GaSP: METHANE MITIGATION IN THE ATLANTIC PROVINCES

Professor Grant Wach
Dalhousie University

DALHOUSIE UNIVERSITY

Basin & Reservoir Lab

Natural Resources Canada | Ressources naturelles Canada

Canada

Energy Innovation Program
Project code: CEI-MET-620

GAS SEEPAGE PROJECT

ASSESSING METHANE EMISSIONS FROM LEGACY FOSSIL RESOURCES DEVELOPMENT AND METHANE MITIGATION POTENTIAL IN ATLANTIC CANADA

Dr. Grant Wach, Dr. David Risk, Dr. Michelle Gray, Dr. Owen Sherwood, Dr. Kerry MacQuarrie, Dr. Karl Butler, Dr. Maurice Dusseault, Dr. Richard Jackson and Dr. Robert Walsh

eosense environmental gas monitoring | exp. | SkySquirrel technologies | Geofirma Engineering Ltd

DALHOUSIE UNIVERSITY | UNB UNIVERSITY OF NEW BRUNSWICK | ST. FRANCIS XAVIER UNIVERSITY | UNIVERSITY OF WATERLOO

PARTNERS AND COLLABORATORS

University Involvement

Dalhousie University (Proponent)
- Grant Wach, Tom Martel, Owen Sherwood

University of New Brunswick
- Kerry MacQuarrie, Dave Keighley, Karl Butler, Michelle Gray

St. Francis Xavier University
- Dave Risk (Flux Lab), Patrick Withey

University of Waterloo
- Maurice Dusseault

Industry Involvement

Geofirma Engineering
- Richard Jackson, Robert Walsh

Eosense
- Nick Nickerson

SkySquirrel / VineView
- Richard Van der Put

EXP Services Inc.
- Fred Baechler

EMG
- Edwin Macdonald

PURPOSE OF STUDY

- **Canada** strives to **reduce methane emissions** by 40-45% from the oil and gas sector below **2012 levels by 2025**
- **New Brunswick**: 85% onshore wells are suspended / abandoned
- **Nova Scotia** has approx. 7,000 historic mine openings, including 1,922 pits, shafts, adits and stopes
- **Improperly sealed wells** may lead to well bore leakage and gas migration into groundwater, soils and the atmosphere
- **Abandoned mines** may emit methane at a near-steady rate for an extended period

