

# **MEND – Halifax 2006**

## **Acid Rock Drainage in the Halifax Formation Slates; What Have We Learned?**

**Terry A. Goodwin**

**Nova Scotia Department of Natural Resources**

**and**

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**Nova Scotia Department of Environment and Labour**

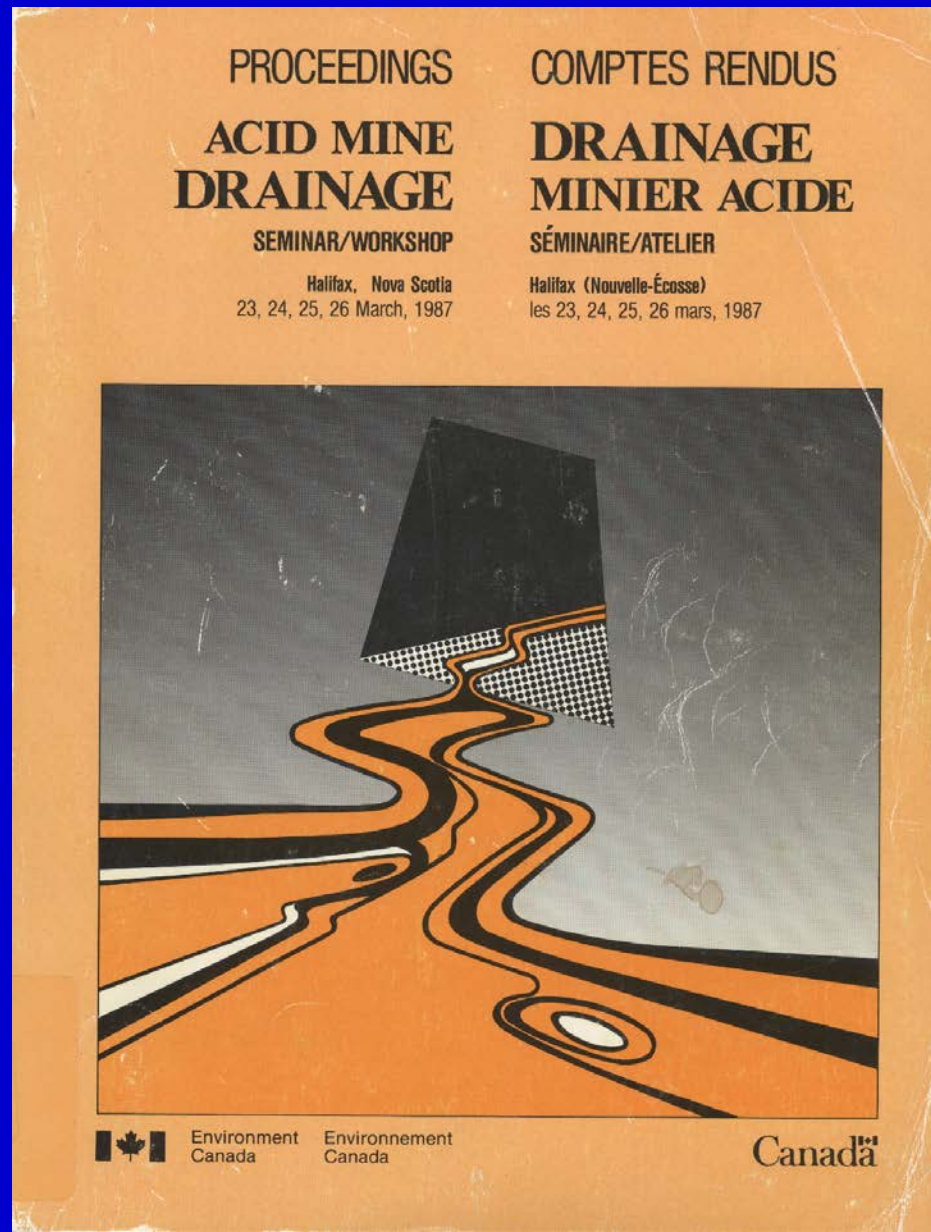
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**Acid Rock Drainage in the Halifax Formation Slates: What Have We Learned?**

**PART 1 - Geological Perspective**

**PART 2 – Policy, Planning and Process**

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# *Nova Scotia Geology*





**Avalon Terrane**

**Meguma Terrane**

**CCFZ**

100 km

-  Triassic to Jurassic:  
*red beds; basalt*
-  Late Carboniferous:  
*sandstone; shale; conglomerate; coal*
-  Early Carboniferous:  
*sandstone; shale; limestone;  
gypsum; anhydrite; halite*
-  Early Carboniferous:  
*sandstone; shale;  
conglomerate; limestone*
-  Precambrian to Carboniferous:  
*undifferentiated intrusive rocks*

