinc) exceeded the guideline in less than 1% of samples
  - Therefore, not considered to be elevated across the Study Area
- Two of these elements (manganese and iron) are not correlated with smelter-related metals and are not in excess of regional background levels
  - Therefore, presence of elevated levels in soil are not related to HBMS complex
- Identified COC are: Arsenic, Cadmium, Copper, Lead, Mercury, and Selenium (consistent with those identified in the Manitoba Conservation Study)

Receptor Identification

- To assess risks for non-carcinogenic endpoints, receptors within 5 age categories as recommended by Health Canada were considered:
  - Infant (0 to 6 months)
  - Toddler (7 months to 4 years)
  - Child (5 to 11 years)
  - Adolescent or teen (12 to 19 years)
  - Adult (20 to 80 years)
- To assess risks for carcinogenic endpoints, a lifetime composite receptor was considered

Identification of Exposure Pathways and Scenarios

Inhalation exposure pathways

- Direct inhalation of COC in outdoor air
- Direct inhalation of COC in indoor air

Dermal exposure pathways

- Dermal contact with COC in outdoor soil
- Dermal contact with COC in indoor dust
- Dermal contact with COC in surface water

Identification of Exposure Pathways and Scenarios con't

Oral exposure pathways

- Ingestion of COC in outdoor soil
- Ingestion of COC in indoor dust
- Ingestion of COC *via* consumption of home garden vegetables
- Ingestion of COC *via* consumption of local wild blueberries
- Ingestion of COC *via* consumption of local fish and wild game
- Ingestion of COC *via* incidental surface water ingestion while swimming
- Ingestion of COC present in typical market basket items (*i.e.*, groceries)
- Ingestion of COC in drinking water derived from Flin Flon and Creighton area water resources
- Ingestion of COC in snow

Identification of Exposure Pathways and Scenarios con't

- Residential
- Typical Background Residential
- Outdoor Commercial Worker
- Additional Recreational Pathways

Identification of Exposure Pathways and Scenarios con't

Residential Scenario

- Receptors of all age categories
- Four communities of interest
- Community-based exposure pathways (*e.g.*, soil, dust, air, local foods)
- Market basket exposure
- Any additional sources of exposure (*e.g.*, mercury in dental amalgam)

Identification of Exposure Pathways and Scenarios con't

Typical Background Residential Scenario

- Included to allow for comparison of site-related risks to background risk levels
- Receptors of all age categories
- Exposure from typical background concentrations of COC in environmental media
- Market basket exposure
- Any additional sources of exposure (*e.g.*, mercury in dental amalgam)

Identification of Exposure Pathways and Scenarios con't

Outdoor Commercial Worker

- Members of the TAC requested that outdoor workers be included in the HHRA
- Adults only (10 hrs/day, 5 days/week, 48 weeks/year)
- Exposure to COC in environmental media while working outdoors (*i.e.*, soil, air, drinking water)
- Market basket exposure
- Reflective of a receptor that works but does not live in the study area

Identification of Exposure Pathways and Scenarios con't

Additional Recreational Pathways

- Exposure to COC in surface water while swimming *via* incidental ingestion and dermal contact
- Acute exposure to COC *via* ingestion of snow (as requested by members of the TAC)

Derivation of PRGs and PTCs

- Under the residential scenario, risk calculations were derived using community-based exposure point concentrations
- Unrealistic to assume that receptors will move randomly throughout the community
- Derived Preliminary Remediation Goals (PRGs) or Provisional Trigger Concentrations (PTCs) for residential soils
- PRGs and PTCs can then be used to determine on a property-by-property basis, which properties contain concentrations that have the potential to cause unacceptable risks

Presentation 3 - Mr. Adam Safruk

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Independent Expert Review Panel

Human Health Risk Assessment Flin Flon, Manitoba and Creighton, Saskatchewan

•**Exposure Assessment**

June 23rd and 24th, 2009

Exposure Assessment

- Derivation of Exposure Point Concentrations (EPCs)
- Multi-media exposure estimates
- Spreadsheet-based deterministic calculations
- Additional assessment using IEUBK model for lead

Derivation of EPCs

- EPCs represent the upper 95% confidence interval on the arithmetic mean of the data set (95% UCLM) calculated using ProUCL software
- ProUCL tests the data set for normality, lognormality, and gamma distributions using parametric and non-parametric methods to calculate a conservative and stable 95% UCLM
- All data that were less than the method detection limit (MDL) were conservatively assumed to be present at the MDL value
- For some environmental media, EPCs are community-specific (*i.e.*, outdoor soil, indoor dust, air, and drinking water)

Derivation of EPCs con't

Outdoor Soil

- For the residential exposure scenario, EPCs are based on the results of the residential soil study completed by Jacques Whitford
- Data was divided into each of the 4 communities of interest
- Samples from the 0 to 5 cm profile
- Commercial scenario used maximum concentration from the Manitoba Conservation and Jacques Whitford soils study
- Use of maximum concentrations reduced the need to derive PRGs for commercial land use

Derivation of EPCs con't

Indoor Dust

- Residential indoor dust sampling program provided measured concentrations of COC in indoor dust at 15 locations in West Flin Flon, 14 locations in East Flin Flon, 8 locations in Creighton, and 1 location in Channing
- Regression equations were derived to relate indoor dust concentrations to outdoor soil concentrations based on co-located samples
- Statistically significant relationship between indoor dust and outdoor soil was found for arsenic, cadmium, copper, mercury, and selenium
- Regression equations and outdoor soil EPCs were used to derive indoor dust EPCs for these COC
- Measured indoor dust data was used to derive EPC for lead

Derivation of EPCs con't

Ambient Air

- Based on data collected from air monitors within different communities
- Data from a one-year period during 2007-2008
- Concentrations of COC associated with the PM10 component
- Assumed indoor air was equal to outdoor air

Derivation of EPCs con't

Drinking Water

- Drinking water for Flin Flon and Creighton are taken from separate surface water sources
- EPCs were derived for Flin Flon communities and Creighton based on data from an ongoing monitoring program completed by HBMS and a supplementary study by Jacques Whitford (2008)
- Samples were collected from post-treatment locations including residents and schools

Derivation of EPCs con't

Home Garden Vegetables

- EPCs are based on the study completed by Manitoba Conservation (2002)
- Included 5 different vegetables from 9 locations in Flin Flon
- Concentrations were from washed samples only
- Grouped into "root vegetable" and "other vegetable" categories to correspond with recommended ingestion rates recommended for Canadian populations
- Assumed residents in each of the 4 COI would consume home garden vegetables with the same COC concentrations

Derivation of EPCs con't

Local Fish

- Sampling plan was developed based on the results of a local food survey
- Stantec and Manitoba Conservation collected samples in 2008 from over 160 fish collected from 11 separate lakes
- Selection of EPCs was guided based on the most commonly consumed fish species reported within the local survey
- Although a small portion of the population may consume organs, EPCs were based on muscle samples only

Derivation of EPCs con't

Wild Game

- Measured data was not available, therefore, concentrations in tissue were predicted for two large mammals (*i.e.*, moose and deer) and two upland birds (*i.e.*, grouse and mallard)
- Conservatively assumed all wild game foraged within 15 km of the HBMS complex
- Used COC concentrations measured in forest soils, surface water, sediments, and vegetation

Derivation of EPCs con't

Other Media

- EPCs for wild blueberries were based on measured samples collected from 13 locations at varying distances and direction from the smelter complex in August 2008
- EPCs for surface water were the maximum concentration measured in 12 lakes sampled in summer 2008
- EPCs for snow were based on the results of a sampling program completed in March 2008 from 12 locations in Flin Flon and Creighton

Derivation of EPCs con't

Typical Background and Market Basket

- Based on concentrations in environmental media from areas not influenced by a direct source of emissions
- Used data from as close to the study area as possible when available
- Concentrations in market basket food items were taken from databases from Canadian sources

