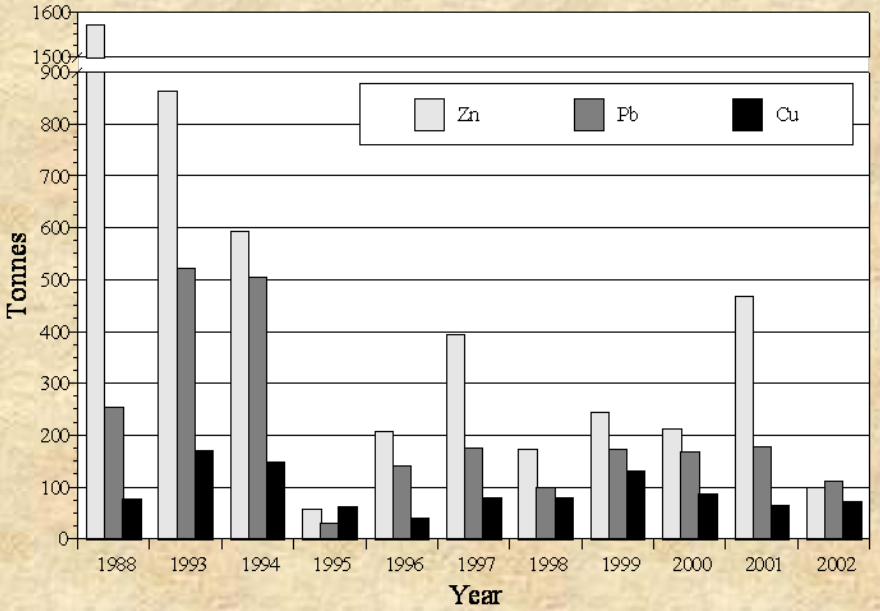
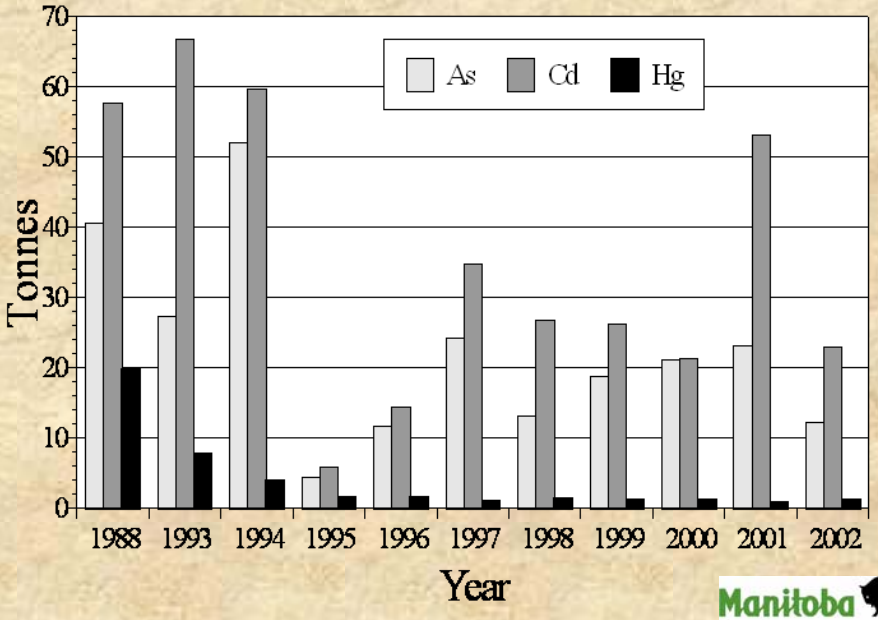
Concentrations of Metals and Other Elements in Surface Soils of Flin Flon, MB and Creighton, SK

Habitat Management and Ecosystem Monitoring Section,
Wildlife and Ecosystem Protection Branch,
Manitoba Conservation
October 15, 2007

Introduction & Background

- HBM&S has operated a base metal mining and smelting facility in Flin Flon since 1930.
- Produces Cu and Zn, with lesser amounts of Cd, Pb, Au, Ag, (latter are transported off site for refining).
- Historically, atmospheric emissions from the smelter consisted mainly of SO_2, Zn, Pb, and Fe.
- Smaller amounts of Cu, Cd, Hg, and As, and trace amounts of Se have also been present in the emissions.





Introduction & Background

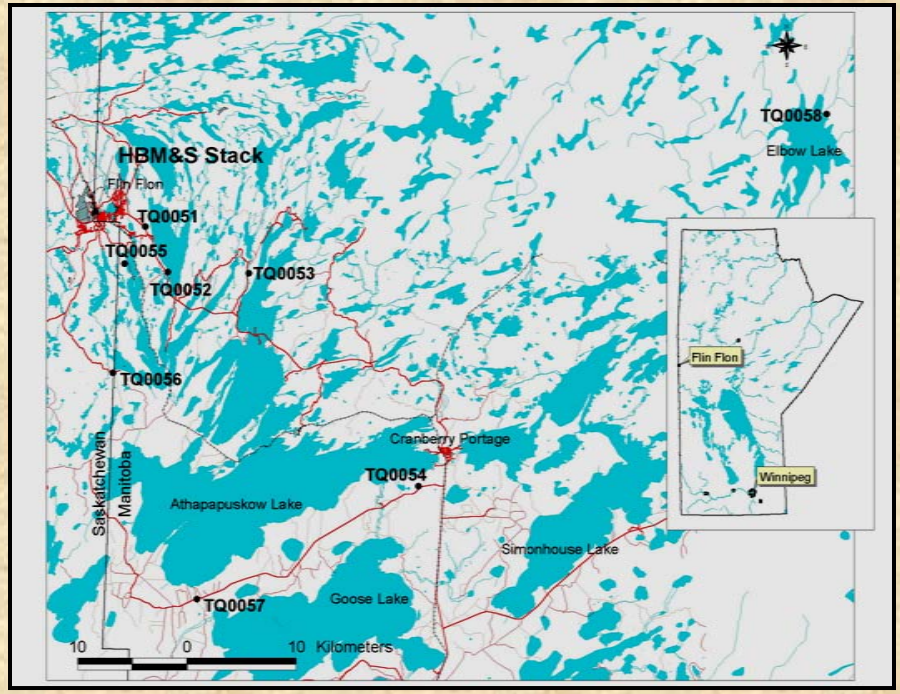
- Prior to 1974 atmospheric emissions from the smelter were discharged via a series of smoke stacks ranging from 30 to 69 m tall.

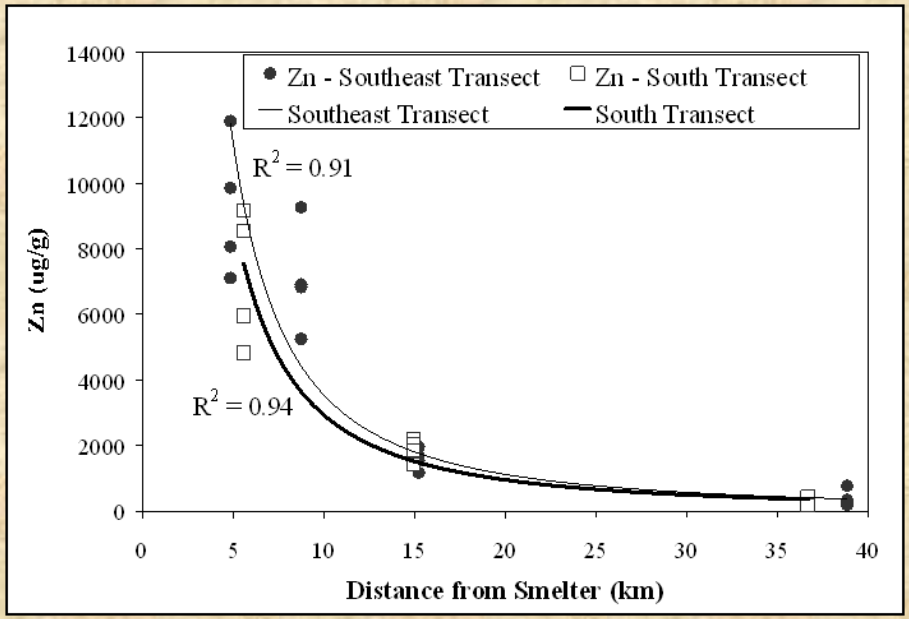
- Since 1974 atmospheric emissions from the smelter have been primarily discharged via a 251 m stack
- Dust from the complex site and the tailings management area is also a source of deposition.

Manitoba
Conservation

Introduction & Background

- Government monitoring programs began in the late 1970s to investigate the environmental effects of atmospheric emissions on the surrounding forest.
- Monitoring at permanent sites in the boreal forest near Flin Flon revealed elevated levels of As, Cd, Cu, Pb, Hg, Se, and Zn in snow, soils, and vegetation.





- Concentrations decrease rapidly with distance away from the smelter and are near background at approximately 35 – 40 km. This is variable depending on the element.

Manitoba Conservation

Introduction & Background

- Data exists for drinking water and air quality in Flin Flon and Creighton, but concentrations of metals and other elements in the soils is limited.
  - Environment – Pb in sod/soil on boulevards in 1983
  - Pip & HBM&S – garden studies in 1990s
  - Conservation – garden study 2002

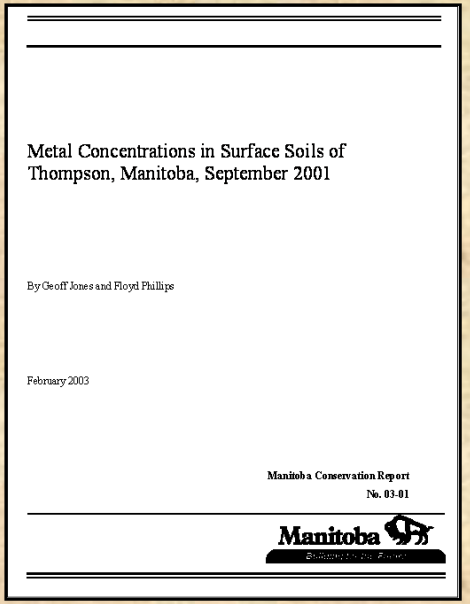
- These studies, along with the long-term forest monitoring, suggest that levels might be elevated across the entire community.

