McLaughlin Centre for Population Health Risk Assessment Workshop on:

# The Role of Geoscience in Environmental Health

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# Environmental Health

## 4 steps*

1. Determine the source and nature of each environmental contaminant or stress
2. Assess exposure - how and in what form it comes into contact with people.
3. Measure the effects.
4. Apply controls when and where appropriate.

*from Moeller, Dade (1992). Environmental Health, Harvard University Press, Cambridge, USA.

# The Role of Geoscience in Environmental Health

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# 1. Determine the source and nature of each environmental contaminant or stress.

## Characterize the source

- Area: e.g., an agricultural zone, a geological unit
- Point: e.g., farms, smelters, processing plants
- Linear: e.g., traffic routes, fault zone

## Quantify the rate of transfer (flux)

- What proportion is geological?
- Windblown dust, gaseous elemental mercury

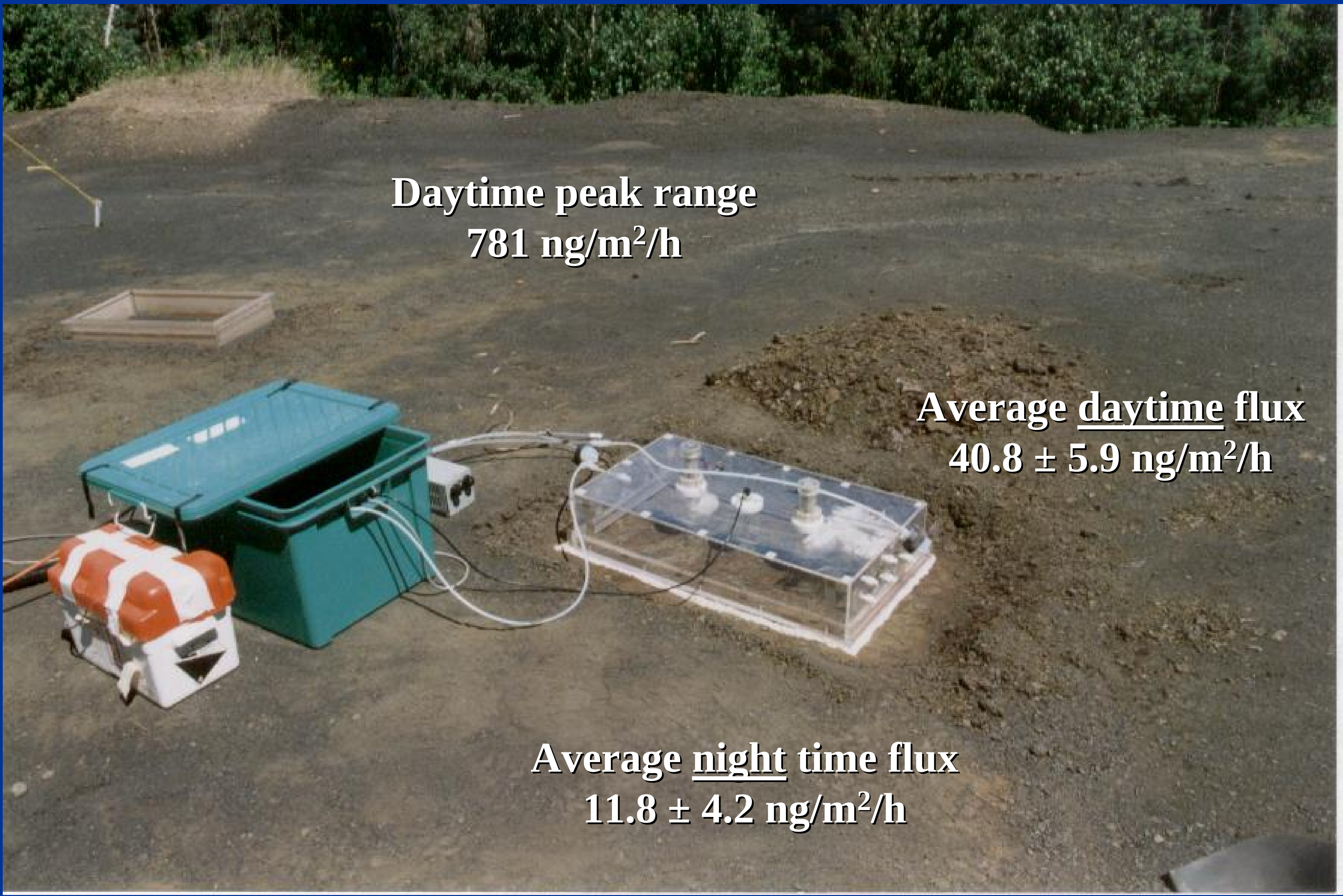
# Quantifying Rates of Transfer (Flux)