Exposure Estimates

- Point-estimate exposures were predicted for receptors for each of the 5 age classes as well as the lifetime composite
- Exposures were predicted on a per body weight basis (µg/kg/day)
- The contribution to internal dose *via* the inhalation route was combined with oral and dermal exposure to produce a total exposure for comparison to the RfD or cancer slope factor
- For COC where the inhalation exposure limit is based on effects on the respiratory tissues, the air EPC was used to represent exposure for an inhalation-related exposure and risk

Exposure Estimates con't

Ingestion of Outdoor Soil and Indoor Dust

- Based on recommendations from the TAC and Health Canada, it was assumed that during summer (8 months), 100% of the daily soil/dust ingested was outdoor soil, and during winter (4 months), 100% was indoor dust
- Based on recommendations from the TAC and Health Canada, only the results of the single-phase bioaccessibility analysis for arsenic and lead in outdoor soil were utilized in the HHRA
- Assumed 100% oral bioavailability for cadmium, copper, mercury, and selenium in outdoor soil, and all COC in indoor dust

Exposure Estimates con't

Consumption of Local Foods

- Based on the results of the local food survey, respondents generally indicated that receptors of all age categories consume wild blueberries, local fish, and local wild game throughout the year
- Consumption rates assumed for wild blueberries were elevated but not considered to be unrealistic based on survey response and the abundance of local blueberries
- Consumption rates for local fish and wild game were based on the frequency of consumption reported by survey respondents and a typical adult serving size of 8 oz (adjusted by body weight for younger receptors)

IEUBK Model for Lead in Children

- Computer simulation model derived by the U.S. EPA to predict childhood lead exposure and retention
- Has the ability to quantify the relationship between environmental lead concentrations in different media (*e.g.*, soil, water, air and food) to blood lead levels in children of different ages (0 to 84 months)
- Estimates of a likely distribution of blood lead concentrations are centered on the geometric mean concentration and can be used to calculate the probability that blood lead concentrations in children will exceed an acceptable level
- Standard tool for assessing lead in risk assessments

IEUBK Model for Lead in Children con't

- As recommended by the U.S. EPA, peer-reviewed exposure parameters and risk characterization assumptions set as default values within the IEUBK model were maintained unless scientifically defensible site-specific values were available
- This allowed for the prediction of blood lead concentrations that were reflective of the unique characteristics of the distribution of lead throughout the Flin Flon-Creighton area, while still relying on the widely accepted approaches used within the IEUBK model

IEUBK Model for Lead in Children con't

- Site-specific parameters used within the IEUBK model were:
  - Concentrations in outdoor soil, indoor dust, drinking water, and outdoor air
  - Site-specific bioavailability in outdoor soil
  - Contribution of local foods to total dietary intake (added to the recommended dietary intake from market basket foods)
- All other default receptor characteristics, bioavailabilities, and exposure assumptions were maintained despite discrepancies with values used in the spreadsheet-based exposure assessment

Presentation 4 - Mr. Elliot Sigal

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Independent Expert Review Panel

Human Health Risk Assessment Flin Flon, Manitoba and Creighton, Saskatchewan

- **Hazard Assessment**

June 23rd and 24th, 2009

Development of Toxicity Reference Values (TRVs)

- TRVs were obtained from regulatory agencies including the Health Canada, U.S. EPA, U.S. Agency for Toxic Substances and Disease Registry (ATSDR), California Environmental Protection Agency Office of Environmental Health Hazard Assessment (Cal EPA OEHHA), the Ontario Ministry of the Environment (MOE), U.S. Centers for Disease Control (CDC), the European Union (EU), and the World Health Organization (WHO)
- A detailed toxicological assessment was conducted for each COC, involving identification of mechanism of action and relevant toxic endpoints, and determination of receptor- and route-specific toxicological criteria

TRVs (continued)

- Toxicological profiles based primarily on secondary information sources, such as ATSDR toxicological profiles and other detailed regulatory agency reviews, and supplemented with recent relevant scientific literature
- TRVs selected for acute (1-hour and 24-hour) and chronic (lifetime) duration exposures
- Cancer and non-cancer endpoints selected as appropriate
- Chronic TRVs well established and accepted for use in Risk Assessment; acute TRVs less established

Arsenic

- Comprehensive toxicity profiles for arsenic have been established by the following regulatory agencies: U.S. EPA (1984); U.S. EPA IRIS (1993; 1998); Cal EPA (1999; 2000); WHO (2000); RIVM (2001); ATSDR (2007); and, Health Canada (2004a,b; 2006; 2008).

Chronic-Cancer (Non-threshold) Effects					
Oral	0.0015 (µg/kg-day)$^{-1}$	SFo	skin cancer	Tseng et al., 1968; Tseng, 1977	EPA, 1998
Inhalation	0.0043 (µg/m^3)$^{-1}$ 0.015 (µg/kg-day)$^{-1}$	IUR* SFi	lung cancer	Higgins et al, 1982; Enterline and Marsh, 1982; Brown and , 1983a,b; Lee-Feldstein, 1983	EPA, 1998
Chronic-Non-cancer (Threshold) Effects					
Oral	0.3 µg/kg-day	RfD	hyperpigmentation, keratosis, and possible vascular complications	Tseng et al., 1968; Tseng, 1977	EPA, 1993

Arsenic Slope Factors

- Oral slope factor based on Tiawanese data sets
- Many problems with this data set and the slope factor derived from this data
  - Exposure to arsenic impacted drinking water
  - Nutritional status of exposed population poor compared to NA population
  - Concomitant exposure (food preparation, locally grown foods)
- US EPA update on-going
- Complicates assessment since background risk often exceed acceptable risk level

Cadmium

- Cadmium has been reviewed by Health Canada (1986; 2004a; 2008); JECFA (1989); WHO (1990; 1992; 2000; 2005); U.S. EPA IRIS (1992; 1994); ATSDR (1999); Cal EPA (2000, 2005a,b); European Commission (2000); RIVM (2001); and, MOE (2006, 2008).

Chronic-Cancer (Non-threshold) Effects					
Inhalation	0.0036 (µg/m^3)$^{-1}$	Unit Risk	Detection of lung tumours	Takenaka et al., 1983; Oldiges et al., 1984	Health , 2004a; Health , 2008
Chronic-Non-cancer (Threshold) Effects					
Oral	1 µg/kg/day	pTDI	Renal tubular dysfunction	WHO 2001; 2004 based upon Friberg et al., 1971	Health , 2008

Copper

- Copper has been reviewed by Health Canada (1990; 1992; 2004a,b; 2008); U.S. EPA IRIS (1991); Cal EPA (1999); IOM (2000); RIVM (2001); ATSDR (2004); and, MOE (2008).

Chronic-Non-cancer (Threshold) Effects					
Oral	90 (0-6 mo) 90 (7 mo-4 yrs) 100 (5-11yrs) 100 (12-19 yrs) 100 (20+) µg/kg-day	UL	Hepatoxicity, gastrointestinal effects	Pratt et al., 1985; O'Donohue, et al., 1993	Health , 2008
Inhalation	1.0 µg/m^3	TCA	Respiratory and immunological effects	Not Provided	RIVM, 2001

Lead

- Comprehensive toxicity profiles for lead have been established by the following regulatory agencies: JECFA (1987); MOE (1994; 2006; 2007; 2008); WHO (1995; 2000); CCME (1999); RIVM (2001); Cal EPA (2001; 2005a,b); ATSDR (2007) and U.S. EPA (2007a,b; 2008)

Chronic-Non-cancer (Threshold) Effects					
Oral	3.6 µg/kg/day	pTDI	Behavioural effects and learning disabilities in children	Based upon the pTWI derived by: Ziegler et al., 1978 ; Ryu et al., 1983; JECFA, 1987	Health , 2004a; 2008
Inhalation (3 month averaging time)	0.15 ug/m3	AAQC	Protective of children and other at-risk populations	--	EPA, 2008

The Lead TRV and Blood Lead Level

- The current community intervention level for lead is 10 µg/dL
- There is a large volume of literature which suggests that health effects in children and adults occur at concentrations lower than this level (*e.g.*, Lanphear *et al.* 2005; Shih *et al.*, 2006; Bellinger, 2008)
- The 10 µg/dL value is currently under review by Health Canada, and it is anticipated that Health Canada will reduce the intervention level in the near future
- The Toxicity Reference Value will also likely be lowered in the near future
- While it is anticipated that the level will be lowered, it not possible to confirm what the final accepted intervention level/TRV will be at this time

Mercury

- Comprehensive toxicity profiles for mercury have been previously published by JECFA (1972); WHO (1978; 1990; 1991; 2000; 2004), Health Canada (1979; 2007a,b; 2008); U.S. EPA IRIS (1995a,b; 2001); ATSDR (1999); Cal EPA (1999); CCME (1999); OEHHA (1999); RIVM (2001); and, U.S. EPA (2001).