- Conservation decided this required further investigation and designed a systematic soil survey for the area.

Manitoba
Conservation

Survey Objectives and Preliminary Activities

- Three principle objectives:
  1. Determine the concentrations of metals and other elements in surface soil in the community of Flin Flon,
  2. Map the distribution of metals and other elements using GIS,
  3. Provide a preliminary assessment of the results by comparing the Flin Flon concentration data to existing CCME environmental quality guidelines.



Metal Concentrations in Surface Soils of Thompson, Manitoba, September 2001

By Geoff Jones and Floyd Phillips

February 2003

Manitoba Conservation Report
No. 03-01

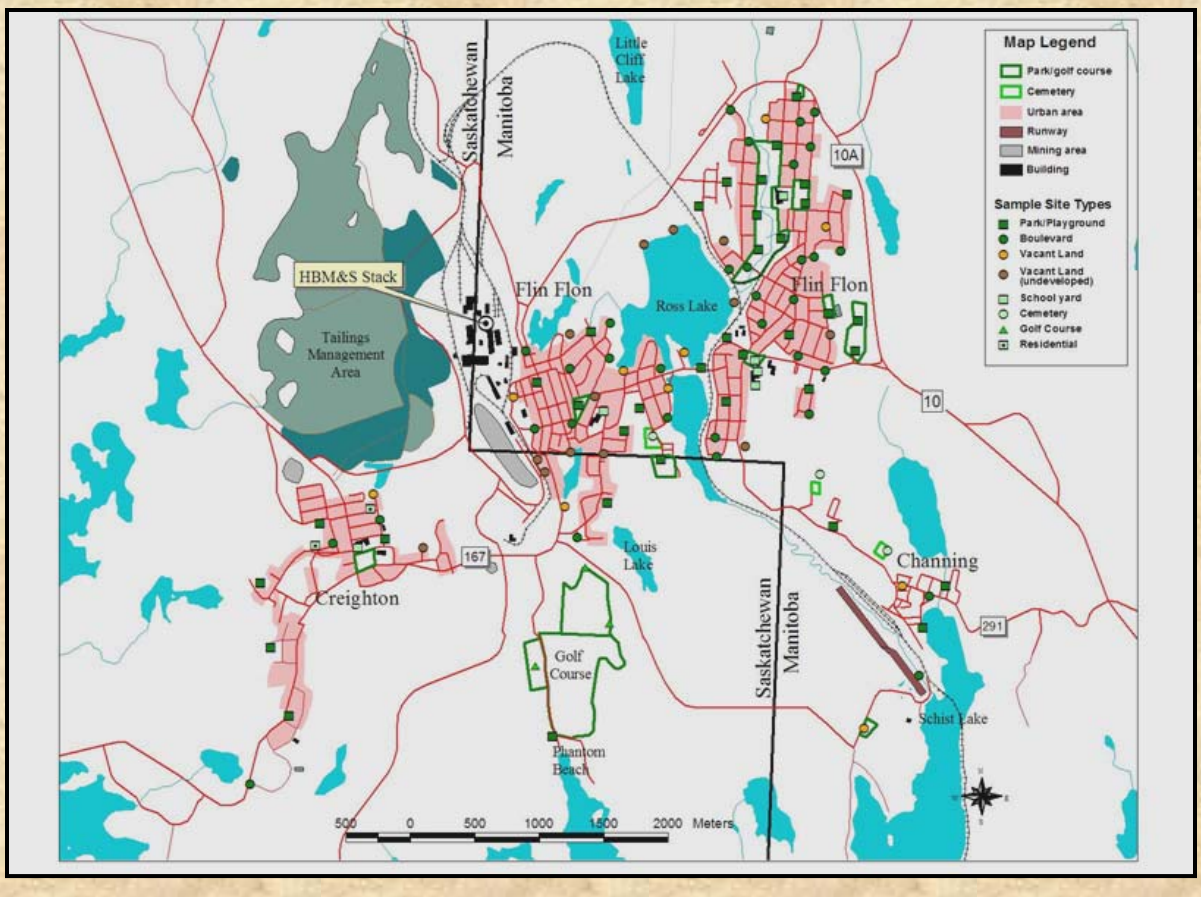
Manitoba

- Survey based on similar work done in Thompson in 2001.
- Plan submitted to and approved by Executive (in Conservation) in June/July 2006.
- Study design and objectives sent out for 30 day comment period.
- Creighton added to study area after consultation with SK.
- Study conducted August 20 – 24, 2006.

Manitoba
Conservation

Site Selection

- Total of 108 sites selected for sampling (93 in Flin Flon, 13 in Creighton, 2 controls).
- Main criteria for selection – publicly accessible areas such as playgrounds, parks, school yards, vacant lots, and grassed boulevards.



Site Type	Number of Sites
park/playground (includes controls)	38
boulevard	34
vacant land (undeveloped)	13
vacant land	10
school yard	6
cemetery	2
golf course	3
residence (Creighton only)	2

Soil Sampling

- Sampled top 2.5 cm of soil.
- Each sample was a composite of 20 soil cores extracted at approximately 5 cm intervals along a metre stick.

- Metre stick was placed at 3 random locations at each site to collect 3 replicate samples per site.

Soil Analysis

- Soil sampling tool was cleaned and rinsed with distilled water between sites.
- Cores were placed in labeled plastic bags and kept cool prior to laboratory analysis.
- Vegetation cover and soil texture recorded for each site.
- Each site was geo-referenced and photographed.

Variables Analyzed

Aluminum – Al	Nickel - Ni
Antimony - Sb	Phosphorus - P
Arsenic - As	Potassium - K
Barium - Ba	Selenium - Se
Beryllium - Be	Silver - Ag
Boron - B	Sodium – Na
Cadmium - Cd	Strontium - Sr
Calcium - Ca	Sulphur - S
Chromium - Cr	Thallium - Tl
Cobalt - Co	Tin - Sn
Copper - Cu	Titanium - Ti
Iron - Fe	Vanadium - V
Lead - Pb	Zinc - Zn
Magnesium - Mg	Zirconium - Zr
Manganese - Mn	pH
Mercury - Hg	Bulk Density
Molybdenum - Mo	

CCME Soil Quality Guidelines

- Mean concentration was calculated for each site and compared to CCME soil quality guidelines

- CCME guidelines are:
  - ➢scientifically defensible limits developed to protect environmental and/or human health for four land use categories:

    (1) agricultural, (2) residential/parkland, (3) commercial, and (4) industrial**.**
  - ➢exist for As, Ba, Cd, Cr, Cu, Pb, Hg, Ni, Se, Tl, V, and Zn.
  - ➢generally are **very conservative** (significant safety margins).
  - ➢are for guidance only and site-specific conditions have to be considered when applying guidelines and criteria.

- Separate guidelines are derived to for protection of the environment and for the protection of human health. Overall guideline is the lower of the two.
- Because the survey is concentrated in an urban area, guidelines for the protection of human health for residential/parkland land use will be used to assess the results.

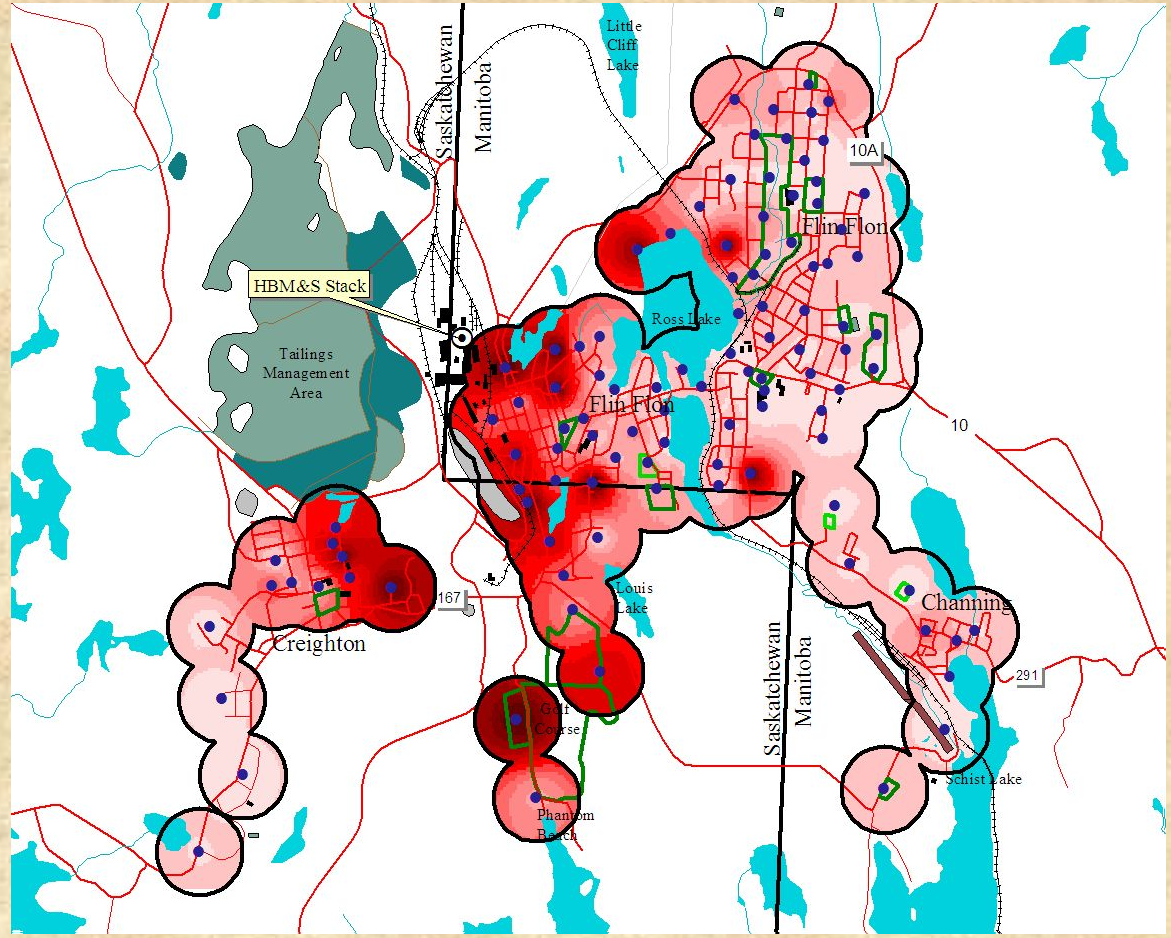
Distribution Maps

- Used computer programs:
  Arcview GIS
  Spatial Analyst

- Interpolation of existing data to create a surface grid showing projected distribution of elements across study area.