Hon. Catherine McKenna MP
Minister of Environment and Climate Change

Hon. James Carr
Minister of Natural Resources

Prime Minister Justin Trudeau

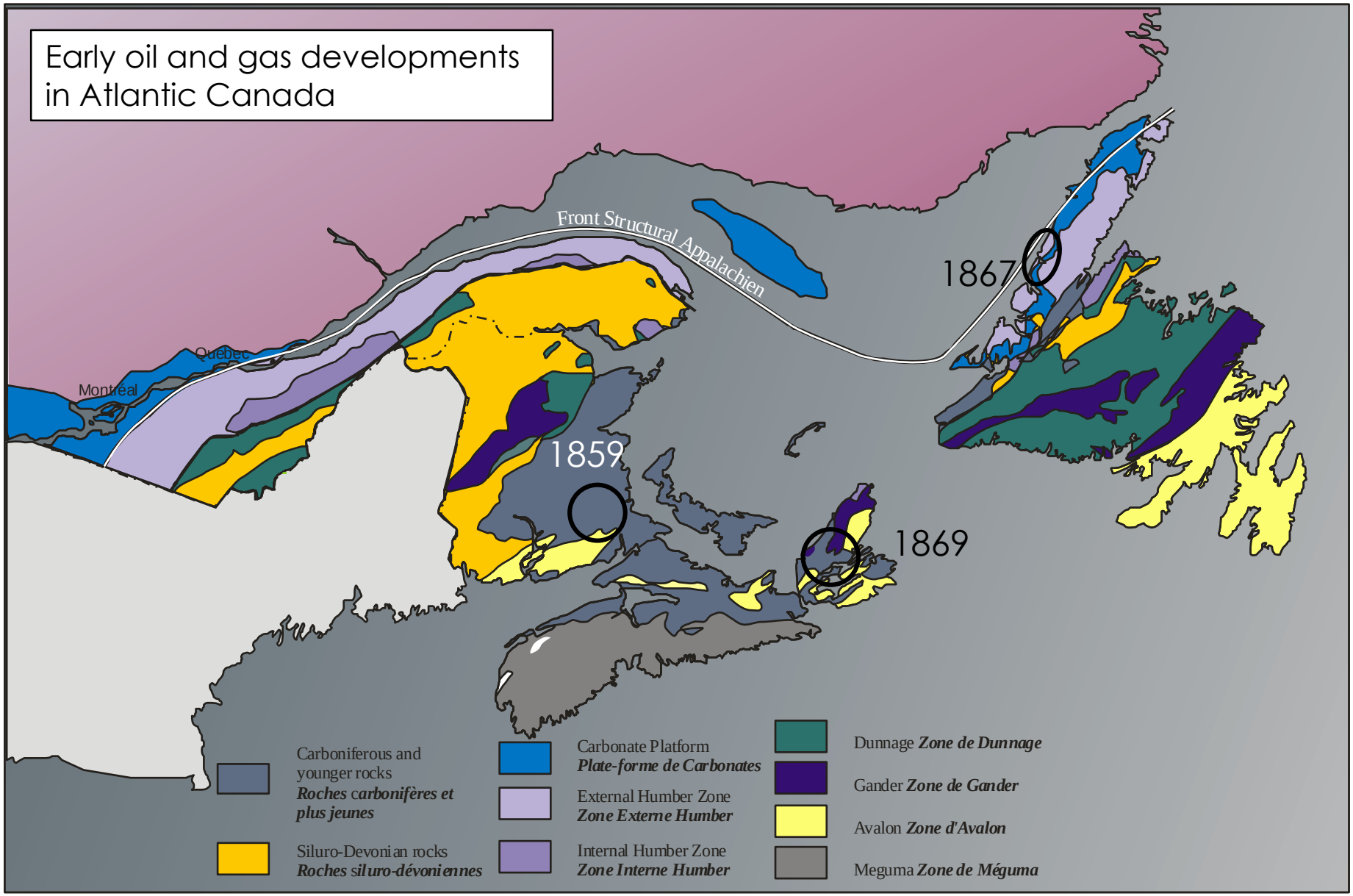
GASP PROJECT OBJECTIVES

- Measuring **methane emissions** from fossil fuel resource sites in NS and NB
- Identify mechanisms of **gas migration** (source and pathways)
- Develop new or improve existing, **methane inventory models**
- Determine **emission factors** for legacy wells & coal adits
- Examine **mitigation potential** for government and industry decision making
- **Develop sensors** and field deployable analytical **technology**
  - Eosense Inc: autonomous methane detection sensors
  - SkySquirrel : drone-based gas impact sensing for oil and gas markets.