Mercury TRVs

ELEMENTAL MERCURY					
Chronic-Non-cancer (Threshold) Effects					
Inhalation	0.06 (µg/m³)	TC (provisional) (mercury vapour)	Neurobehavioral effects	Ngim *et al.*, 1992	Health , 2008
INORGANIC MERCURY					
Chronic-Non-cancer (Threshold) Effects					
Oral	0.3 (µg/kg-day)	(inorganic, ionic)	Kidney effects	Druet *et al.*, 1978; Bernaudin *et al.*, 1981; Andres, 1984	Health , 2004a, 2008
Inhalation	1.0 (µg/m³)	Annual average guideline (inorganic vapour)	Objective tremor, renal tubular effects and non-specific symptoms	WHO, 1991; Cardenas *et al.*, 1993	WHO, 2000
METHYL MERCURY					
Chronic-Non-cancer (Threshold) Effects					
Oral	0.47 (µg/kg-day) (general adult population) and 0.20 (µg/kg-day) (women of childbearing age, children (<12 yrs)	pTDI	Neurotoxicity and neurodevelopmental toxicity	Grandjean *et al.*, 1997; Feeley and Lo, 1998	Health , 2007a, 2008

Selenium

- Selenium has been reviewed by U.S. EPA IRIS (1991); Health Canada (1992; 2008); IOM (2000); Cal EPA (2001); ATSDR (2003); and, MOE (2005; 2008).

Chronic-Non-cancer (Threshold) Effects					
Oral	<6mo: 5.5; 7mo-4yrs: 6.2; 5-11yrs: 8.3; 12-19yrs: 6.2, 20+(70.7kg): 5.7 g/kg/day	UL	Selenosis	Shearer and Hadjimarkos, 1975; Yang and Zhou, 1994	Health , 2008
Inhalation	20 µg/m³		Clinical selenosis	Yang *et al.*, 1989a	Cal EPA, 2001

Bioaccessibility Study

- Soil samples collected as part of the Residential Soil Study were utilized for the bioaccessibility study.
- The study was conducted by Dr. Ken Reimer at Royal Military College/Queens University
- An *in vitro* physiologically based extraction test (PBET) methodology was utilized
- *in vitro* extraction consisted of a two-phase protocol (*i.e.*, simulating both gastric and intestinal phases of absorption) designed to simulate a human receptor
- Protocol developed and vetted through technical committee
- Range finding studies were conducted to consider factors such as particle size and dilution ratio
- ONLY gastric phase results for lead and arsenic were utilized in the risk assessment

Presentation 5 - Mr. Elliot Sigal

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Independent Expert Review Panel

Human Health Risk Assessment Flin Flon, Manitoba and Creighton, Saskatchewan

•**Results, Risk Characterization, Uncertainties**

June 23rd and 24th, 2009

HHRA Considerations

- Six chemicals of concern (COC) (arsenic, cadmium, copper, lead, mercury, and selenium);
- Four communities of interest (COI) (East Flin Flon, West Flin Flon, Creighton, and Channing) as well as a Typical Background scenario;
- Five receptor age classes (*i.e.*, infant, toddler, child, teen and adult) and a composite lifetime receptor;
- Receptor characteristics characterized by upper bound or *Reasonable Maximum Exposure* (RME) estimates;
- Inhalation, oral and dermal exposure pathways;
- Short-term (acute) and long-term (chronic) residential exposure scenarios, and long-term outdoor worker scenario; and,
- A large database of site-specific media concentrations characterized by RME concentrations represented by the 95% upper confidence limit on the mean (95% UCLM).

HHRA Scenarios

- Acute inhalation (1 hour and 24 hour durations);
- Acute oral (short-term soil and snow exposure events);
- Residential chronic multiple pathways (*i.e.*, inhalation, oral and dermal exposures); and,
- Commercial/industrial (outdoor worker) chronic multiple pathways (*i.e.*, inhalation, oral and dermal exposures).

Acute Inhalation Risk Estimates

COC	Exposure Duration	Air Concentration (µg/m³)	TRV (µg/m³)	CR_{acute}
West Flin Flon				
Arsenic	1 hr	0.74	0.19	**3.9**
	24 hrs	0.74	0.3	**2.5**
Cadmium	24 hrs	0.66	0.25	**2.6**
Copper	1 hr	4.2	100	0.043
	24 hrs	4.2	50	0.085
Lead	24 hrs	2.4	0.5	**4.8**
Mercury (inorganic) (inorganic)	1 hr	0.056[b]	1.8	0.031
	24 hrs	0.056[b]	2.0	0.028
Selenium	24 hrs	0.27[b]	10	0.027

Frequency of 24 hour Exceedances

COI	Arsenic	Cadmium	Copper	Lead	Mercury	Selenium
West Flin Flon	9 of 210	6 of 210	0 of 210	26 of 210	ND	ND
Flon and Channing	0 of 57	1 of 57	0 of 57	0 of 57	0 of 57	0 of 57
Creighton	0 of 59	0 of 59	0 of 59	0 of 59	0 of 59	0 of 59

Hazard Quotients for Acute Soil Exposure for Toddlers

COC	Max Soil Concentration (µg/g)	Estimated Exposure (µg/kg-day)	TRV (µg/kg-day) (oral exposure limit)	HQ
West Flin Flon				
Arsenic	237	5.8	5.0	**1.2**
Cadmium	71	1.7	4.1	0.42
Copper	7,810	190	10	**19**
Lead	820	20	NA	NA
Mercury	971	24	7.0 (inorganic)	**3.4**
Selenium	286	6.9	NA	NA

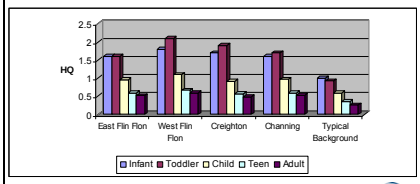
Hazard Quotients for Acute Snow Exposure for Toddlers

COC	Snow Concentration (µg/L)		Estimated Exposure (µg/kg-day)		TRV (µg/kg-day) (oral exposure limit)	HQ_{acute}	
	MAX	95% UCLM	MAX	95% UCLM		MAX	95% UCLM
Arsenic	147	96	0.15	0.10	5	0.03	0.02
Cadmium	183	113	0.18	0.11	4.1	0.05	0.03
Copper	4940	3000	5.0	3.0	10	0.50	0.30
Lead	732	483	0.74	0.49	3.6	0.21	0.14
Mercury	1.8	1	0.0018	0.0010	7	0.0003	0.0001
Selenium	2.8	2	0.0028	0.0020	6.2	0.0005	0.0003

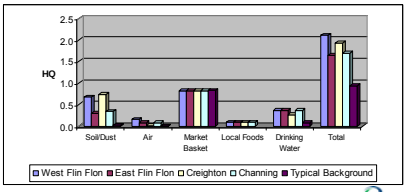
Summary of Assessment Results for Non-Cancer Endpoints (Toddler)