-  Cambrian to Early Carboniferous:  
*mixed sedimentary & volcanic rocks;  
metamorphic equivalents*
-  Cambrian to Ordovician:  
*slate; minor greywacke*
-  *greywacke; slate*
-  Precambrian: *volcanic & sedimentary rocks  
basement complex (gneiss; schist)*

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## STRATIGRAPHY

### Historically Halifax Formation:

- ... referred to shale
- ... referred to pyritiferous slate
- ... mapped as one single, undivided unit
- ... ALL Halifax Formation considered acid producing



### From a planning perspective, questions were raised:

- ... Is the entire Halifax Formation acid generating?
- ... Is ARD within the Halifax Formation predictable?
- ... What information is needed to make predictions?

Led to detailed mapping, mineralogical studies and magnetic studies.

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## STRUCTURE

- ... cleavage
- ... preferential alignment of minerals
- ... disseminated
- ... clots
- ... pervasive pathway
- ... exacerbated by development increasing surface area of minerals

### Other considerations:

- ... slates form topographic highs (airport)
- ... further exacerbated by thin till cover and limited buffering capacity



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## MINERALIZATION

... pyrrhotite > pyrite

... monoclinic pyrrhotite (magnetic, fast reacting), detectable As, Ni, Co

... marcasite, arsenopyrite, chalcopyrite, sphalerite, galena

... schwertmannite, rozenite, jarosite



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## MAGNETIC SIGNATURE

... Pyrrhotite

... Airborne magnetics

... Regional mapping tool

... Cunard Member is (i) identifiable and (ii) continuous = (ARD) PREDICTABLE



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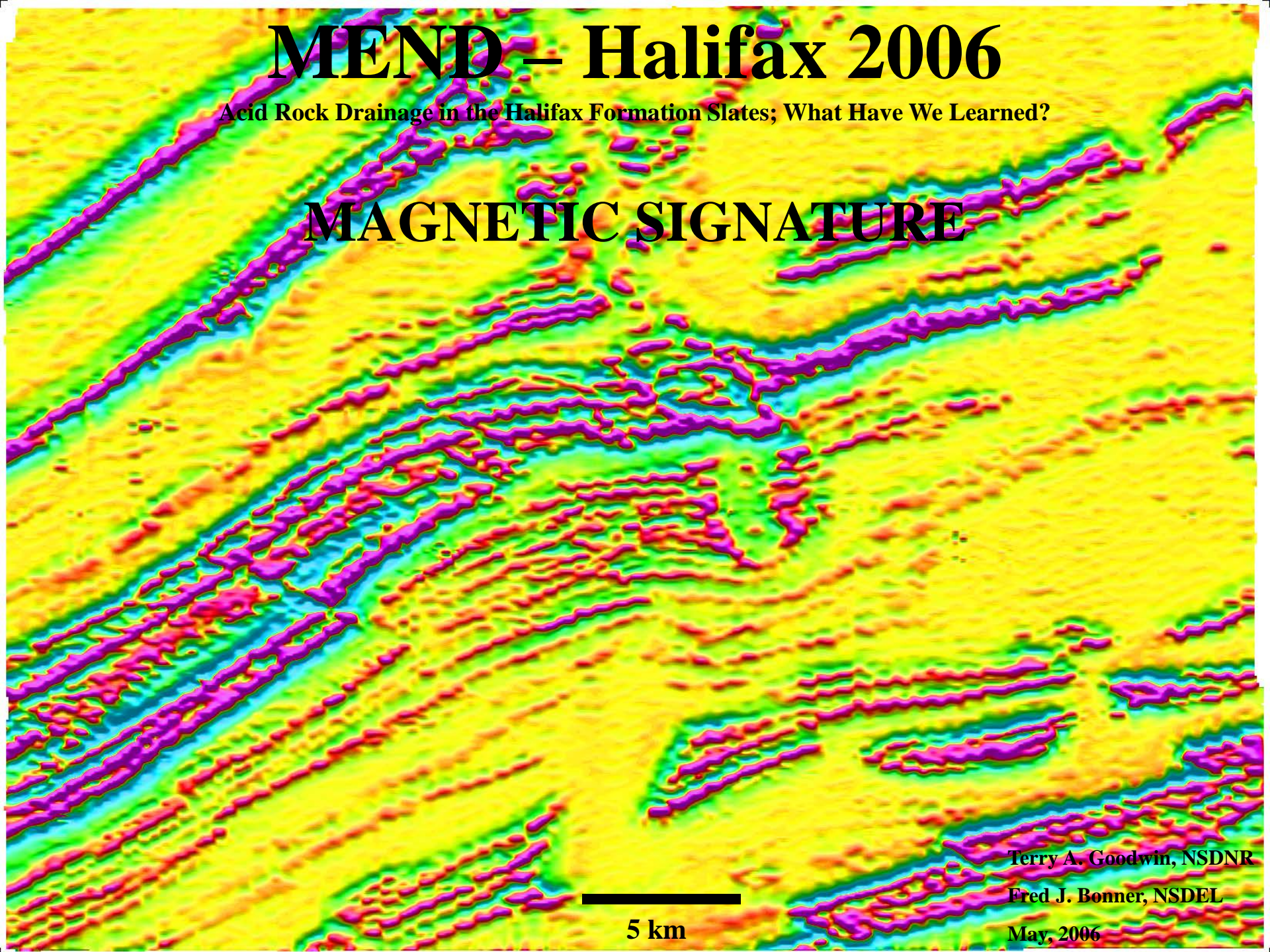
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## MAGNETIC SIGNATURE