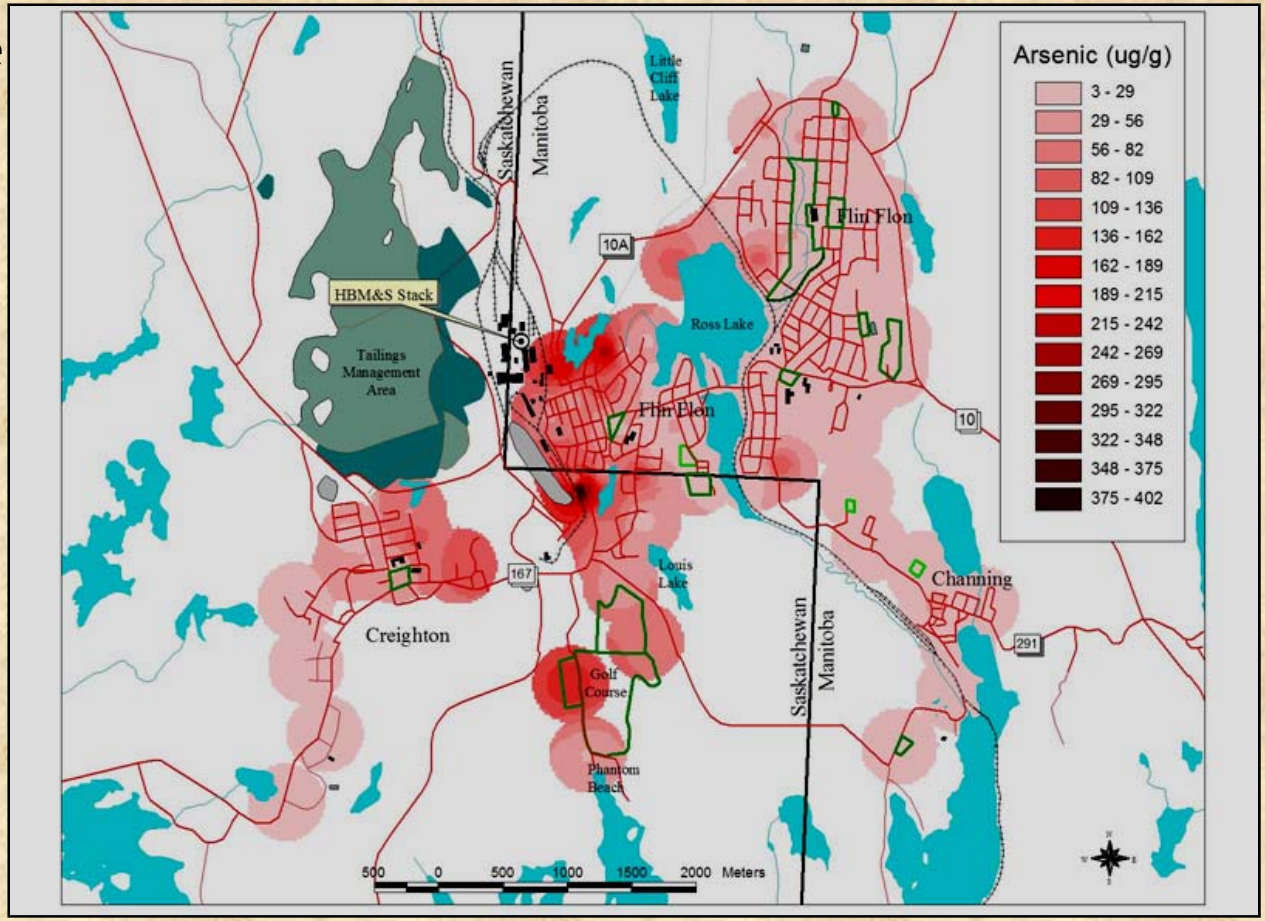
- More points the greater the confidence in the surface grid – accuracy is lower around points along edge of distribution and around isolated points.

- Used 300 m buffer (arbitrary) to extract surface grid covering Flin Flon and Creighton.



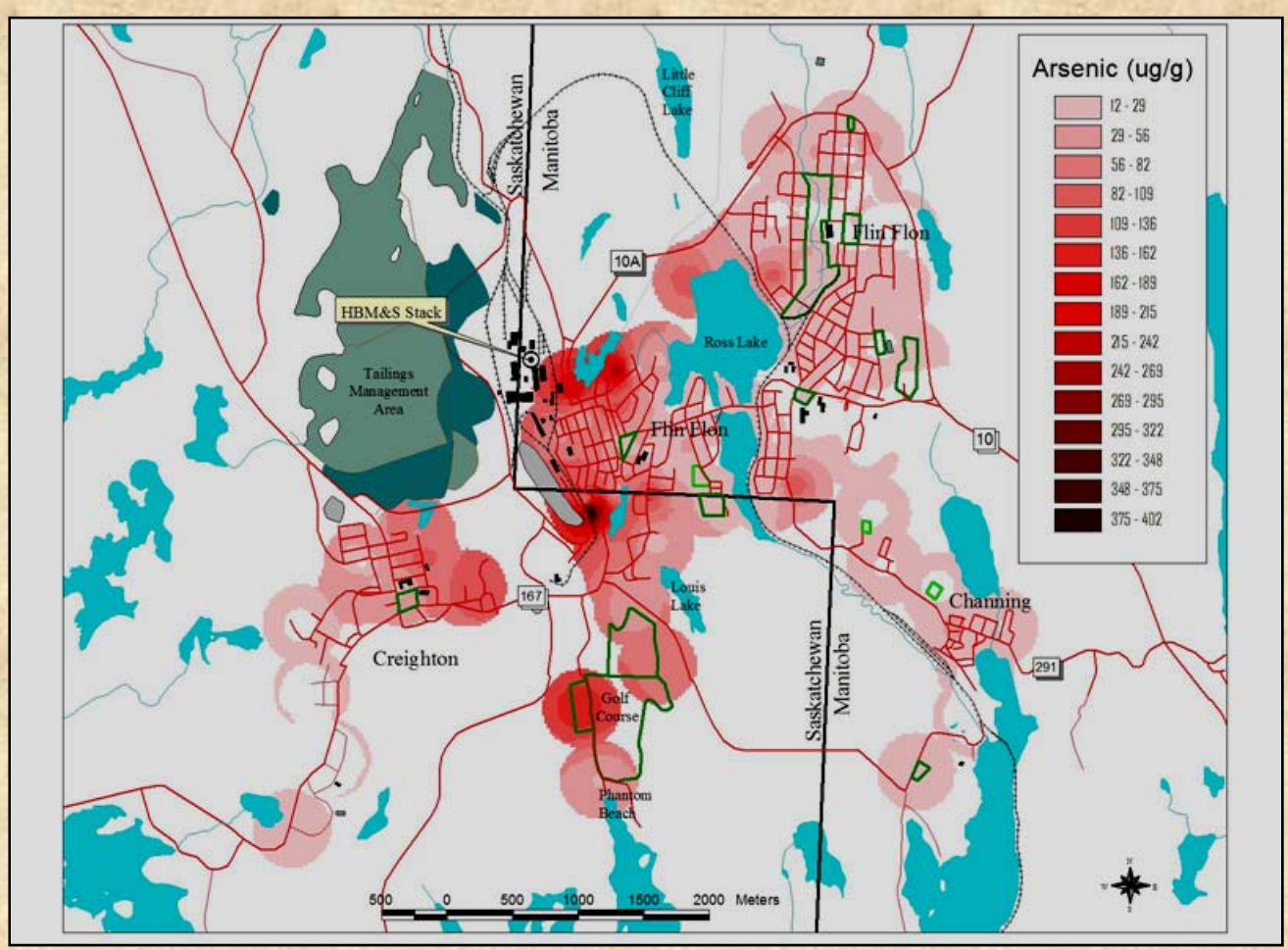
Results – Arsenic

- Mean concentrations of As ranged from 2.5 µg/g to 407 µg/g, and all except one were higher than Cranberry Portage site.
- Highest concentrations in down town area of Flin Flon and at undeveloped sites closest to and NE of the smelter.
- Very high concentrations with great deal of variability at a few sites.
- Variability between sites was high - due to differences in distance and direction to smelter, topography, soil origin, vegetation cover, organic matter, and duration of exposure.