COC	West Flin Flon	East Flin Flon	Creighton	Channing	Typical Background
Arsenic	**1.6**	**2.1**	**1.9**	**1.7**	0.93
Cadmium	0.81	0.88	0.79	0.81	0.58
Copper	0.84	0.93	0.68	0.83	0.58
Lead	0.51	0.64	0.51	0.51	0.21
Inorganic mercury	0.44	**1.9**	0.46	0.41	0.31
Methyl mercury	**1.8**	**1.9**	**1.8**	**1.8**	0.42
Selenium	0.90	0.92	0.90	0.90	0.70

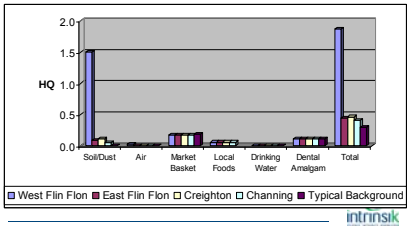
Predicted Hazard Quotients as a Result of Exposure to Arsenic



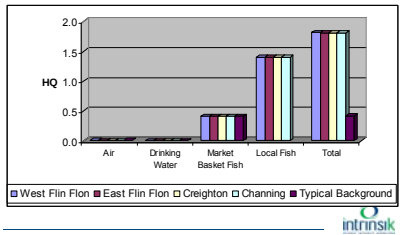
Pathway-Specific Hazard Quotients for Toddlers as a Result of Exposure to Arsenic



Pathway-Specific Hazard Quotients for a Toddler as a Result of Exposure to Inorganic Mercury



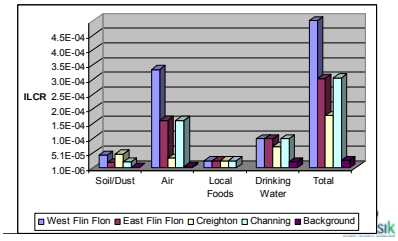
Pathway-Specific Hazard Quotients for a Toddler as a Result of Exposure to Methyl Mercury



Summary of Assessment Results for Carcinogenic Endpoints (Lifetime Receptor)

COC	*West Flin Flon*	*East Flin Flon*	*Creighton*	*Channing*
Arsenic	**3.0E-04**	**5.0E-04**	**1.8E-04**	**3.1E-04**
Cadmium	**2.5E-04**	**6.9E-04**	**4.5E-05**	**2.5E-04**

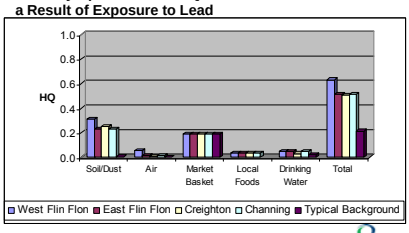
ILCRs for a Lifetime Composite - Arsenic



Lead

- The assessment of lead exposure was completed using the excel-based HHRA exposure model used for all COC as well as the U.S. EPA IEUBK model
- Blood lead monitoring data is the most effective indication of recent exposure levels to lead from all sources
- Since blood lead data for the Flin Flon area was not available, the IEUBK model was used as an additional tool as it is widely acknowledged as a very effective method of assessing risks to young children from exposure to lead

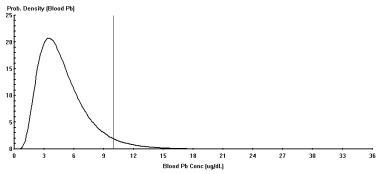
Pathway-Specific Hazard Quotients for a Toddler as a Result of Exposure to Lead



Blood Lead Concentrations Predicted by the IEUBK Model (µg/dL)

Age Categories (years)	*Flon*	*Flon*	*Creighton*	*Channing*	*Typical Background*
0 to 1	4.8	4.1	4.1	4.1	0.8
1 to 2	5.6	4.8	4.7	4.8	0.7
2 to 3	5.2	4.4	4.4	4.4	0.6
3 to 4	5.0	4.3	4.2	4.3	0.6
4 to 5	4.2	3.6	3.5	3.6	0.5
5 to 6	3.6	3.1	3.0	3.1	0.5
6 to 7	3.2	2.8	2.7	2.8	0.5
Geometric Mean	4.5	3.8	3.8	3.8	0.66
95th Percentile BLL	9.7	8.2	8.2	8.2	1.4
Probability of exceeding a BLL of 5 µg/dL	41%	29%	28%	29%	0%
Probability of exceeding a BLL of 10 µg/dL	4.4%	2.1%	1.9%	2.1%	0%

Probability Density of Blood Lead Concentrations (µg/dL) in West Flin Flon Children Relative to a Blood Lead Level of 10 µg/dL



Provisional Trigger Concentrations (PTCs) and Soil Risk Management Levels (SRML) for Lead (µg/g)

IEUBK Model Derived PTC	*HHRA Model Derived PTC*	*EPA SRML*	
		Play area	*Bare soil Remainder*
370 (protective of a 5% probability of exceeding a BLL of 10 µg/dL)	**570** (protective of a blood lead level of 10 µg/dL)	400	1,200

Sensitivity Analysis for the Assessment of Risks to a West Flin Flon Toddler Exposed to Lead as Assessed Using the HHRA Model

Variable	*Value Used in HHRA*	*Adjusted Value*	*% Change in Risk Level*
Indoor Air Concentration	100% of Measured Outdoor Air Concentration	30% of Measured Outdoor Air Concentration	5.5% decrease in total HQ
Outdoor Air Concentration	0.34 µg/m³	0.17 µg/m³ (50% reduction)	4.2% decrease in total HQ
Local Fish Consumption Rate	1.5 local fish meals per week	3 local fish meals per week	0.79% increase in total HQ
Local Wild Game Consumption Rate	1 local wild game meal per week	2 local wild game meals per week	0.31% increase in total HQ
Soil Ingestion Rate	80 mg/day for toddler	100 mg/day for toddler	12% increase in total HQ
Bioaccessibility in Soil	58% (single-phase analysis)	12% (two-phase analysis)	24% decrease in total HQ
Bioaccessibility in Soil	58% (single-phase analysis)	100%	22% increase in total HQ

Presentation 6 - Mr. Elliot Sigal

Independent Expert Review Panel

Human Health Risk Assessment Flin Flon, Manitoba and Creighton, Saskatchewan

- **Conclusions and Recommendations**

June 23rd and 24th, 2009

Community Health

- The Community Health Status Assessment of Flin Flon and Creighton, completed by public health officials from Manitoba Health and Healthy Living and the Saskatchewan Ministry of Health found that the overall health status of the Flin Flon area population is as good if not better than the provincial averages for most of the indicators studied.