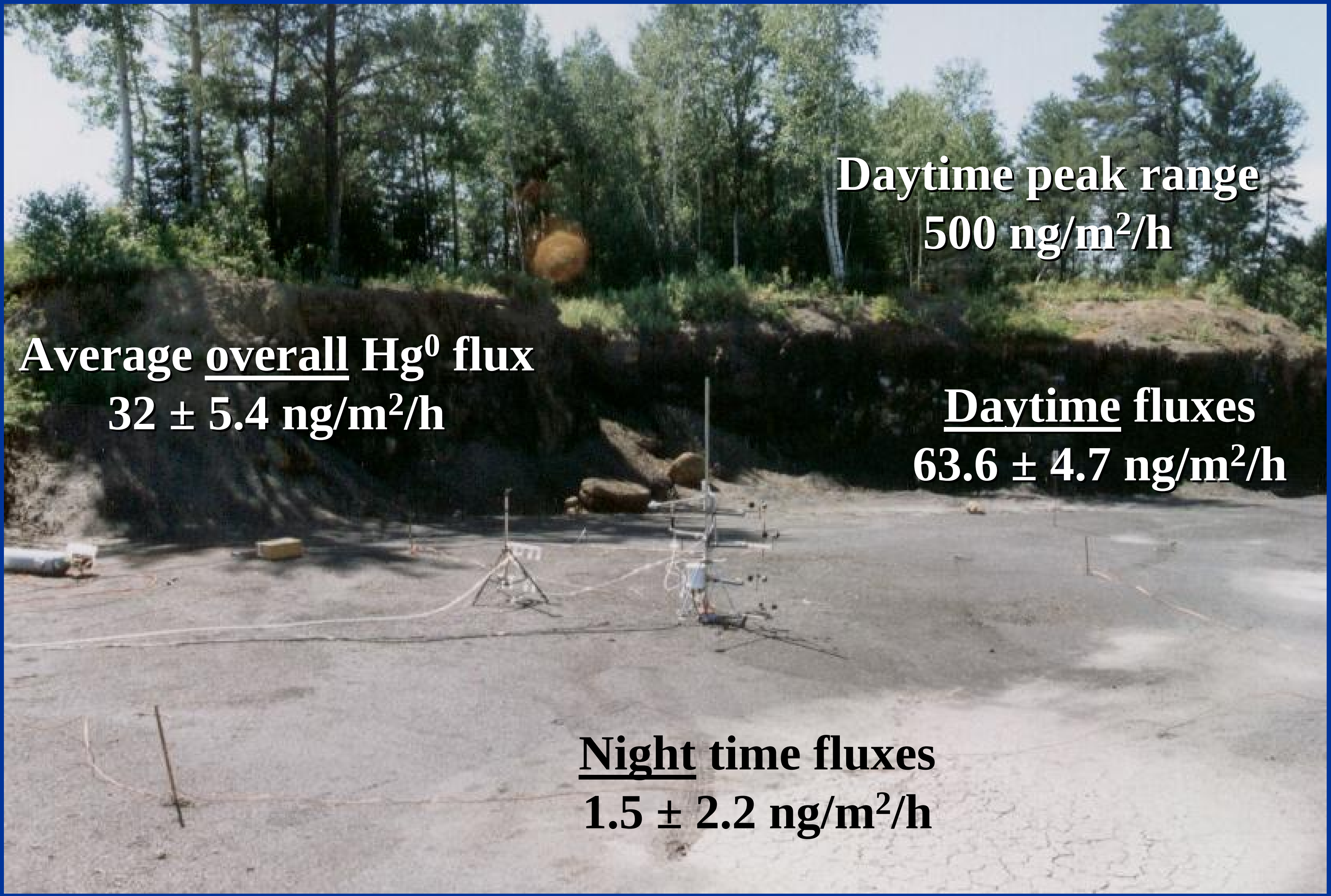
**References for the following examples of Natural Mercury Flux Measurements & Assessment of Spatial/Temporal Variability:**


- **Rasmussen, P.E., Edwards, G.C, Schroeder, W.H., Ausma, S., Steffen, A., Kemp, J., Hubble Fitzgerald,C.,El Bilali, E., Dias, G. (2005) Measurement of Gaseous Mercury Flux in Terrestrial Environments. In Mercury: Sources, Measurements, Cycles, and Effects. (Eds. M.B.Parsons & J.B.Percival). Mineralogical Association of Canada Short Course Series 34 (7), pp 123-138.**