5 km

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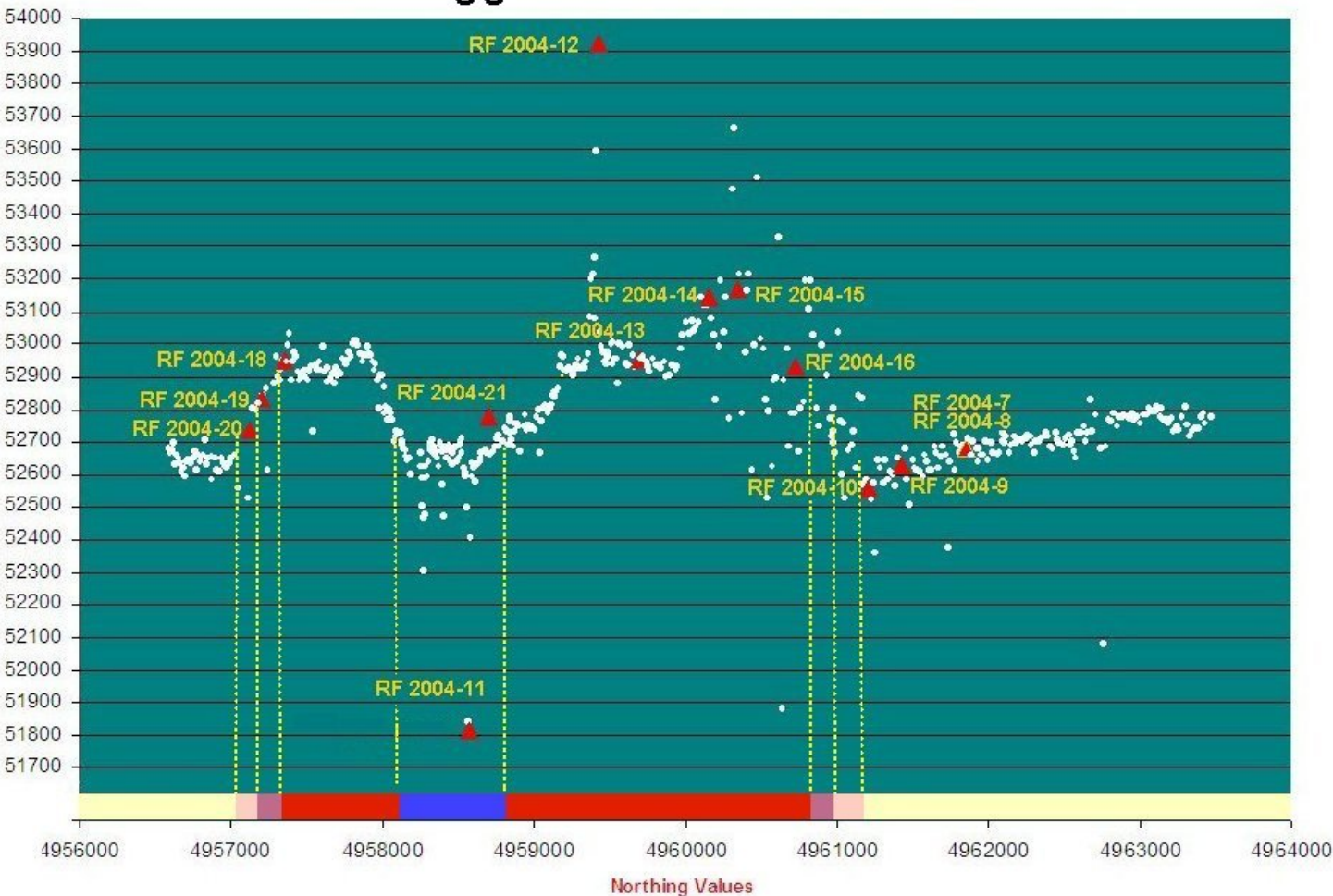
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## NanoTesla (nT) Total Field Magnetic Readings, Sample Locations, and Suggested Contacts: Beaverbank