Arsenic

- Both non-cancer and cancer numerical risk estimates for arsenic exceeded standard acceptable benchmarks for both oral/dermal and inhalation exposures
  - Market basket foods were the main contributor to non-cancer arsenic-related risks
  - For carcinogenic risks, the inhalation of ambient air was the most significant source of risk
  - The consumption of drinking water and exposure to soil/dust also contributed significantly to both cancer and non-cancer risk estimates

Arsenic Weight of Evidence

- The most powerful and persuasive piece of evidence in other weight-of-evidence evaluations was the urinary arsenic study results
- These provide a comparison urinary arsenic levels of an impacted community with those of a control community
- It is recommended that a Urinary Arsenic study be undertaken for the Flin Flon area, focusing on homes in West Flin Flon and Creighton in which a significant number of homes included within the residential soil sampling program contained concentrations of arsenic in excess of the PTC

Cadmium

- Oral/dermal and non-cancer inhalation exposures were within acceptable levels
- Concentrations of cadmium in ambient air may have the potential to result in an unacceptable increase in the risk of developing lung cancer
- ILCR for Cadmium are quite elevated and consideration should be given to future reductions in smelter-related emissions, which would have a direct and immediate effect on reducing inhalation-related exposure and risks

Copper

- The estimated HQ values associated with copper exposures were less than 1.0 under all exposure and receptor scenarios
- Overall, the health risks to Flin Flon-area residents associated with exposure to copper are within risk levels deemed to be acceptable by Health Canada and the CCME
- Risk management measure or soil remediation are not considered to be necessary to prevent or reduce human health risks associated with exposure to copper in residential soils

Lead

- Both the HHRA model and the IEUBK model predicted average lead related exposure within acceptable levels
- A significant number of residential properties in West Flin Flon, as well as a few in East Flin Flon and Creighton, contain concentrations of lead in outdoor soil that are above the residential PTC protective of a 5% probability of exceeding a BLL of 10 µg/dL
- The health benchmarks for lead (10 µg/dL and 3.6 ug/kg/day) are currently under review by regulatory agencies such as Health Canada, and it is anticipated that these benchmarks will be reduced in the near future

Lead Follow-up

- Since a significant percentage of homes in the Flin Flon area contain soil concentrations in excess of those predicted to be protective of a 5% probability of exceeding a BLL of 10 µg/dL, the completion of a blood lead survey would be an appropriate method of reducing uncertainty in the exposure assessment and provide a more accurate measure of the levels occurring in young children in these communities
- The blood lead survey should primarily focus on children up to the age of 7 years as they are the most sensitive to the impaired neurobehavioral development associated with elevated BLLs

Mercury-Inorganic

- With the exception of toddlers in West Flin Flon, all exposures were below the acceptable levels indicating that adverse effects associated with elevated exposure to inorganic mercury are not anticipated
- Exposure of the toddler to inorganic mercury, and subsequent risk levels, are dominated by contributions from soil
- Biomonitoring would be an appropriate option to more accurately assess inorganic mercury exposure to individuals in West Flin Flon
- For long-term, low level exposures to inorganic mercury, measurement through urine samples is the preferred medium

Mercury-Methyl

- Exposure to methyl mercury was assumed to occur *via* the consumption of fish from market basket foods, consumption of local fish, consumption of drinking water, and inhalation of ambient air
- the primary route of exposure for all receptors other than the infant was the consumption of local fish
- Based on the assessment results, it is recommended that fish consumption advisories be considered, particularly for sensitive receptors

Selenium

- The estimated HQ values associated with selenium exposures were less than 1.0 under all exposure and receptor scenarios
- Overall, the health risks to Flin Flon-area residents associated with exposure to selenium are expected to be similar to those observed in other parts of Canada and are within risk levels deemed to be acceptable by Health Canada and the CCME.

Number of Properties with Concentrations of Arsenic in Outdoor Soil in Excess of the PTC of 80 µg/g

	Flon	*Flon*	*Creighton*	*Channing*	*Total*
# of Properties Sampled	77	66	30	10	183
# of Properties >80 µg/g	26 (34%)	0	10 (33%)	0	36 (20%)

Number of Properties with Concentrations of Cadmium in Outdoor Soil in Excess of the Residential Soil PRG of 58 µg/g

	Flon	*Flon*	*Creighton*	*Channing*	*Total*
# of Properties Sampled	77	66	30	10	183
# of Properties >80 µg/g	2 (2.6%)	0	0	0	2 (1.1%)

Number of Properties with Concentrations of Lead in Outdoor Soil that Exceed a Residential PTC of 370 µg/g

	Flon	*Flon*	*Creighton*	*Channing*	*Total*
# of Properties Sampled	77	66	30	10	183
# of Properties >375 µg/g	31 (40%)	2 (3%)	4 (13%)	0	37 (20%)

Number of Properties with Concentrations of Copper in Outdoor Soil in Excess of the Residential Soil PRG of 5,000 µg/g

	West Flin Flon	East Flin Flon	Creighton	Channing	Total
# of Properties Sampled	77	66	30	10	183
# of Properties >5,500 µg/g	5 (6.5%)	0	0	0	5 (2.7%)

Number of Properties with Concentrations of Mercury in Outdoor Soil in Excess of the Residential PTC of 56 µg/g

	West Flin Flon	East Flin Flon	Creighton	Channing	Total
# of Properties Sampled	77	66	30	10	183
# of Properties >46 µg/g	44 (57%)	0	0	0	44 (24%)

Number of Properties with Concentrations of Selenium in Outdoor Soil in Excess of the Residential PRG of 170 µg/g

	West Flin Flon	East Flin Flon	Creighton	Channing	Total
# of Properties Sampled	77	66	30	10	183
# of Properties >400 µg/g	1 (1.3%)	0	0	0	1 (0.55%)

Recommendations

- The HHRA provides a recommendation for a comprehensive biomonitoring program to evaluate environmental contaminant exposure in children (under 16) in Flin Flon, Manitoba and Creighton, Saskatchewan
- The study will examine urinary arsenic; blood lead; and, urinary inorganic mercury levels.
- A study of this nature is recommended for the fall of 2009, with results likely available in early 2010.

Objectives

- Broadly, the assessment of biomarkers of exposure will help refine and validate the HHRA's exposure estimates of COCs associated with elevated levels of risk.
  - What is the current level of internal exposure to arsenic, lead, and inorganic mercury in the child population residing in or about the contaminated areas of Flin Flon?
  - Do Flin Flon Area child residents have higher arsenic, lead, and/or inorganic mercury levels than residents living in other parts of Canada?
  - Based upon the current scientific literature, what are the health risks from the levels of arsenic and inorganic mercury in urine and lead in blood found in children in the Flin Flon Area?
  - What personal factors are associated with the level of measured internal exposure of children in Flin Flon Area (e.g., place of residence, place of work, level of COC in soil, age, gender, diet, personal habits, etc.)?

Appendix D

Independent Expert Review Panel (IERP)
Human Health Risk Assessment for Flin Flon, Manitoba and Creighton, Saskatchewan

June 23-24, 2009

Additional Handouts

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ESG Bioaccessibility Report ASD2008c

Site: Flin Flon
Analyst: Jessica Harris, Kim House (ESG)
Extraction Date: July 25 2008
Analysis Date: August 12, 22 2008
Report Date: September 03 2008
Method: PBET method, liquid to solid ratio 100:1 and <250 µm soil particle size

Results

Sample Name	Bioaccessible Hg (mg/kg)	Total Hg (mg/kg)	% Bioaccessible Hg (%)	Bioaccessible As (mg/kg)	Total As (mg/kg)	% Bioaccessible As (%)	Bioaccessible Cd (mg/kg)	Total Cd (mg/kg)	% Bioaccessible Cd (%)	Bioaccessible Cu (mg/kg)	Total Cu (mg/kg)	% Bioaccessible Cu (%)
PHASE 1												
FF410 P1	0.037	3.4	1.1	4.4	36	12	8.9	14	62	266	630	47
FF4088 P1*	0.028	4.0	0.70	<5.0	14	<36	7.4	9.3	80	112	284	39
CS111F P1	0.038	4.8	0.78	6.4	36	18	6.9	13	54	209	720	29
FF408F P1	0.019	4.8	0.40	<5.0	17	<29	7.8	15	50	84	540	17
FF221F P1	0.040	5.0	0.80	4.9	10	48	4.9	4.0	124	182	335	54
FF404F P1	0.036	5.5	0.66	<5.0	17	<29	14	21	68	108	660	16
FF313F P1	0.031	6.1	0.52	4.3	17	25	11	11	103	211	630	34
FF3128 P1	0.020	6.6	0.30	<5.0	14	<36	20	19	104	404	989	41
PHASE 2												
FF410 P2	0.19	3.4	5.4	7.1	36	20	6.1	14	43	206	630	33
FF4088 P2*	0.052	4.0	1.3	<5.0	14	<36	5.1	9.3	55	110	284	41
CS111F P2	0.25	4.8	5.3	11	36	31	5.1	13	40	194	720	25
FF408F P2	0.038	4.8	0.79	<5.0	17	<29	5.0	15	33	110	540	20
FF221F P2	0.21	5.0	4.2	7.2	10	70	2.9	4.0	73	171	335	51
FF404F P2	0.046	5.5	0.83	5.1	17	30	4.0	21	20	119	660	18
FF313F P2	0.059	6.1	1.0	5.4	17	32	5.9	11	53	185	630	30
FF3128 P2	0.078	6.6	1.2	<5.0	14	<36	8.0	19	42	288	989	29