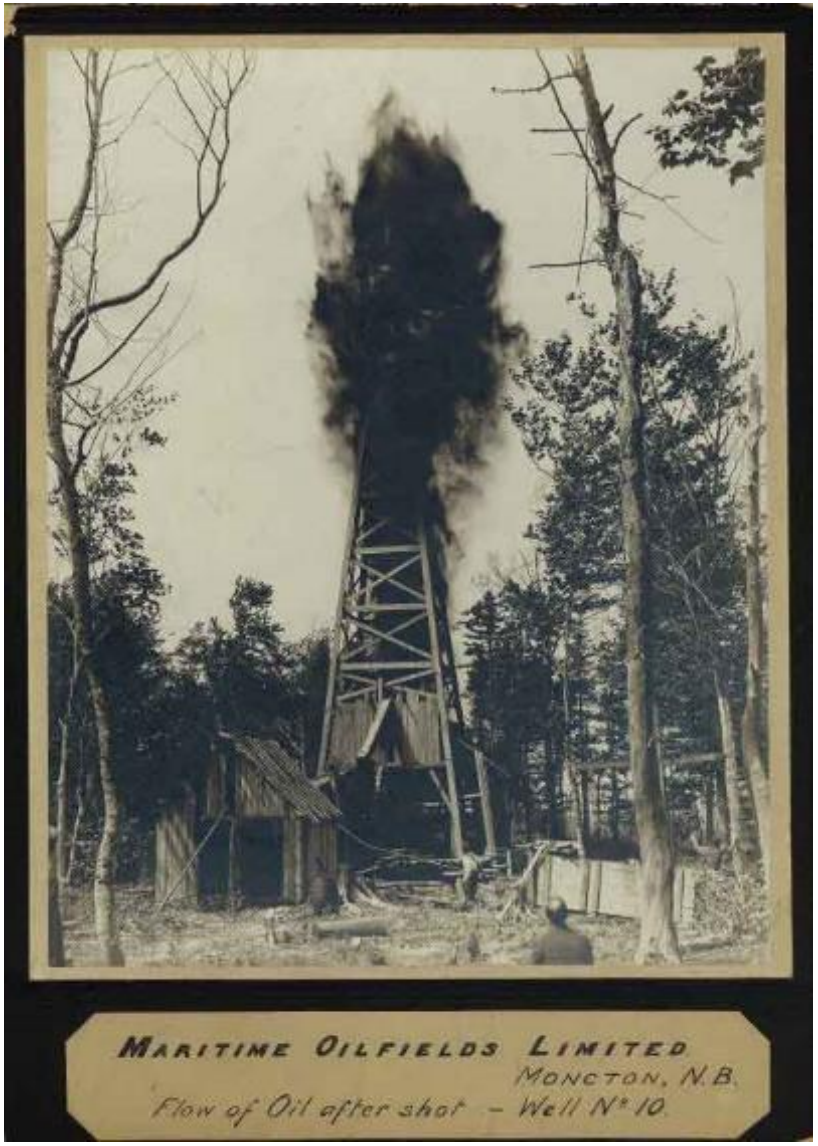
Coal slide, Joggins, Nova Scotia circa 1879

PROJECT TASKS

- Task 1
  - Field logistics, preparation, networking, remote sensing data
- Task 2
  - Gas surveying
- Task 3
  - Surface environmental indicators
- Task 4
  - Groundwater sampling and tracing
- Task 5
  - Geological characterization
- Task 6
  - Techno-economics and synthesis


Early oil and gas developments in Atlantic Canada
Front Structural Appalachien
Québec
Montréal
1867
1859
1869
Carboniferous and younger rocks
Roches carbonifères et plus jeunes
Siluro-Devonian rocks
Roches siluro-dévoniennes
Carbonate Platform
Plate-forme de Carbonates
External Humber Zone
Zone Externe Humber
Internal Humber Zone
Zone Interne Humber
Dunnage Zone de Dunnage
Gander Zone de Gander
Avalon Zone d'Avalon
Meguma Zone de Méguma