- ▲ Sample Location
- Goldenville Formation
- Steve's Road Unit
- Beaverbank Unit
- Cunard Unit
- Glen Brook Unit

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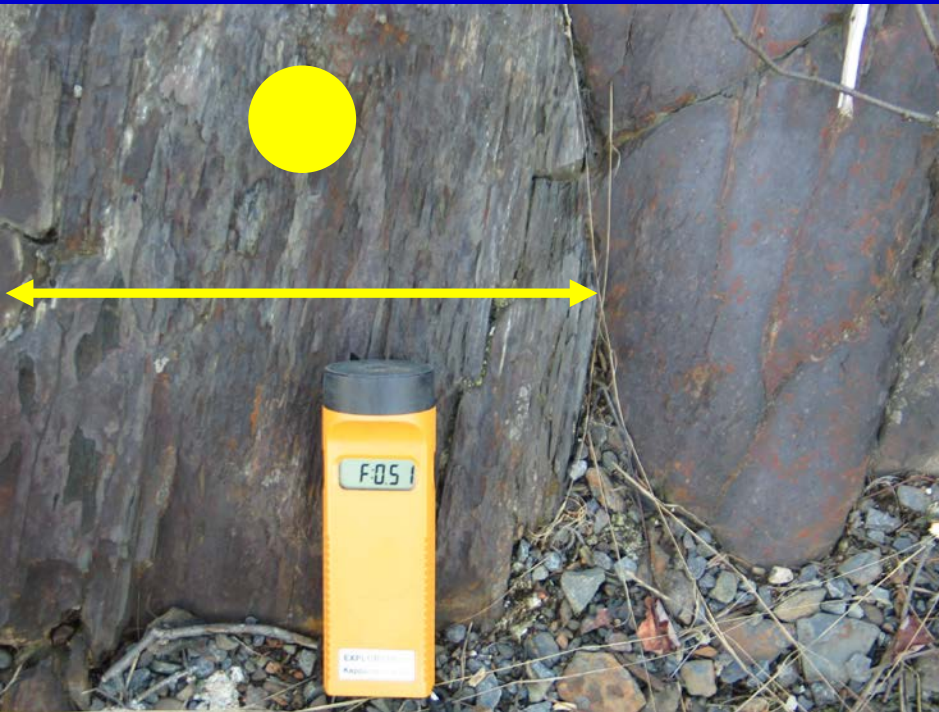


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## MAGNETIC SIGNATURE

Hand-held magnetic susceptibility meter (outcrop scale)

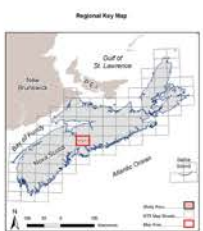


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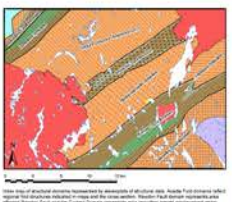
**Map Titles**  
 Geological Map of Nova Scotia, Sheet 11D/13, Mount Uniacke Area, Nova Scotia  
 Base and Digital Data derived from the Nova Scotia Topographic Database (NSTDB). The NSTDB is available from Service Nova Scotia and Atlantic Relations (SNARS), Land Information Service, Halifax, Nova Scotia. (Available from the NSTDB website: www.nstdb.ns.ca)

**Acknowledgments**  
 Field mapping conducted by Canada - Nova Scotia co-operation agreement on Mineral Exploration 1990-1995.  
 Cartography and web design by Nova Scotia Department of Natural Resources, Geomatics Information Services Section.

**Disclaimer**  
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**References**  
 Conry, M.C. Geological Map of Mount Uniacke. Nova Scotia Department of Mines and Energy, May 1974. Scale 1:50,000.