- **Edwards, G. C., P. E. Rasmussen, W. H. Schroeder, D. M. Wallace, L. Halfpenny Mitchell, G. M. Dias, R. J. Kemp, and S. Ausma (2005) Development and evaluation of a sampling system to determine gaseous mercury fluxes using an aerodynamic micrometeorological gradient method, Journal of Geophysical Research (Atmospheres) 110 (10), pp. 1-11.**

- **Edwards, G.C., Rasmussen, P.E., Schroeder, W.H., Kemp, R.J., Fitzgerald-Hubble, C.R., Wong, E.K., Dias, G.M., L. Halfpenny-Mitchell,and Gustin, M.S. (2001). Sources of variability in mercury flux measurements. Journal of Geophysical Research (Atmospheres), Vol. 106 (D6): 5421-5435.**

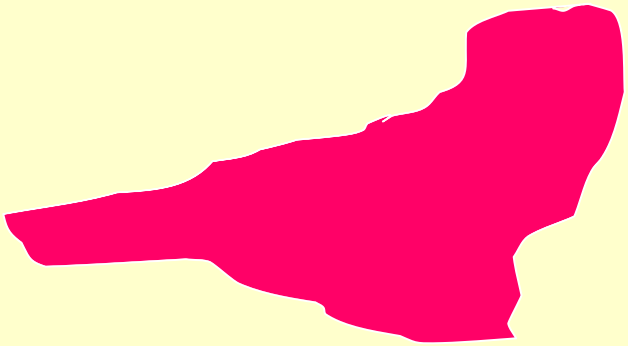

Daytime peak range
781 ng/m²/h
Average daytime flux
40.8 ± 5.9 ng/m²/h
Average night time flux
11.8 ± 4.2 ng/m²/h


Daytime peak range
500 ng/m2/h
Average overall Hg0 flux
32 ± 5.4 ng/m2/h
Daytime fluxes
63.6 ± 4.7 ng/m2/h
Night time fluxes
1.5 ± 2.2 ng/m2/h

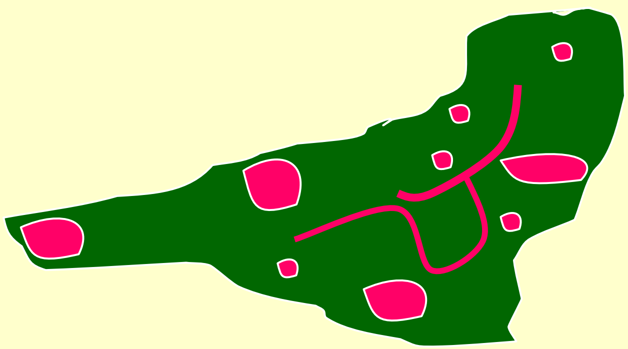
# Scaling up issues: Environmental Factors

- Temperature, light conditions
- Amount of rain, duration of rain and drying period for enhancement or suppression of flux
- Interaction of rain and temperature
- Duration and effect of snow cover
- Role of vegetation
- What is role of overburden

Study
area 1
Canada
Thunder
Bay
U.S.A.
Lake
Superior
0
200
400 km
Lake Michigan
N
Canada



**<u>Bedrock polygon from geology map</u>** treated as
area source:
300 sq km
@ 10 ng/m2/hour
= 2.2 kg Hg emitted per month
~ 11.2 kg Hg emitted per year