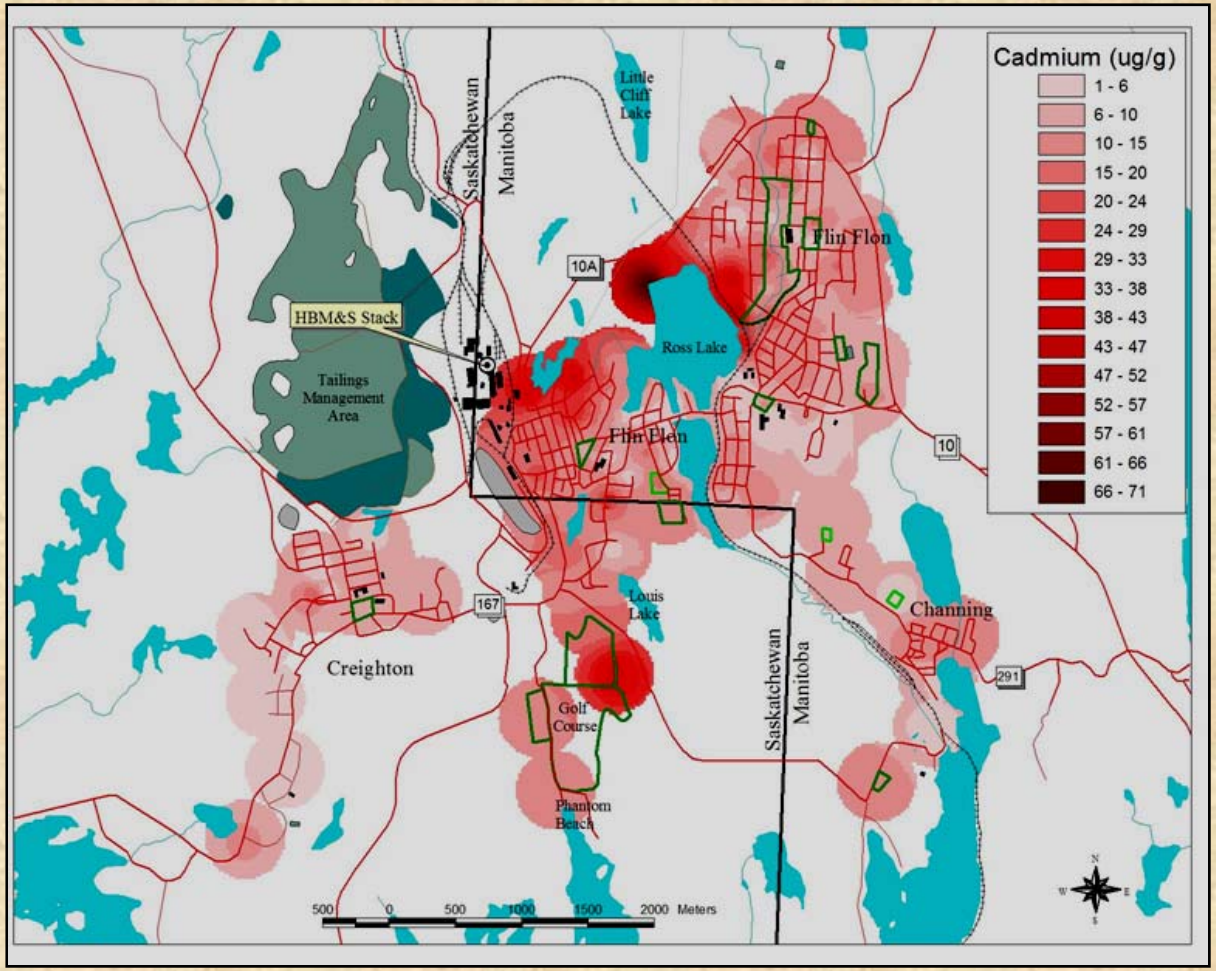
Results – Arsenic

- Soil quality guideline for the protection of human heath is 12 µg/g for all land uses.
- Guideline exceeded at 61 sites in Flin Flon and 9 sites in Creighton.
- Almost all vacant lands exceeded guideline.
- More than half of the parks/playgrounds and school yards were below guideline levels.



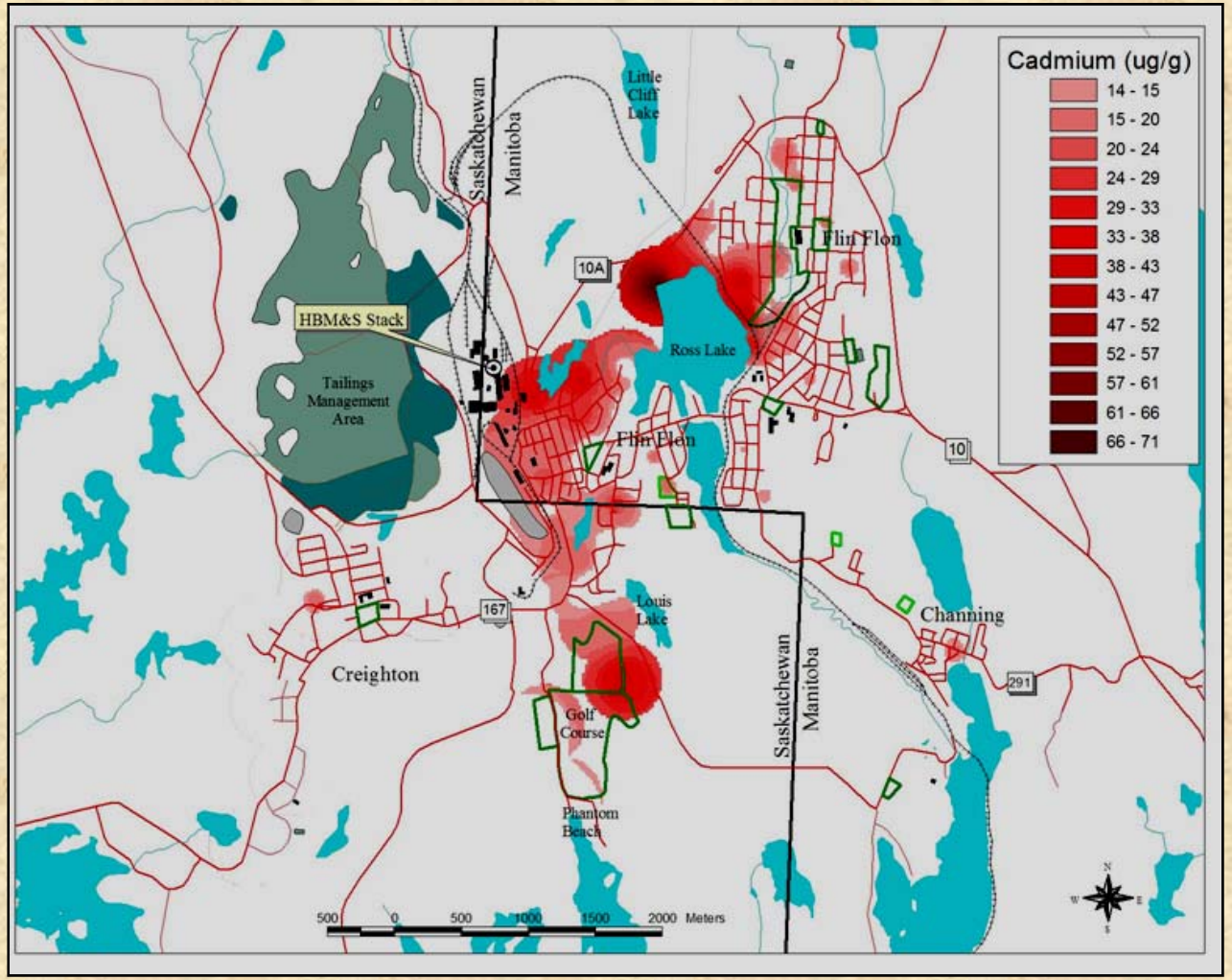
Results – Cadmium

- Mean concentrations of Cd ranged from 0.7 µg/g to 70.9 µg/g. (detected at all sites in Flin Flon and Creighton).
- Highest levels found at undeveloped sites closest to and NE of the smelter.
- Relatively low concentrations in Creighton considering proximity to tailings.



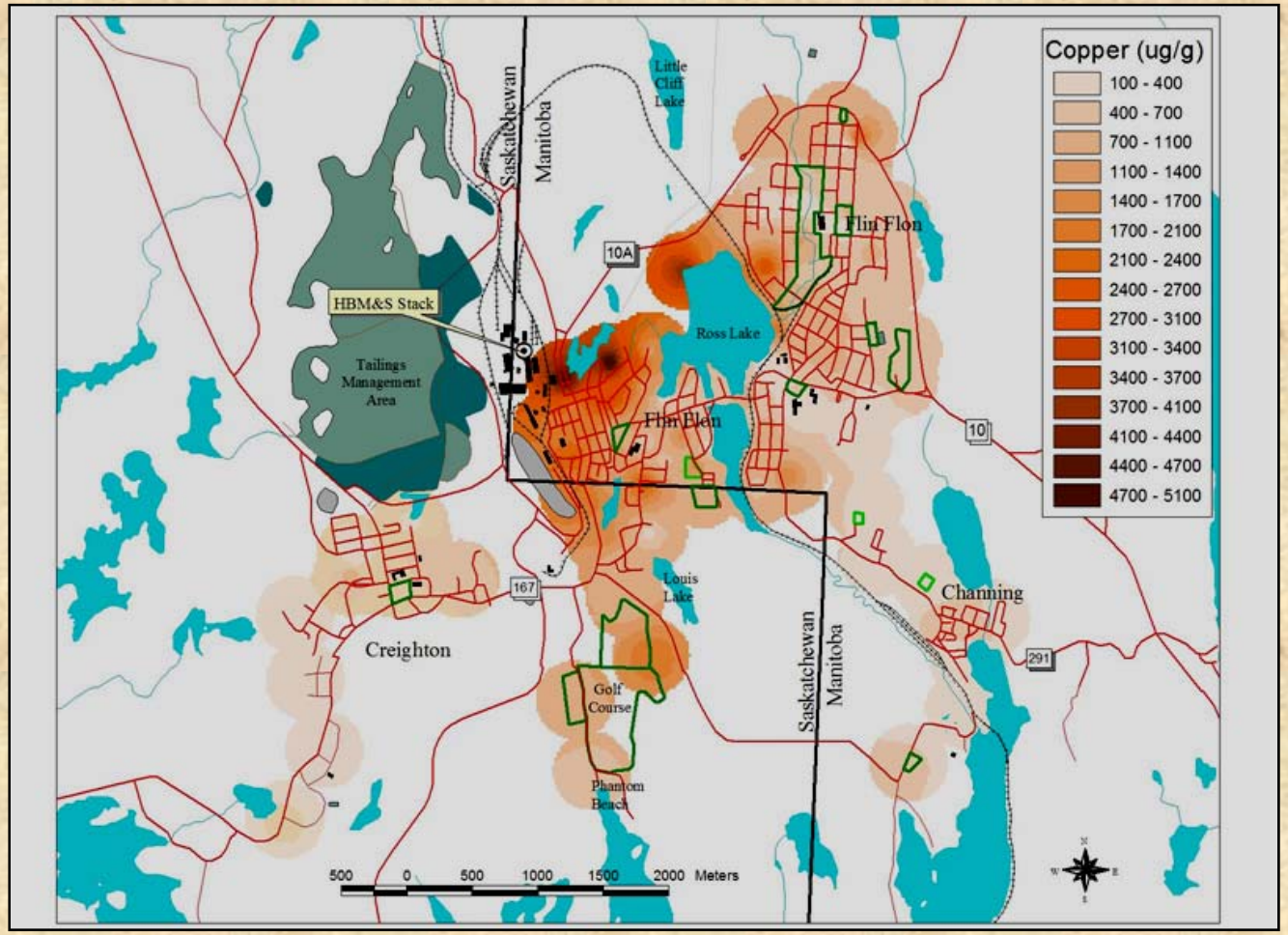
Results – Cadmium

- Guideline for the protection of human heath is 14 µg/g.
- Guideline was exceeded at approximately 31% of the sites sampled.
- Only 1 site in Creighton exceeded guideline.
- Guideline was exceeded most frequently at vacant land sites.
- Almost 80% of parks/playgrounds and boulevards were below guideline levels.
- All school yards were below guideline.