**Recommended Citation**  
 Home, R.J., Ryan, R.J., Conry, M.C. and Fox, D.L. 2006. Geological map for NTS 11D/13, Mount Uniacke Area, Nova Scotia. Nova Scotia Department of Natural Resources, Mineral Resources Branch. Open File Map 11D/13, scale 1:50,000.



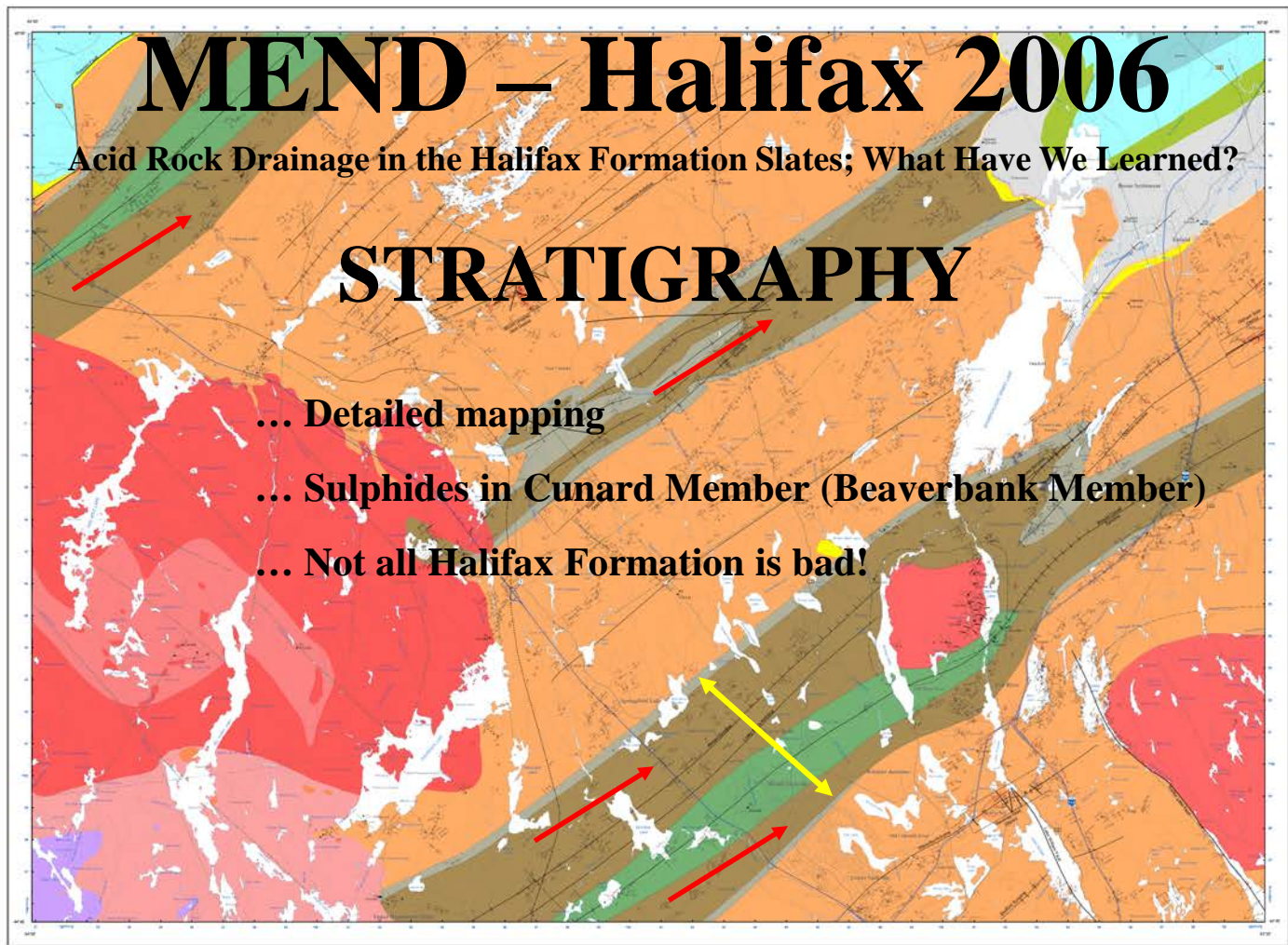
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## Acid Rock Drainage in the Halifax Formation Slates; What Have We Learned?

# STRATIGRAPHY

- ... Detailed mapping
- ... Sulphides in Cunard Member (Beaverbank Member)
- ... Not all Halifax Formation is bad!