HISTORICAL CONTEXT



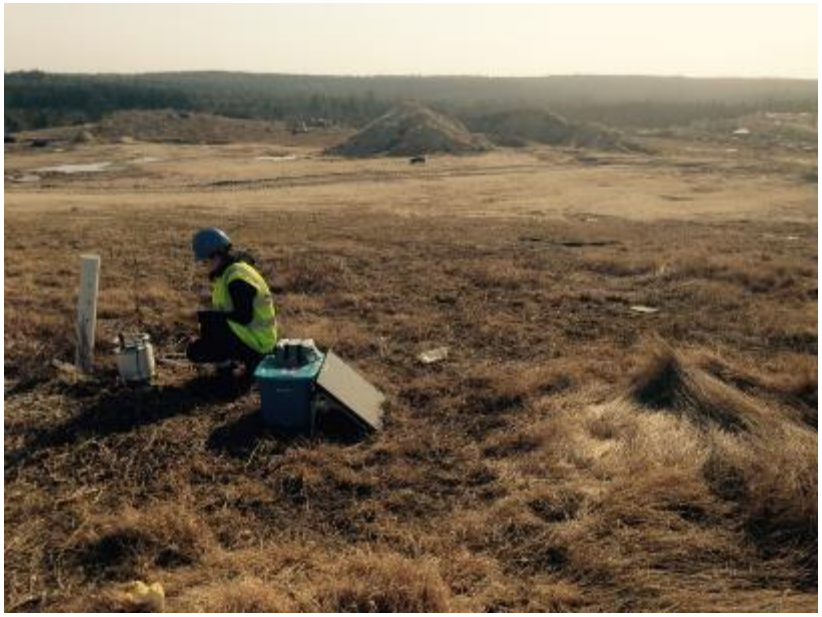
Source: New Brunswick Museum, New Brunswick Maritime Oilfields Ltd

Abandoned well before reclamation processes
Hants County, Nova Scotia
Source: Halifax Media Co-op, June 2014

TASK 1: FIELD LOGISTICS, PREPARATION, NETWORKING, REMOTE SENSING DATA

Edwin MacDonald
Context, Logistics: **Historical context**, group education, networking, logistics, **past geological interpretations**

Fred Baechler
Geology, Gases: (1) collect relevant data on **mine pools and bootleg workings** in the Sydney area;(2) assist StFX surface **methane detection activities** with airborne assessment of emissions surrounding outfall points



TASK 2: GAS SURVEYING

Nick Nickerson

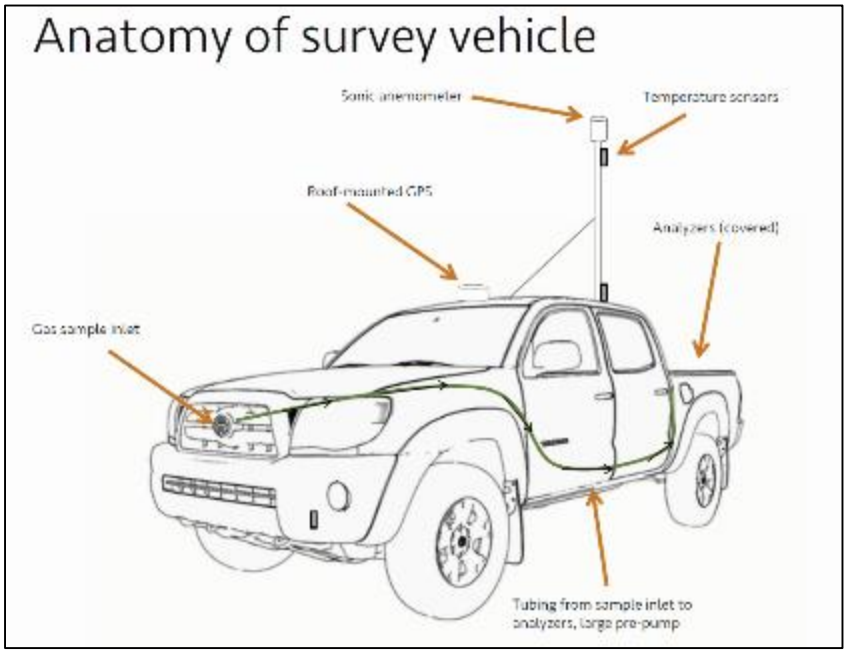
Instrumental development: Refine and build **CH_4-CO_2-O_2 flux continuous measurement prototypes**, deploy for measuring episodic releases, quantification of flux rates