Sample Name	Bioaccessible Pb (mg/kg)	Total Pb (mg/kg)	% Bioaccessible Pb (%)	Bioaccessible Se (mg/kg)	Total Se (mg/kg)	% Bioaccessible Se (%)	Bioaccessible Zn (mg/kg)	Total Zn (mg/kg)	% Bioaccessible Zn (%)
PHASE 1									
FF410 P1	100	183	55	<10	3.0	RND	1355	3350	40
FF4088 P1*	73	95	81	<10	1.9	RND	905	1210	59
CS111F P1	84	154	49	<10	4.2	RND	349	478	51
FF408F P1	87	193	45	<10	3.1	RND	1304	3000	44
FF221F P1	31	49	75	<10	1.8	RND	331	464	68
FF404F P1	53	136	39	<10	3.0	RND	725	1190	61
FF313F P1	196	111	177	<10	3.6	RND	2228	3350	67
FF3128 P1	118	164	72	<10	3.6	RND	1367	1640	83
PHASE 2									
FF410 P2	11	183	6.1	<10	3.0	RND	544	3350	16
FF4088 P2*	24	95	27	<10	1.9	RND	450	1210	31
CS111F P2	15	154	10	<10	4.2	RND	96	478	20
FF408F P2	16	193	8.8	<10	3.1	RND	620	3000	21
FF221F P2	4.8	49	11	<10	1.8	RND	127	464	28
FF404F P2	5.1	136	3.7	<10	3.0	RND	116	1190	10
FF313F P2	22	111	19	<10	3.6	RND	576	3350	17
FF3128 P2	16	164	9.8	<10	3.6	RND	405	1640	25

* average of duplicate pair
RND = total initial concentration is less than the detection limit of bioaccessible fraction, therefore % bioaccessibility cannot be calculated

ESG Bioaccessibility Report A8000095

Site: Flin Flon
Analyst: Jessica Harris, Kim House (ESG)
Extraction Date: July 23 2008
Analysis Date: August 12, 22 2008
Report Date: August 26 2008
Method: PBET method, liquid to solid ratio 100:1 and <250 µm soil particle size

Results

Sample Name	Bioaccessible Hg (mg/kg)	Total Hg (mg/kg)	% Bioaccessible Hg (%)	Bioaccessible As (mg/kg)	Total As (mg/kg)	% Bioaccessible As (%)	Bioaccessible Cd (mg/kg)	Total Cd (mg/kg)	% Bioaccessible Cd (%)	Bioaccessible Cu (mg/kg)	Total Cu (mg/kg)	% Bioaccessible Cu (%)
PHASE 1												
FF402F P1	0.024	0.31	7.8	<5.0	8.9	<56	2.0	2.9	70	51	118	43
FF408G P1*	0.0081	0.46	1.8	<5.0	7.8	<66	2.0	2.3	87	21	95	22
FF402G P1	0.013	0.55	2.4	6.5	16	42	5.0	5.3	96	59	195	30
CR112G P1	0.036	0.60	6.1	5.1	19	27	5.1	3.8	132	47	141	33
FF304B P1	0.011	1.2	0.94	<5.0	13	<38	7.2	7.9	91	141	369	38
FF407B P1	0.0094	1.2	0.77	<5.0	12	<40	3.1	3.9	78	69	165	42
FF402B P1	0.014	2.4	0.60	5.1	25	20	12	13	96	189	468	39
CR114F P1	0.030	2.6	1.2	5.6	34	16	23	28	84	199	1290	16
PHASE 2												
FF402F P2	0.018	0.31	5.7	<5.0	8.9	<56	<2.0	2.9	<69	46	118	41
FF408G P2*	0.013	0.46	2.9	7.1	7.8	93	<2.0	2.3	<87	86	95	89
FF402G P2	0.020	0.55	3.7	7.4	16	48	2.1	5.3	40	71	195	37
CR112G P2	0.065	0.60	11	6.5	19	35	<2.0	3.8	<53	55	141	39
FF304B P2	0.068	1.2	5.6	<5.0	13	<38	2.0	7.9	25	124	369	32
FF407B P2	0.061	1.2	5.0	<5.0	12	<40	2.1	3.9	54	70	165	43
FF402B P2	0.15	2.4	4.1	7.9	25	31	6.4	13	50	155	468	33
CR114F P2	0.076	2.6	2.9	6.1	34	18	6.1	28	22	194	1290	15

Sample Name	Bioaccessible Pb (mg/kg)	Total Pb (mg/kg)	% Bioaccessible Pb (%)	Bioaccessible Se (mg/kg)	Total Se (mg/kg)	% Bioaccessible Se (%)	Bioaccessible Zn (mg/kg)	Total Zn (mg/kg)	% Bioaccessible Zn (%)
PHASE 1									
FF402F P1	48	56	85	<10	0.3	BND	245	515	48
FF408G P1*	21	31	68	<10	0.7	BND	233	436	53
FF402G P1	61	107	57	<10	1.1	BND	698	1030	68
CR112G P1	1048	1490	70	<10	5.8	BND	348	350	99
FF304B P1	51	56	92	<10	1.4	BND	371	567	65
FF407B P1	63	74	85	<10	0.8	BND	309	655	47
FF402B P1	122	226	54	<10	2.3	BND	2073	2960	70
CR114F P1	77	200	38	<10	5.6	BND	1219	1270	96
PHASE 2									
FF402F P2	7.3	56	13	<10	0.3	BND	89	515	19
FF408G P2*	23	31	72	<10	0.7	BND	<100	436	<23
FF402G P2	8.4	107	8.0	<10	1.1	BND	264	1030	26
CR112G P2	131	1490	8.8	<10	5.8	BND	<100	350	<29
FF304B P2	5.9	56	11	<10	1.4	BND	<100	567	<18
FF407B P2	9.5	74	13	<10	0.8	BND	112	655	17
FF402B P2	20	226	8.9	<10	2.3	BND	844	2960	29
CR114F P2	7.1	200	3.6	<10	5.6	BND	173	1270	14

*average of duplicate pair reported
BND = total initial concentration is less than the detection limit of bioaccessible fraction, therefore % bioaccessibility cannot be calculated

ESG Bioaccessibility Report: ASD09004

Site: Flin Flon
Analyst: Jessica Harris, Kim House (ESG)
Extraction Date: July 28 2008
Analysis Date: August 18, Sept 02, 2008
Report Date: September 03 2008 AMENDED REPORT
Method: PBET method <250 µm soil particle size 100:1