**Geology Legend**

**PALEOZOIC**

**HALIFAX GROUP**

- Halifax Group** (Orange): Includes the Halifax Formation, which is further divided into the Cunard Member and the Beaverbank Member.
- Beaverbank Member** (Red): Contains the Cunard Member.
- Cunard Member** (Green): Contains the Beaverbank Member.

**PROTEROZOIC**

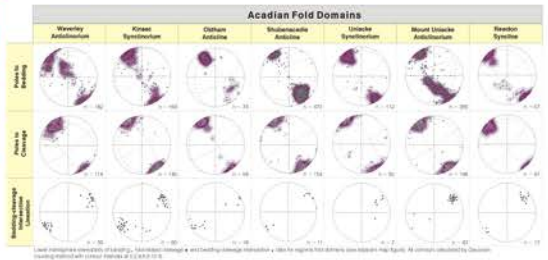
- Acadian Fold Domains** (Brown, Purple, Yellow): Includes the Wierley, Kinnaird, Clifton, and others.

**Geological Symbols**

- Various symbols for faults, folds, and other geological features.

**Legend**

- Scale: 1:50,000
- North Arrow
- Map Date: 2006



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## Halifax Formation (ARD) Summary:

aerially extensive

topographic highs

thin till cover (low buffering capacity)

mineralogy (pyrrhotite, crystal form, distribution, magnetic)

rate of reaction (very rapid - chemically and biologically)

structure (cleavage)

stratigraphy (Cunard Member)

aggregate (low cost, easily accessible, compacts)

+ rate of ARD production exacerbated by development

= “**PERFECT STORM**”

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## Policy, Planning and Process

ARD – “Perfect” example of disconnect between geology and human activities.

### WHY?

- Limited “policy” direction or guidelines
- Geology generally ignored during planning in past
- Attitudes, perceptions and actions (process)
  - “I didn’t know”
  - Extreme environmental impacts rare
  - We CAN “engineer” solutions

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## *Policy without Geology - Lessons*

Historically ...

- **Poor understanding of complex concepts**
- **Ineffective regulations**
- **Severe environmental impacts at a number of sites**



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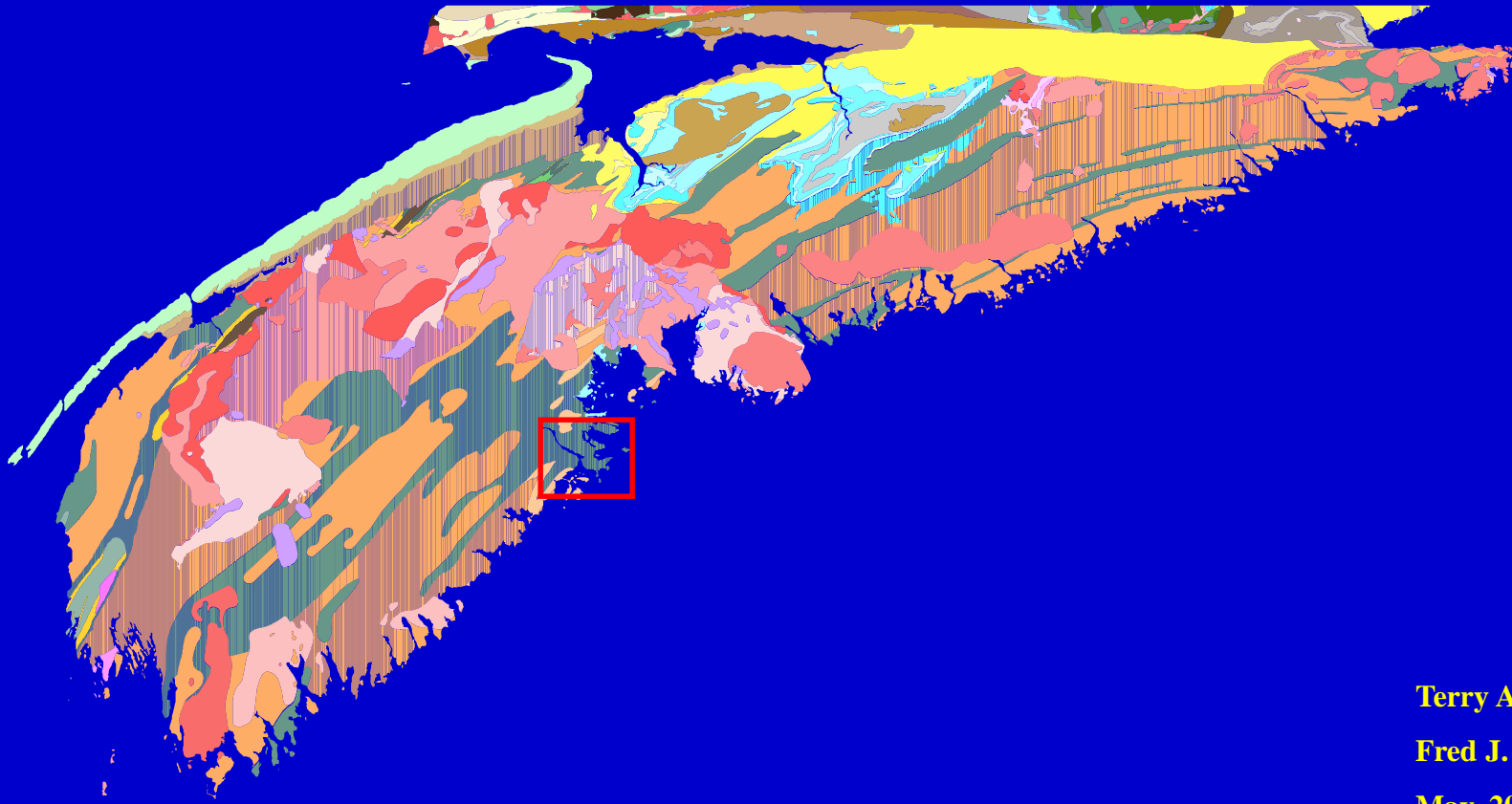