**<u>Bedrock polygon covered with</u>**
**<u>impermeable mantle</u>**
(@ 0.0 ng/m2/hour)

point sources: 10 outcrops, 15 quarries

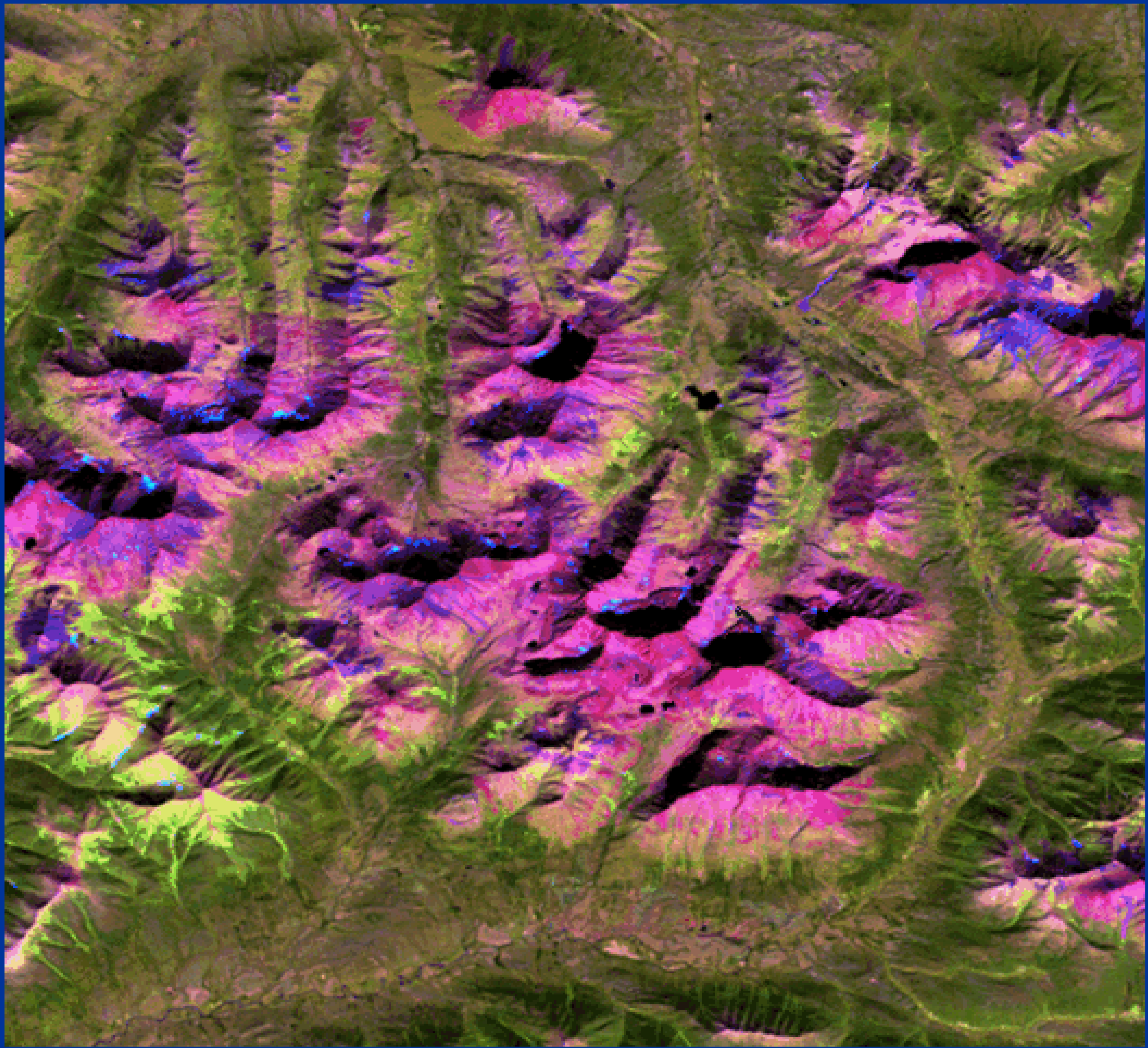
linear sources: 30 m wide shale roads for 700 km
@ 10 ng/m2/hour
= 0.17 mg per month
~ one mg Hg emitted per year

# Scaling up issues


Canada
Alaska
Yukon Territory
Northwest Territories
Study area 2
Ross River
Whitehorse
N
0
200 km