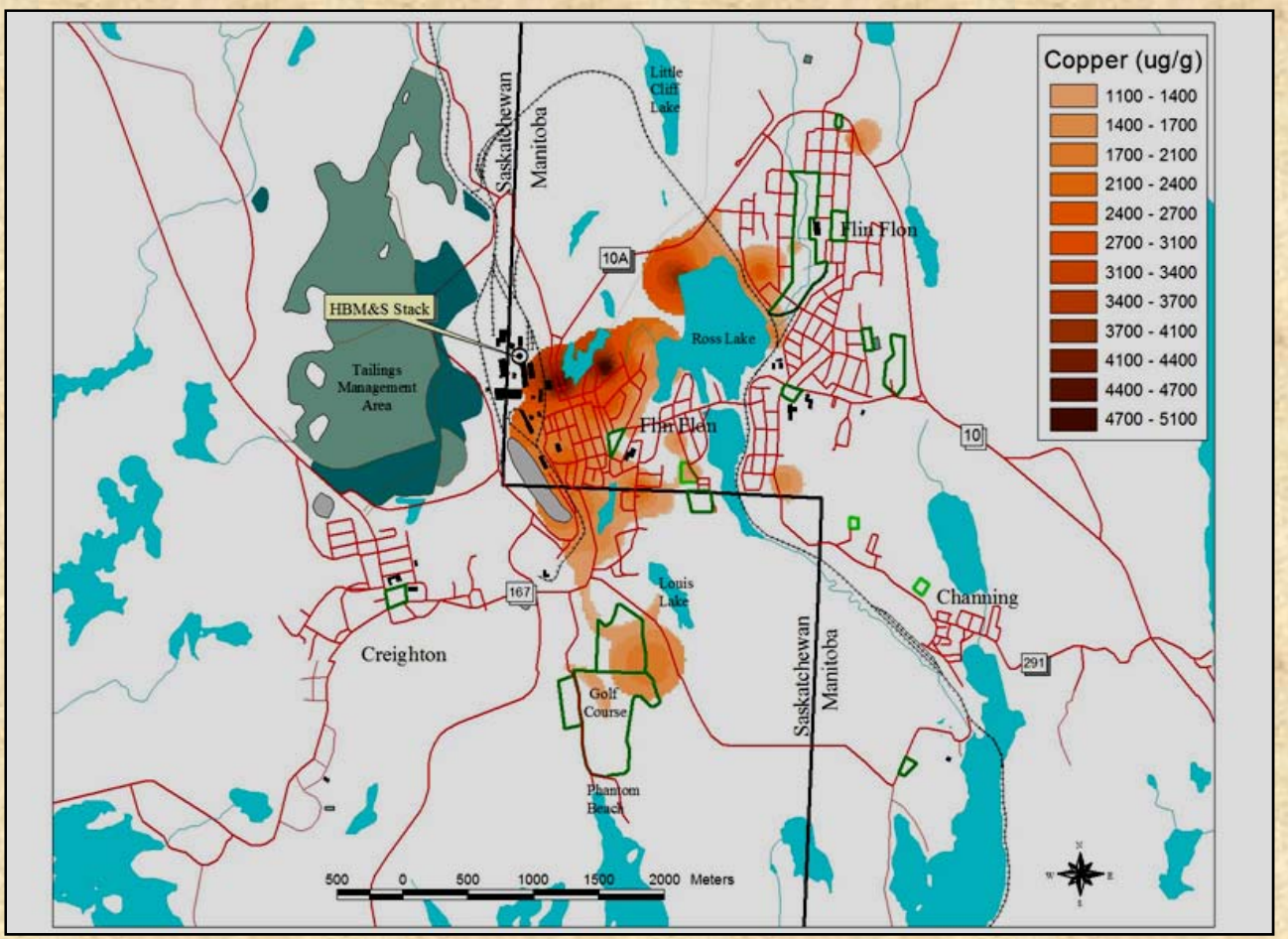
Results – Copper

- Mean concentrations of Cu ranged from 54 µg/g to 5103 µg/g in Flin Flon.
- Ranged from 54 µg/g to 899 µg/g in Creighton.
- Like As and Cd, the highest levels found at undeveloped sites closest to and NE of the smelter.



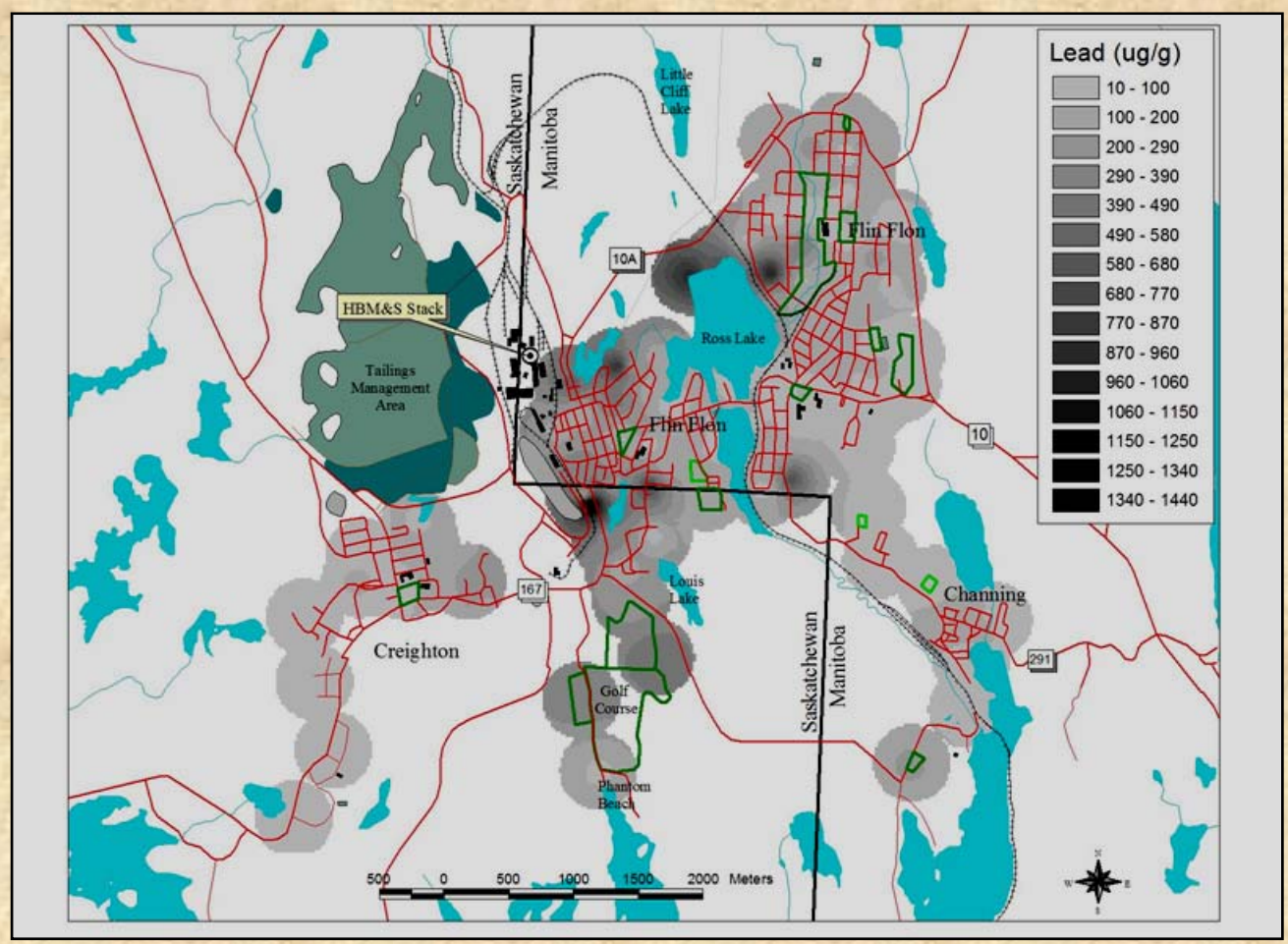
Results – Copper

- Guideline for residential/ parkland land use is 1100 µg/g.
- 28 sites exceeded guideline – all located in Flin Flon.
- Guideline was exceeded most frequently at sites located on vacant undeveloped land (11) and boulevards (9).
- Only 4 of the 36 sites located in parks and playground areas exceeded the guideline.
- Mean concentrations in samples from school yards were below guideline levels.