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## *Policy without Geology - Lessons*

**Extensive potential for impacts associated with ARD**



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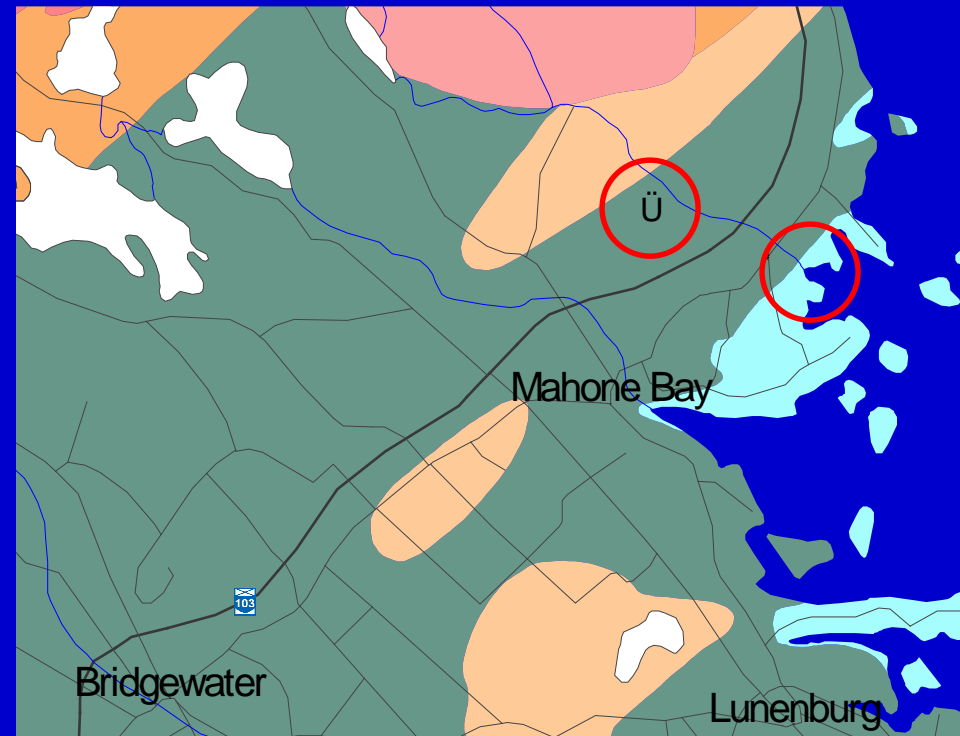
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## *Policy without Geology - Lessons*

“Accidental” disruption of slate material problematic

- Halifax International Airport (1960’s – 2000’s)
- Martin’s Brook (1990’s)



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## *Policy without Geology - Lessons*

**Geological investigation**

**+ proper sampling**

**= ARD Potential**

**• Petpeswick Lake**



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## *Policy and Planning - Lessons*

*Caveats in Current Legislation??*

**Sulphide Bearing Material Disposal Regulations (exemptions)**  
**Municipal Government Act - Development Agreements (HRM)**

- **Waterstone Subdivision (late 1990's)**
- **Fairmont Subdivision (today!)**

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## ***Policy and Planning - Lessons***