Results

Sample Name	Bioaccessible Hg (mg·kg)	Total Hg (mg·kg)	% Bioaccessible Hg (%)	Bioaccessible As (mg·kg)	Total As (mg·kg)	% Bioaccessible As (%)	Bioaccessible Cd (mg·kg)	Total Cd (mg·kg)	% Bioaccessible Cd (%)	Bioaccessible Cu (mg·kg)	Total Cu (mg·kg)	% Bioaccessible Cu (%)
PHASE 1												
CS104F P1	<0.2	38.6	<0.5	27	314	8.6	16	20.5	78	546	1270	43
FF201F P1	<0.2	45	<0.4	<5.0	18.9	<26	5.8	7.22	81	232	640	36
FF206B P1	<0.2	100	<0.2	23	49.2	46	20	21	97	893	1610	54
FF210B P1	<0.2	101	<0.2	19	88.5	21	20	26.8	76	905	2120	43
FF225B P1 *	<0.2	90.0	<0.2	28	77.9	36	21	24	89	752	1830	41
FF236F P1	<0.2	127	<0.2	27	104	26	49	57.9	85	1614	3770	43
FF256F P1	<0.2	42	<0.5	27	139	19	28	35.1	73	936	2310	41
FF276F P1	<0.2	71	<0.3	15	138	12	15	25.4	64	895	2920	30
PHASE 2												
CS104F P2	1.8	38.6	4.7	46	314	15	3.9	20.5	19	482	1270	38
FF201F P2	0.71	45	1.6	<5.0	18.9	<26	2.9	7.22	41	186	640	29
FF206B P2	4.2	100	4.2	24	49.2	48	11	21	52	845	1810	46
FF210B P2	3.9	101	3.8	35	88.5	40	15	26.8	59	700	2120	33
FF225B P2 *	3.0	90	3.2	26	77.9	34	14	24	57	704	1830	38
FF236F P2	3.1	127	2.4	28	104	27	23	57.9	40	1135	3770	30
FF256F P2	1.3	42	3.0	29	139	21	15	35.1	41	893	2310	38
FF276F P2	3.0	71	4.2	23	138	17	11	25.4	42	767	2920	26

Sample Name	Bioaccessible Pb (mg·kg)	Total Pb (mg·kg)	% Bioaccessible Pb (%)	Bioaccessible Se (mg·kg)	Total Se (mg·kg)	% Bioaccessible Se (%)	Bioaccessible Zn (mg·kg)	Total Zn (mg·kg)	% Bioaccessible Zn (%)
PHASE 1									
CS104F P1	101	394	26	<10	20.4	<49	743	1690	44
FF201F P1	47	81.5	57	<10	10.2	<98	995	1280	78
FF206B P1	135	209	65	<10	32.4	<31	3256	4410	74
FF210B P1	266	420	63	<10	26.5	<38	2491	4260	58
FF225B P1 *	211	274	77	<10	28.4	<35	3053	4520	68
FF236F P1	467	638	64	<10	43.3	<23	6035	8790	69
FF256F P1	259	478	56	<10	30.5	<33	2977	7210	56
FF276F P1	219	481	47	<10	25.2	<40	2328	5675	41
PHASE 2									
CS104F P2	31	394	7.9	<10	20.4	<49	180	1690	9.5
FF201F P2	4.9	81.5	6.0	<10	10.2	<98	315	1280	25
FF206B P2	18	209	8.5	<10	32.4	<31	1478	4410	34
FF210B P2	31	420	7.5	<10	26.5	<38	1560	4260	40
FF225B P2 *	39	274	13	<10	28.4	<35	1215	4520	27
FF236F P2	41	638	6.4	<10	43.3	<23	2226	8790	25
FF256F P2	22	478	4.6	<10	30.5	<33	1739	7210	24
FF276F P2	28	481	6.1	<10	25.2	<40	1194	5675	21

* Average of the duplicate is reported

ESG Bioaccessibility Report ASCBRSs

Site: Flin Flon
Analyst: Jessica Harris, Kim House (ESG)
Extraction Date: July 30 2008
Analysis Date: August 14 -15, Sept 02, 2008
Report Date: September 03 2008 **AMENDED REPORT**
Method: PBET method <250 µm soil particle size 100:1

Results

Sample Name	Bioaccessible Hg (mg/kg)	Total Hg (mg/kg)	% Bioaccessible Hg (%)	Bioaccessible As (mg/kg)	Total As (mg/kg)	% Bioaccessible As (%)	Bioaccessible Cd (mg/kg)	Total Cd (mg/kg)	% Bioaccessible Cd (%)	Bioaccessible Cu (mg/kg)	Total Cu (mg/kg)	% Bioaccessible Cu (%)
PHASE 1												
CS108F P1	<0.2	30.5	<0.66	12	97.3	13	14	20.1	68	560	1200	47
CS125F P1	<0.2	20.7	<0.97	19	153	13	26	31.8	83	844	1800	36
CS126F P1	<0.2	19.8	<1.0	29	220	13	6.8	12.2	56	835	1330	48
FP232F P1	0.74	25	3.0	13	33.9	37	14	12.2	111	840	1290	65
FP254F P1	<0.2	22	<0.91	48	140	34	32	46.7	68	954	2190	44
FP341F P1	<0.2	32	<0.63	7.3	34.2	21	24	30.5	80	622	1770	35
FP343F P1 *	<0.2	21.4	<0.93	16	49.7	33	23	30.4	77	739	1640	45
FP344F P1	<0.2	17.9	<1.1	6.2	29	21	25	30.9	81	905	1950	46
PHASE 2												
CS108F P2	0.98	30.5	3.1	14	97.3	14	8.1	20.1	40	328	1200	27
CS125F P2	0.50	20.7	2.4	26	153	17	12	31.8	37	391	1800	22
CS126F P2	1.8	19.8	9.0	50	220	23	3.1	12.2	26	432	1330	33
FP232F P2	0.74	25	3.0	14	33.9	41	7.2	12.2	59	510	1290	40
FP254F P2	0.76	22	3.5	68	140	48	21	46.7	45	679	2190	31
FP341F P2	0.26	32	0.82	9.5	34.2	28	12	30.5	38	449	1770	25
FP343F P2 *	0.32	21.4	1.5	17	49.7	35	14	30.4	45	474	1640	29
FP344F P2	<0.2	17.9	<1.1	7.1	29	24	12	30.9	39	501	1950	26

Sample Name	Bioaccessible Pb (mg/kg)	Total Pb (mg/kg)	% Bioaccessible Pb (%)	Bioaccessible Se (mg/kg)	Total Se (mg/kg)	% Bioaccessible Se (%)	Bioaccessible Zn (mg/kg)	Total Zn (mg/kg)	% Bioaccessible Zn (%)
PHASE 1									
CS108F P1	165	287	57	<10	13	<77	1514	2812	54
CS125F P1	219	456	48	<10	15	<67	2123	4660	45
CS126F P1	201	392	51	<10	16.3	<61	389	1800	24
FP232F P1	112	121	93	<10	7.6	BND	1301	1520	87
FP254F P1	558	820	68	<10	18.1	<55	5983	9010	61
FP341F P1	302	357	56	<10	11.6	<86	4491	5650	79
FP343F P1 *	350	552	63	<10	10.4	<96	6355	8245	77
FP344F P1	275	380	72	<10	11	<91	3532	5400	65
PHASE 2									
CS108F P2	39	287	13	<10	13	<77	729	2812	26
CS125F P2	25	456	5.6	<10	15	<67	987	4660	21
CS126F P2	32	392	8.3	<10	16.3	<61	130	1800	8.2
FP232F P2	19	121	15	<10	7.6	BND	584	1520	38
FP254F P2	67	820	8.1	<10	18.1	<55	2274	9010	24
FP341F P2	39	357	8.3	<10	11.6	<86	1346	5650	24
FP343F P2 *	56	552	10	<10	10.4	<96	2868	8245	32
FP344F P2	21	380	5.6	<10	11	<91	1200	5400	22

* Average of the duplicate is reported
BND = total initial concentration is less than the detection limit of bioaccessable fraction, therefore % bioaccessibility cannot be calculated

[illegible] Bioaccessibility Report: A[illegible]

Site: Flin Flon
Analyst: Jessica Harris, Kim House (ERG)
Extraction Date: July 31 2008
Analysis Date: August 21, September 03 2008
Report Date: September 03 2008
Method: PBET method <250 µm soil particle size 100:1