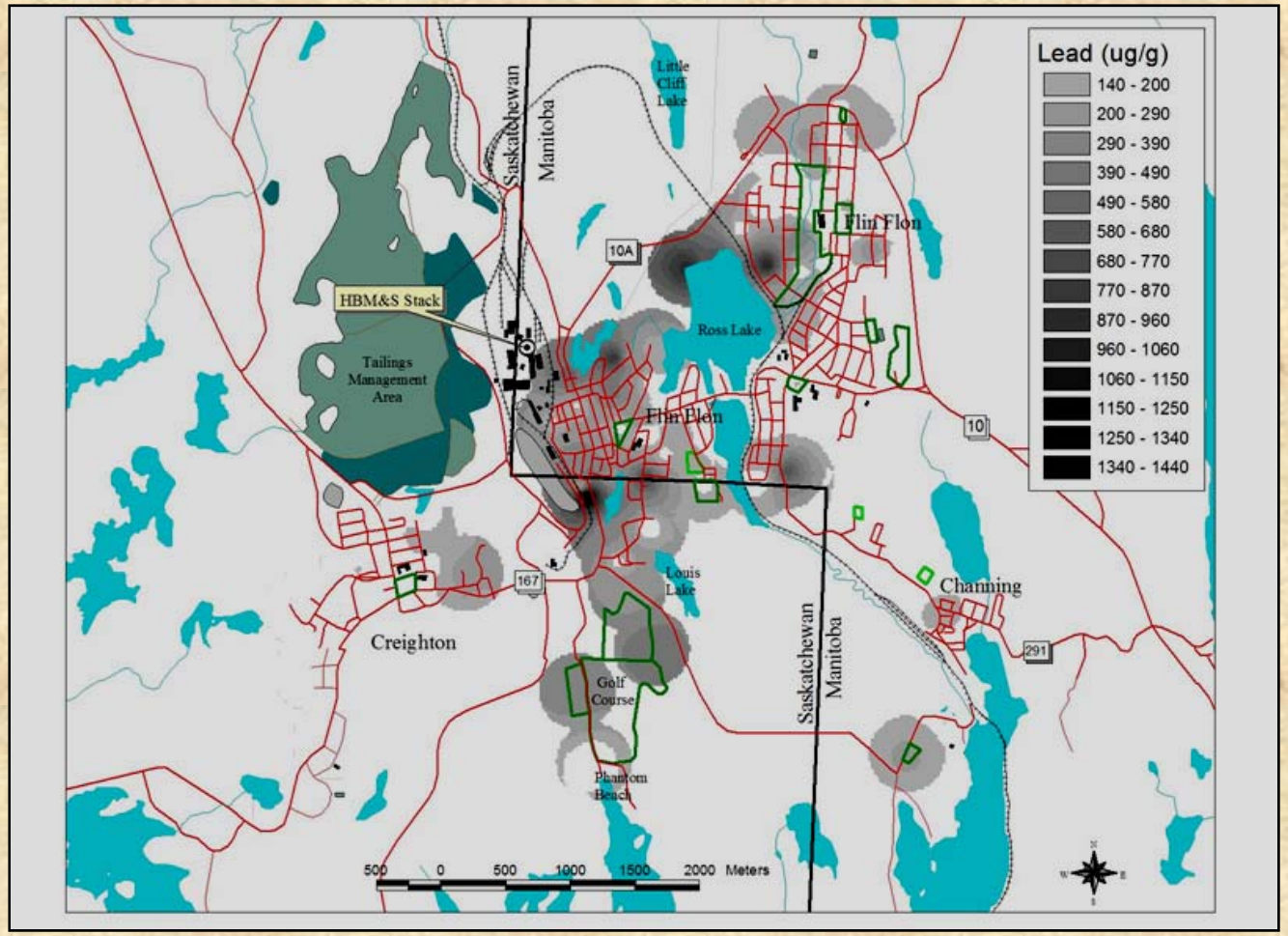
Results – Lead

- Mean concentrations of Pb ranged from 5.0 µg/g to 1447 µg/g in Flin Flon.
- Overall mean in Flin Flon was 196 µg/g.
- Generally highest in the core area and central northeast of Flin Flon.
- Ranged from 6.3 µg/g to 250 µg/g in Creighton.



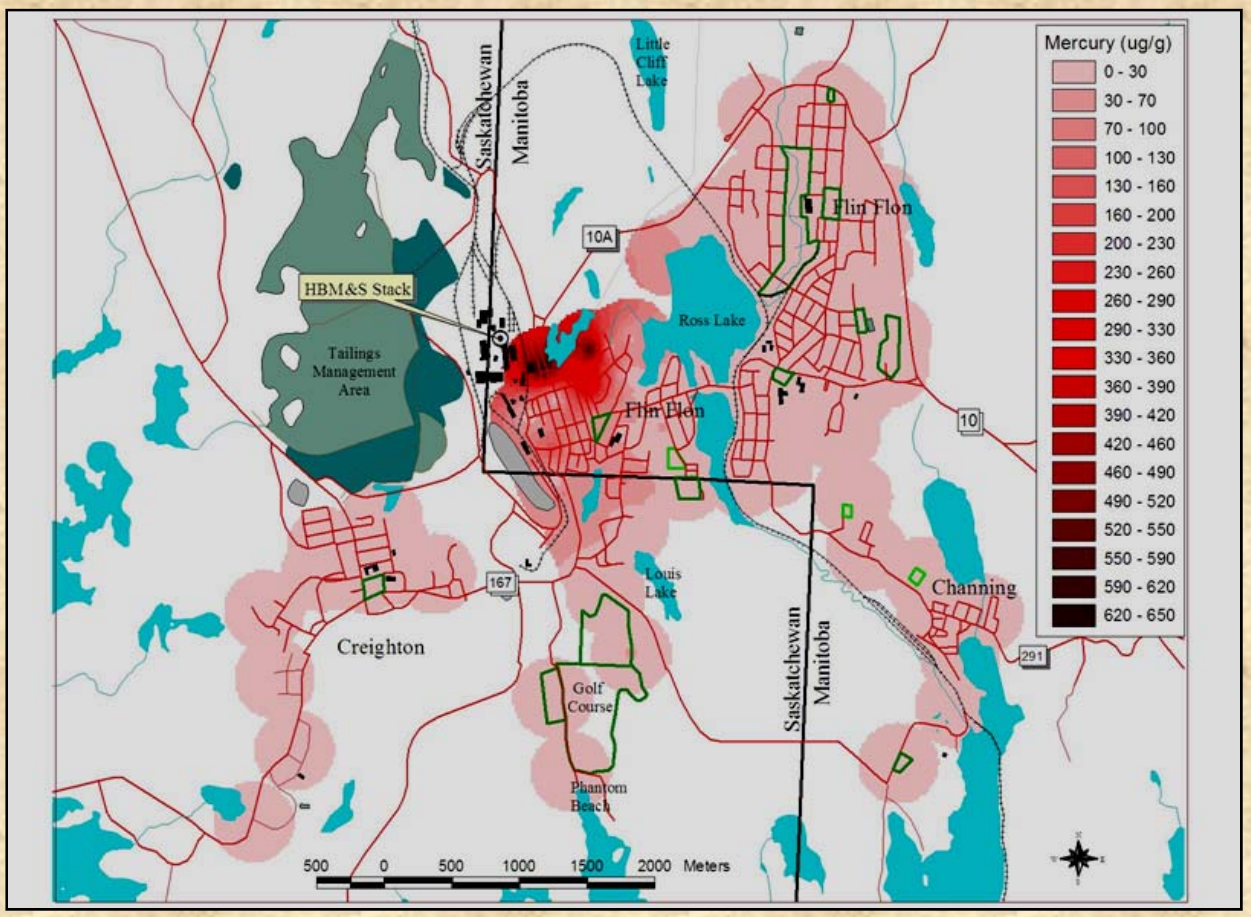
Results – Lead

- Guideline for the protection of human health for residential/ parkland land use is 140 µg/g .
- Guideline exceeded at 39 sites in Flin Flon and 4 sites in Creighton.
- Guideline was exceeded most frequently at sites located on vacant lands and boulevards.
- Only 5 of the 36 sites located in parks and playgrounds and one of the school yard sites exceeded guideline.



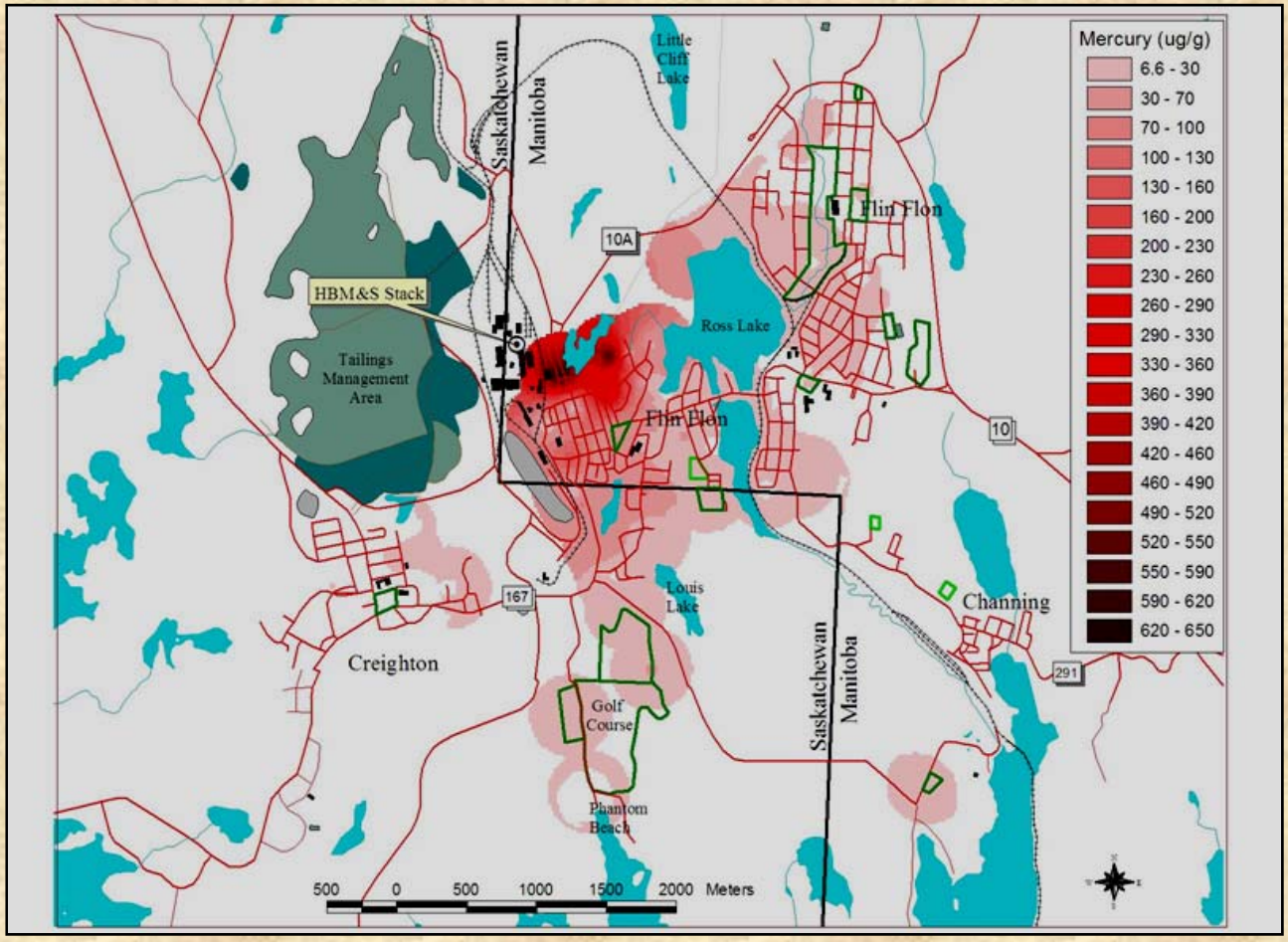
Results – Mercury

- Mean concentrations of Hg ranged from 0.1 µg/g to 653 µg/g in Flin Flon.
- Several very high values in Flin Flon.
- Similar distribution to Pb and other metals - highest in the core area and central northeast of Flin Flon.
- Ranged from 0.1 µg/g to 14.6 µg/g in Creighton.