### ***Caveats in Current Legislation??***

**Environmental Assessment (exemptions)**

**Activities Designation Regulations – Part 2**

**• Pits and Quarries (amendments 2005)**

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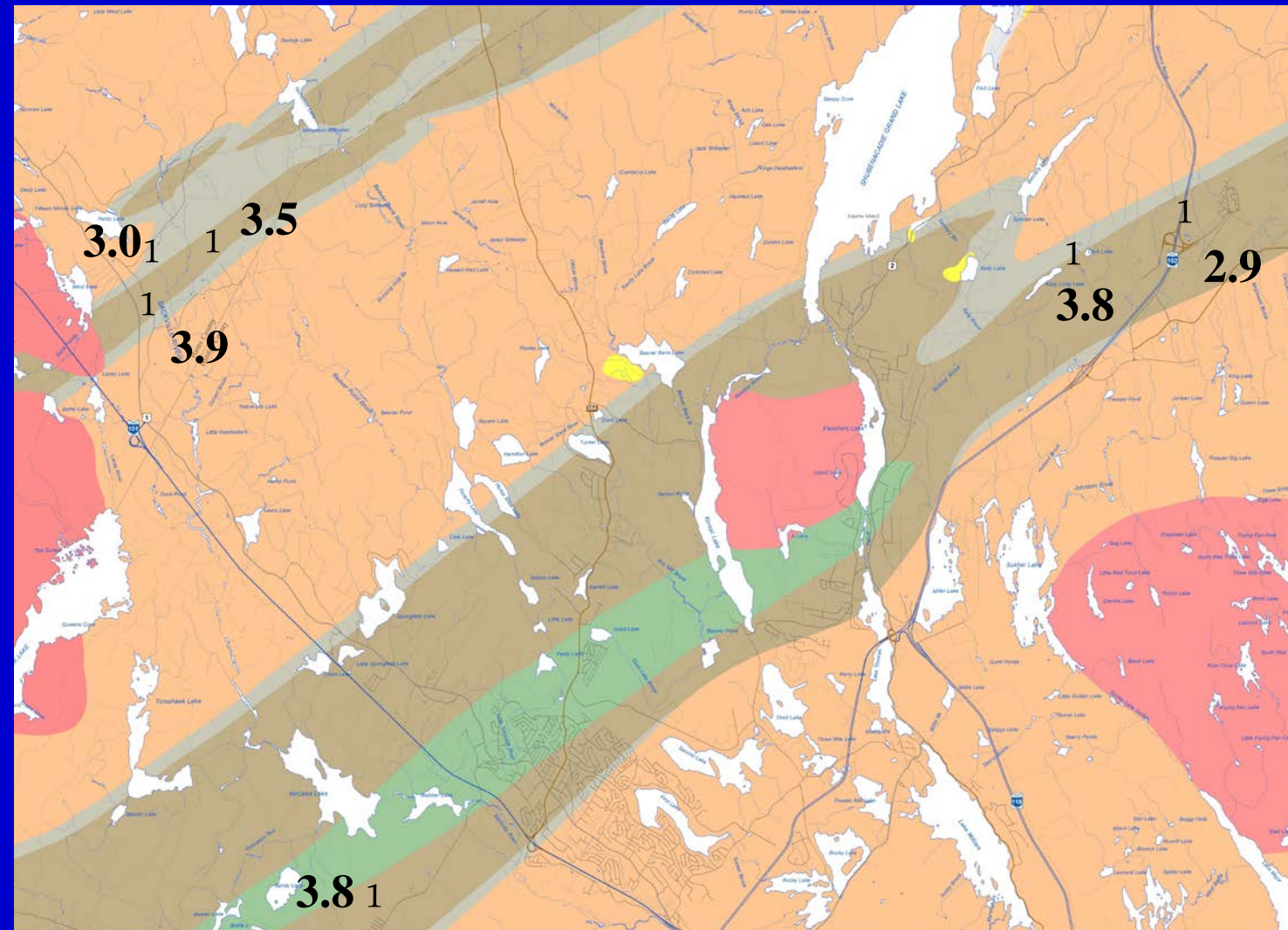
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## *Policy and Planning - Lessons*



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## *Planning and Process – Lessons*

Three most important aspects of connecting geology and planning....

- **Communication (be aware, be informed and be available)**
- **Communication (promote geological information integration)**
- **Communication (build linkages)**

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**“PERFECT STORM”**

+

**Policy, Planning and Process =**

**Future Directions??**

**Human Health Risks??**

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