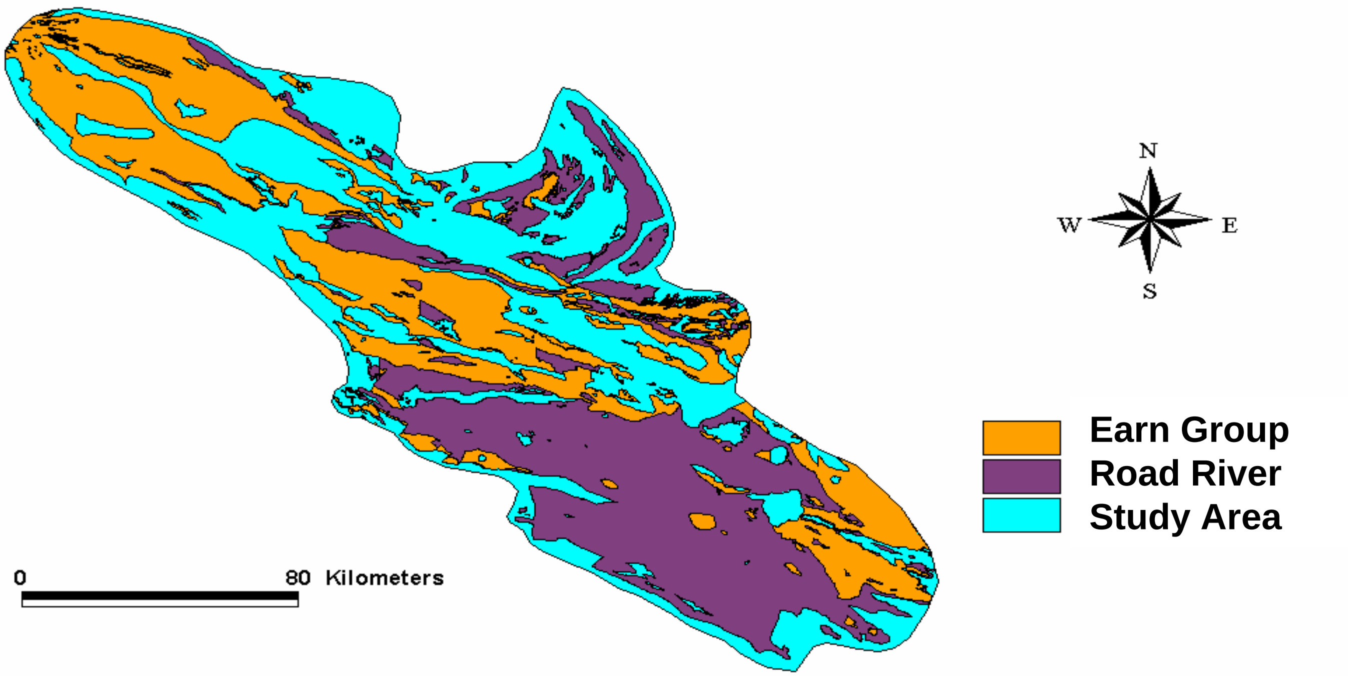
## Classification of Satellite Image

**Purpose: to determine the area of <u>exposed</u> black shale**



**False colour composite (TM bands 3,4 &5)**

# Hg Anomaly




| | total shale area | exposed area | exposed area |
|---|---|---|---|
| | km2 | km2 | % of total |
| Road River | 7749 | 678 | 9% |
| Earn Group | 7313 | 801 | 11% |
| Both | 15061 | 1479 | 10% |

# Area Source:

# Black Shale

**Road River and Earn Group,**

**Selwyn Mountains,**

**Yukon Territory**

## Bedrock polygons from geology map

**Total area 15, 061 sq km**
**@ 10 ng/m$^2$/hour**
**= 107 kg Hg emitted per month**
**For 2 months per year**

**~ 214 kg Hg emitted per year**

## After Landsat interpretation and GIS:

**Corrected area 1,579 sq km**

**@ 10 ng/m2/hour**
**= 11 kg per month**
**For 2 months per year**

**~ 22 kg Hg emitted per year**

# 2. Assess exposure: how and in what form

- Proximity to sources
- Pathway of exposure
  - Inhalation
  - Ingestion
  - Dermal
- Difficulty increases
  - where there are multiple exposures;
  - distinguishing natural and anthropogenic sources

# Refining exposure assessments: airborne

- Proximity to pollution sources
- Identify areas of risk (dispersion models)
- Monitor air quality at set locations
- Monitor Indoor/Outdoor/Personal exposures

# Assess Exposure – how and in what form?


- Rasmussen, P.E., S. Beauchemin, M. Nugent, R. Dugandzic, M. Lanouette and M . Chénier. 2008. Influence of matrix composition on bioaccessible copper, zinc and nickel in urban residential dust and soil. “Human and Ecological Risk Assessment 14:1 (in press)
- Rasmussen, P.E., Wheeler, A.J., Hassan, N.M., Filiatreault, A., and Lanouette, M. (2007) Monitoring personal, indoor, and outdoor exposures to metals in airborne particulate matter: risk of contamination during sampling, handling and analysis. Atmospheric Environment. 41: 5897-5907.
- Rasmussen, P.E.. Can metal concentrations in indoor dust be predicted from soil geochemistry? Canadian Journal of Analytical Science and Spectroscopy, 49 (23), pp. 166-174.

# Gaps in Exposure Assessment

- Focus on exposure measurement errors
- Crude exposure assessments a major weakness
- Profound effect on predicted risks and public policy
- Improving the accuracy of exposure assessments is critical
  - to Risk Assessment
  - to Epidemiological Studies