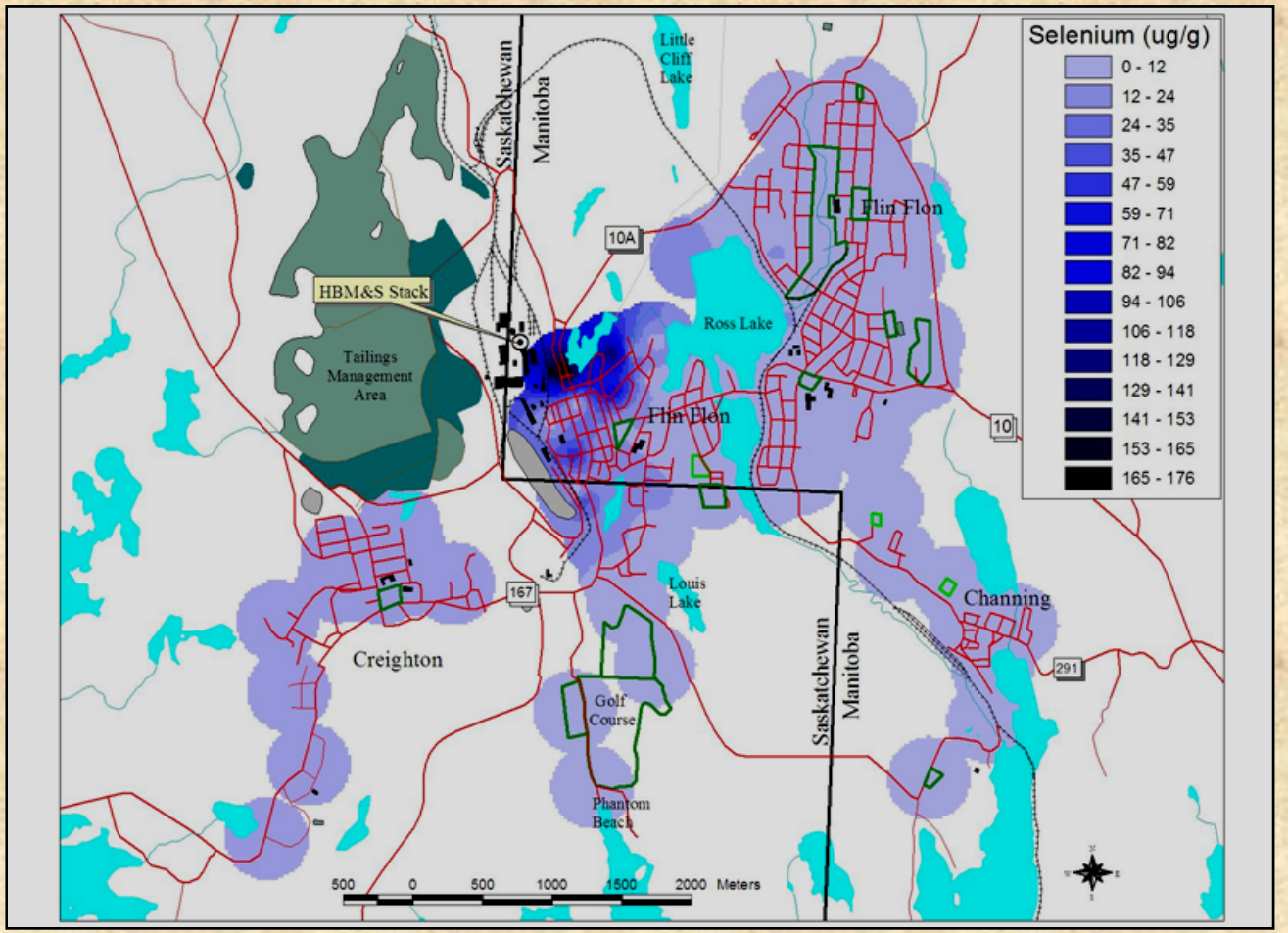
Results – Mercury

- Guideline for the protection of human health for all land use is 6.6 µg/g .
- Guideline exceeded at over half of the sites (52) in Flin Flon and 2 sites in Creighton.
- Guideline exceeded most frequently at sites located on vacant lands and boulevards, and also at a significant number of parks/playground sites.



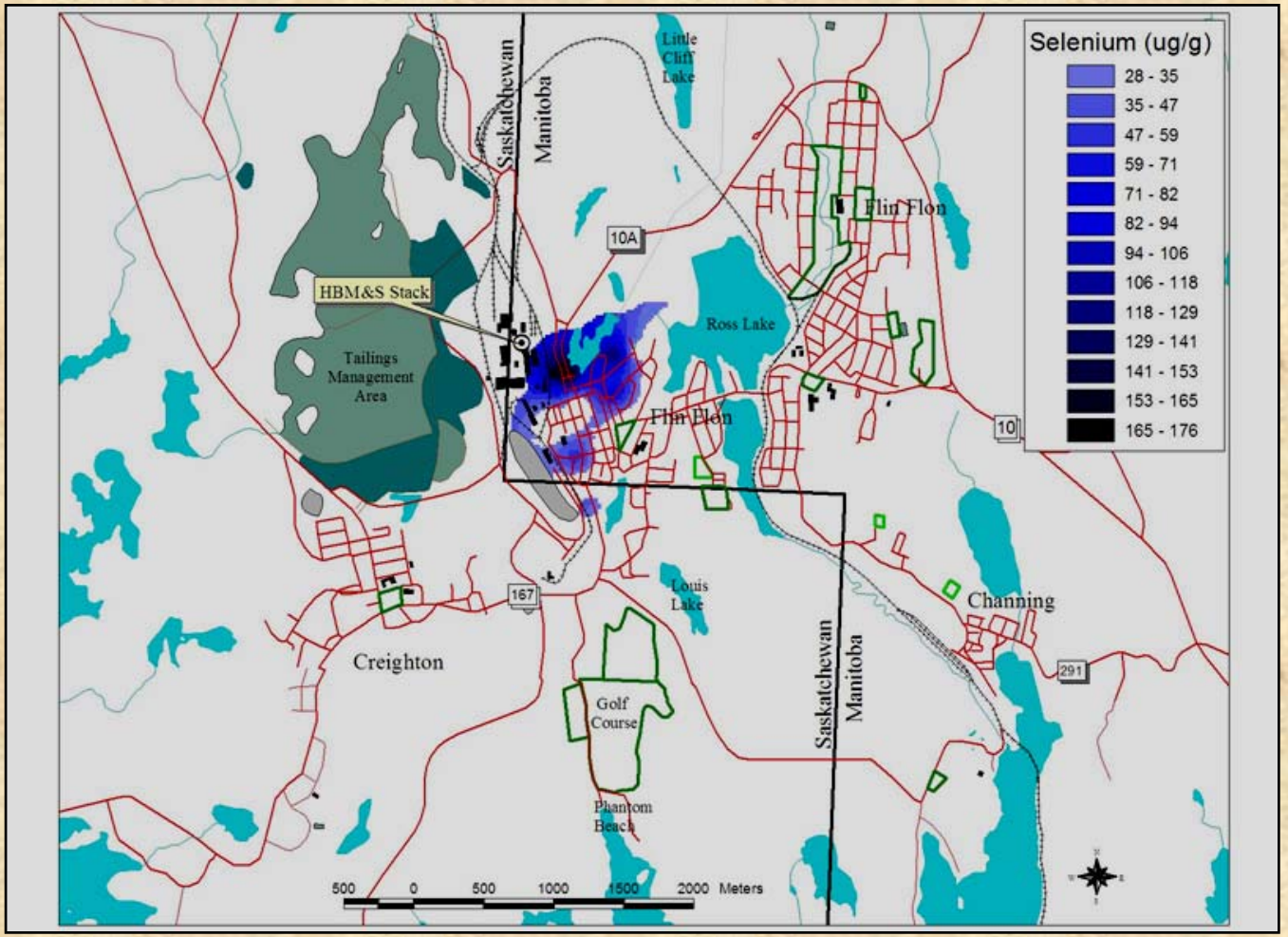
Results – Selenium

- Mean concentrations of Se ranged from <0.2 µg/g to 177 µg/g in Flin Flon.
- Highest values concentrated at sites close to smelter.
- Ranged from <0.2 µg/g to 7.2 µg/g in Creighton.