Results

Sample Name	Bioaccessible Hg (mg/kg)	Total Hg (mg/kg)	% Bioaccessible Hg (%)	Bioaccessible As (mg/kg)	Total As (mg/kg)	% Bioaccessible As (%)	Bioaccessible Cd (mg/kg)	Total Cd (mg/kg)	% Bioaccessible Cd (%)	Bioaccessible Cu (mg/kg)	Total Cu (mg/kg)	% Bioaccessible Cu (%)
PHASE 1												
DB1048-P1	<0.2	8.9	<2.2	35	265	13	21	22	96	668	1380	48
DB1038-P1	<0.2	10.5	<1.9	8.5	60.4	14	18	20	91	434	960	45
PFSDP-P1	<0.2	7.4	<2.7	<5.0	17.4	<29	22	21	105	560	1100	51
PFSDB-P1*	<0.2	7.2	<2.8	<5.0	18	<28	13	15	88	408	1320	40
PFSDP-P1	<0.2	10.2	<2.0	<5.0	20	<25	27	27	97	547	1360	40
PFSDP-P1	<0.2	9.60	<2.0	8.5	37	24	17	20	85	501	970	52
PFADP-P1	<0.2	7	<2.9	8.9	31	22	16	21	76	355	700	36
PHASE 2												
DB1048-P2	0.19	8.9	2.2	39	265	14	6.8	22	31	514	1380	37
DB1038-P2	<0.2	10.5	<1.9	17	60.4	27	8.3	20	42	376	960	39
PFSDP-P2	<0.2	7.4	<2.7	<5.0	17.4	<29	6.6	21	32	368	1100	33
PFSDB-P2*	0.21	7.2	2.9	<5.0	18	<28	3.7	15	25	292	1320	29
PFSDP-P2	<0.2	10.2	<2.0	<5.0	20	<25	9.1	27	33	360	1360	29
PFSDP-P2	<0.2	9.60	<2.0	5.9	37	22	6.9	20	35	395	970	40
PFADP-P2	<0.2	7	<2.9	8.1	31.4	26	7.8	21	37	344	700	35

Sample Name	Bioaccessible Pb (mg/kg)	Total Pb (mg/kg)	% Bioaccessible Pb (%)	Bioaccessible Se (mg/kg)	Total Se (mg/kg)	% Bioaccessible Se (%)	Bioaccessible Zn (mg/kg)	Total Zn (mg/kg)	% Bioaccessible Zn (%)
PHASE 1									
DB1048-P1	153	365	42	<10	15	<67	1290	1400	98
DB1038-P1	165	249	66	<10	5.5	#ND	550	707	78
PFSDP-P1	389	304	128	<10	5.1	#ND	3535	4160	85
PFSDB-P1*	307	221	94	<10	8.0	#ND	2521	3760	66
PFSDP-P1	250	275	91	<10	8.8	#ND	4473	5460	81
PFSDP-P1	263	269	103	<10	8.3	#ND	2208	3260	67
PFADP-P1	203	266	76	<10	4.0	#ND	3258	5660	58
PHASE 2									
DB1048-P2	19	365	5.1	<10	15	<67	186	1400	10
DB1038-P2	31	249	13	<10	5.5	#ND	127	707	25
PFSDP-P2	17	304	5.6	<10	5.1	#ND	569	4160	14
PFSDB-P2*	17	221	7.7	<10	8.0	#ND	371	3760	9.8
PFSDP-P2	17	275	6.2	<10	8.8	#ND	1025	5460	19
PFSDP-P2	31	269	11	<10	8.3	#ND	502	3260	15
PFADP-P2	18	266	6.8	<10	4.0	#ND	1214	5660	21

*Average of duplicate pair
#ND = total initial concentration is less than the detection limit of bioaccessible fraction, therefore % bioaccessibility cannot be calculated

ESG Bioaccessibility Report ASD0808a

Site: Flin Flon
Analyst: Jessica Harris, Kim House (ESG)
Extraction Date: July 21 2008
Analysis Date: August 14 -15 2008
Report Date: August 21 2008
Method: PBET method <250 µm soil particle size 100:1

Results

Sample Name	Bioaccessible Hg (mg/kg)	Total Hg (mg/kg)	% Bioaccessible Hg (%)	Bioaccessible As (mg/kg)	Total As (mg/kg)	% Bioaccessible As (%)	Bioaccessible Cd (mg/kg)	Total Cd (mg/kg)	% Bioaccessible Cd (%)	Bioaccessible Cu (mg/kg)	Total Cu (mg/kg)	% Bioaccessible Cu (%)
PHASE 1												
FF202F P1	0.634	168	0.38	16.1	51	30	22.7	26	86	1221	3290	37
FF206F P1	<0.2	184	<0.11	16.3	42	39	15.4	16	99	914	1690	49
FF206B P1*	<0.2	132	<0.15	33.5	97	34	17.8	20	90	1084	1790	61
FF229F P1	<0.2	300	<0.06	21.2	67	32	28.0	31	84	788	2630	31
FF231F P1	0.366	535	0.068	76.2	124	61	67.5	51	132	2222	3970	56
FF235B P1	<0.2	370	<0.05	85.9	189	51	38.3	50	77	1605	3650	42
FF271F P1	0.191	330	0.058	22.2	99	22	46.3	50	93	2623	5530	48
FF277F P1	<0.2	183	<0.11	127	222	57	30.8	37	84	1456	2940	50
PHASE 2												
FF202F P2	3.80	168	2.1	14.2	51	28	11.2	26	42	868	3290	26
FF206F P2	4.98	184	2.7	14.7	41.7	36	8.80	16	56	915	1690	33
FF206B P2*	6.11	132	4.6	31.9	97.3	33	18.2	20	92	777	1790	43
FF229F P2	4.59	300	1.5	19.7	67	29	10.0	31	32	444	2630	18
FF231F P2	8.93	535	1.7	82.9	124	61	23.8	51	46	1893	3970	43
FF235B P2	2.85	370	0.77	90.3	189	36	18.4	50	33	1338	3650	35
FF271F P2	7.58	330	2.3	22.9	98.9	23	22.4	50	45	1856	5530	30
FF277F P2	5.44	183	3.0	110	222	50	12.0	37	33	1022	2940	35

Sample Name	Bioaccessible Pb (mg/kg)	Total Pb (mg/kg)	% Bioaccessible Pb (%)	Bioaccessible Se (mg/kg)	Total Se (mg/kg)	% Bioaccessible Se (%)	Bioaccessible Zn (mg/kg)	Total Zn (mg/kg)	% Bioaccessible Zn (%)
PHASE 1									
FF202F P1	238	335	71	<10	42	<24	2395	4010	60
FF206F P1	153	199	77	<10	41	<24	2260	3270	69
FF206B P1*	223	281	80	<10	54	<19	3189	4350	73
FF229F P1	142	353	40	<10	76	<13	2699	4550	59
FF231F P1	481	599	80	<10	124	<8.1	13503	14900	91
FF235B P1	635	746	85	<10	98	<10	10114	14900	68
FF271F P1	468	726	64	<10	95	<11	5270	9220	57
FF277F P1	494	640	77	<10	66	<15	8610	14200	61
PHASE 2									
FF202F P2	33	335	10	<10	42	<24	952	4010	24
FF206F P2	22	199	11	<10	41	<24	1079	3270	33
FF206B P2*	36	281	13	<10	54	<19	1429	4350	33
FF229F P2	18	353	5.0	<10	76	<13	794	4550	17
FF231F P2	130	599	22	<10	124	<8.1	4855	14900	33
FF235B P2	95	746	13	<10	98	<10	2711	14900	18
FF271F P2	53	726	7.2	<10	95	<11	2184	9220	23
FF277F P2	107	640	17	<10	66	<15	3371	14200	24

* Average of the duplicate is reported

Appendix E

Independent Expert Review Panel (IERP)
Human Health Risk Assessment for Flin Flon, Manitoba and Creighton, Saskatchewan

June 23-24, 2009

List of Additional Studies.

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