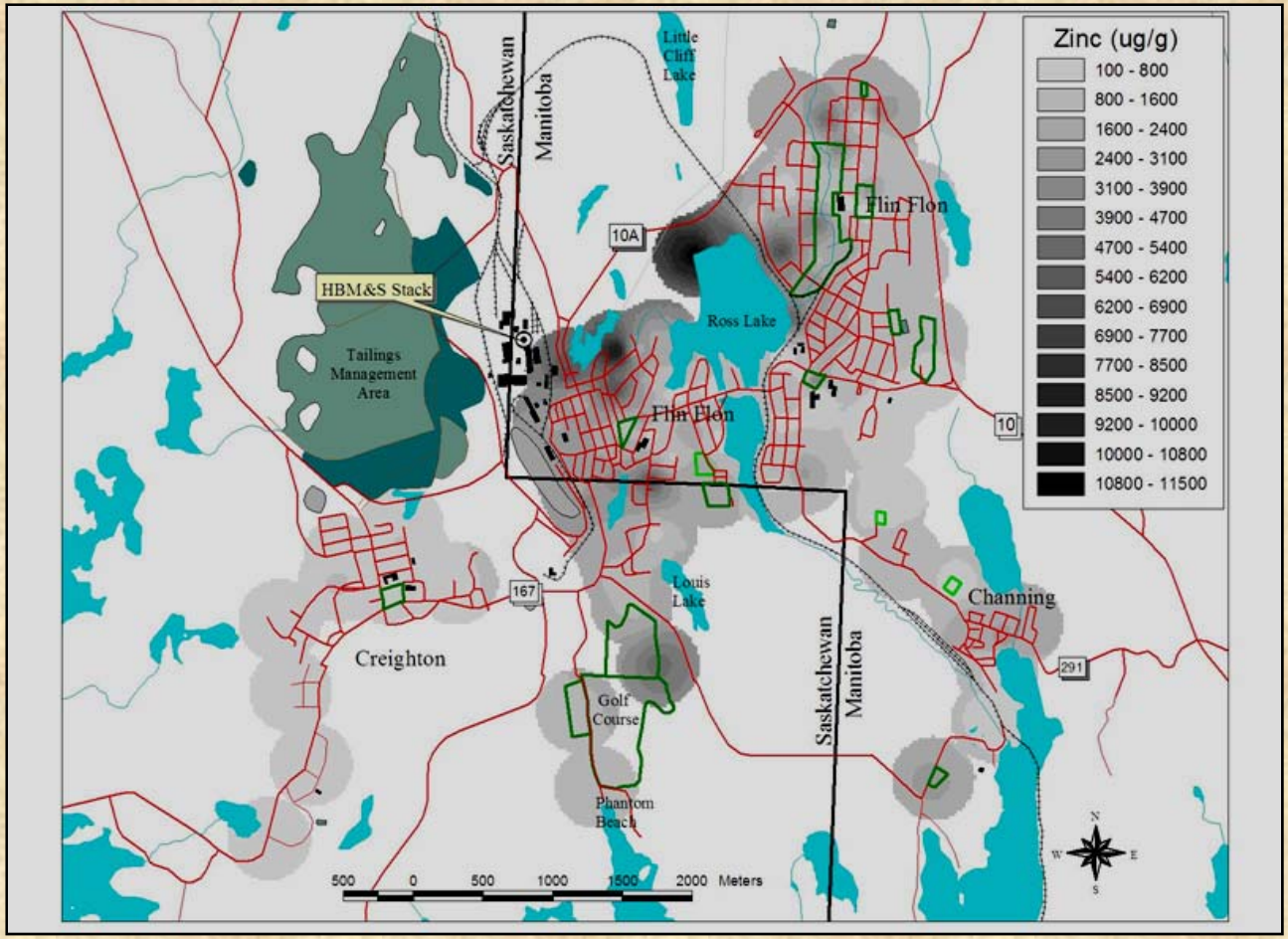
Results – Selenium

- Guideline for the protection of human health for residential/parkland land use is 28 µg/g .
- Guideline exceeded at 5 sites - all in Flin Flon.
- No park/playground or school yard sites exceeded guideline



Results – Zinc

- Mean concentrations of Zn ranged from 39 µg/g to 11550 µg/g in Flin Flon.
- Several very high levels recorded in Flin Flon
- Ranged from 55 µg/g to 1057µg/g in Creighton.
- Highest values concentrated at core area sites close to smelter and at sites in northeast.
- Soil quality guideline of 200 µg/g exceeded at almost all sites sampled. There is no guideline for the protection of human health.



Results – Other Metals and Elements

- Cr, Ni, and Tl, although generally low at most sites, did exceed guideline levels at a few locations.

- Cr exceeded soil quality guideline (64 µg/g for residential/parkland land use) at 3 sites, but did not exceed the human health protection guideline of 220 µg/g.

- Ni slightly exceeded soil quality guideline (50 µg/g, same for all land use categories) at 5 sites. However, this is an environmental health guideline and cannot be directly applied to human health..

- Tl slightly exceeded the human health protection guideline for residential/parkland land use (1 µg/g, same for all land use categories) at 2 sites in Flin Flon.

- Levels of Ba and V were below guideline levels.

Conclusions

- Concentrations of several metals and other elements exceeded guideline levels at several sites in Flin Flon and Creighton.
- In general highest concentrations were recorded at sites in Flin Flon – usually in the core area near the smelter and the northeast area.

- In general sites located on undeveloped land and vacant lots had the highest concentrations and most often exceeded guidelines.
- Park/playgrounds and school yards often had the lowest concentrations and lowest frequency of guideline exceedence.

Manitoba
Conservation

Follow-up Activities

- A working group with representation from Manitoba Health, Manitoba Conservation (Wildlife, Air Quality, Operations), Saskatchewan Health, Saskatchewan Environment, and Health Canada met on several occasions since November 2006 to discuss and interpret the findings of the survey.
- A draft report completed in April 2007 and distributed internally for review.
- Preliminary health risk assessment of the results by Saskatchewan Health and Health Canada indicated that levels of some elements may be of concern (particularly in terms of exposure to children) and further investigation in the form of a detailed human health risk assessment was needed.
- The survey results were discussed in detail with HBM&S in July 2007. HBM&S agreed to contract a consultant (Intrinsik) to conduct a human health risk assessment.
- A final report on the survey was released to the public in late July 2007. This included notifying the *Flin Flon Reminder*, posting report on Provincial Government website, and distributing paper copies of the report to stakeholders and general public (in early August).
- Public presentation of the soil survey results and further distribution of the report at the Healthy Flin Flon meeting on October 1, 2007.
- Presentation and discussion of the survey report at the inaugural meeting of the Community Advisory Committee on October 15, 2007.

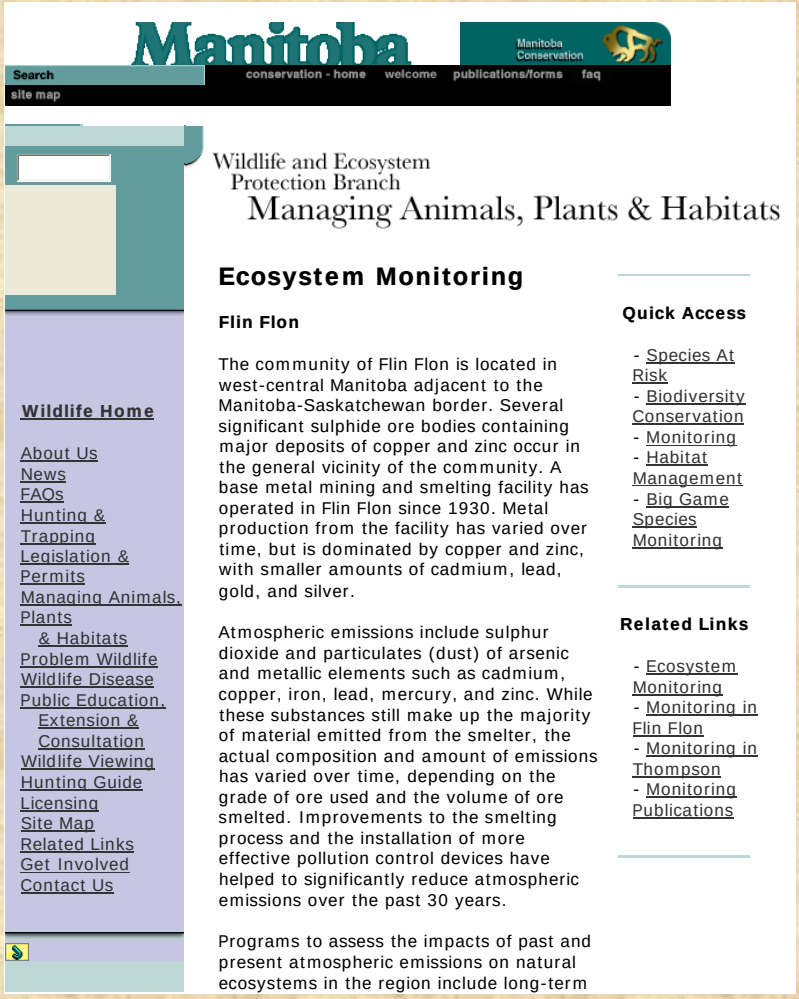
Manitoba
Conservation

- www.gov.mb.ca/conservation/wildlife/managing/mon_ecoflinflon.html
- Geoff.Jones@gov.mb.ca

Concentrations of Metals and Other Elements in Surface Soils of Flin Flon, Manitoba and Creighton, Saskatchewan, 2006

July 2007

Report No. 2007-01



Manitoba

Manitoba Conservation

Search

site map

conservation - home | welcome | publications/forms | faq

Wildlife and Ecosystem Protection Branch

Managing Animals, Plants & Habitats

Wildlife Home

About Us
News
FAQs
Hunting & Trapping
Legislation & Permits
Managing Animals, Plants & Habitats
Problem Wildlife
Wildlife Disease
Public Education, Extension & Consultation
Wildlife Viewing
Hunting Guide
Licensing
Site Map
Related Links
Get Involved
Contact Us

Ecosystem Monitoring

Flin Flon

The community of Flin Flon is located in west-central Manitoba adjacent to the Manitoba-Saskatchewan border. Several significant sulphide ore bodies containing major deposits of copper and zinc occur in the general vicinity of the community. A base metal mining and smelting facility has operated in Flin Flon since 1930. Metal production from the facility has varied over time, but is dominated by copper and zinc, with smaller amounts of cadmium, lead, gold, and silver.

Atmospheric emissions include sulphur dioxide and particulates (dust) of arsenic and metallic elements such as cadmium, copper, iron, lead, mercury, and zinc. While these substances still make up the majority of material emitted from the smelter, the actual composition and amount of emissions has varied over time, depending on the grade of ore used and the volume of ore smelted. Improvements to the smelting process and the installation of more effective pollution control devices have helped to significantly reduce atmospheric emissions over the past 30 years.

Programs to assess the impacts of past and present atmospheric emissions on natural ecosystems in the region include long-term

Quick Access

- Species At Risk
- Biodiversity Conservation
- Monitoring
- Habitat Management
- Big Game Species Monitoring

Related Links

- Ecosystem Monitoring
- Monitoring in Flin Flon
- Monitoring in Thompson
- Monitoring Publications

Manitoba Conservation