David Risk & James Williams

Soil Gas, Atmosphere: **Surface gas prospecting** to locate emitting features via atmospheric methane, ethane, and methane isotopes, soil gas sampling around **46 wells** to look for gas migration, and gas prospecting **near coal mine entrances**

TASK 2: GAS SURVEYING RESULTS

- Data to aid development of **methane detection strategies** within the poorly understood onshore coal and O&G industries
- **Superambient CH_4 concentrations** detected from leaking surface infrastructure (e.g. abandoned well heads)
- **Detection frequency** of gas migration from abandoned wells ranged from **8% to 15%**
  - 1 site of 12 (8%) inspected confirmed to suffer gas migration
    - Soil fluxes measured to be 25 (+/- 32) grams of CH4 per day
  - **Vehicle-based** regional surveying found 7 of 46 wells (15%) were potentially leaking
  - **Overall emission severity is low**, (compared to current regulations) but more work required



TASK 3: SURFACE ENVIRONMENTAL INDICATORS

Michelle Gray

Surface Bio Indicators: Collected **abiotic habitat parameters** (e.g. temperature, conductivity, flow, substrate, diatoms, bugs, fish) identified at important **groundwater seeps** into surface streams and ponds

Richard van der Put & Clarissa Theriault

Drone based techniques: SkySquirrel/Vineview collected multispectral imagery to produce **vegetation index maps** for O&G wells in Stoney Creek, N.B. Imagery is being used to determine **methane impact** on surrounding vegetation and how these techniques may be used to detect leaks at other sites

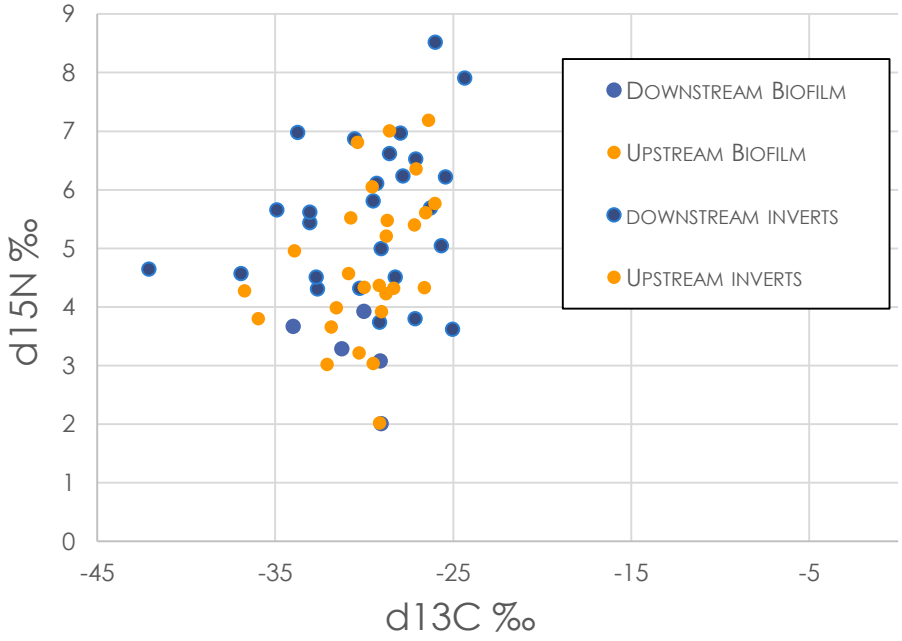
TASK 3: SURFACE ENVIRONMENTAL INDICATORS

- **Thermal imaging camera** detected locations of groundwater input into streams
- Use of IDEC diatom index to assess stream health
  - Compares upstream abundance to downstream
  - All sites were determined to be "Slightly Polluted" (IDEC Eastern Canadian Diatom Index)
- **Drone Camera** found **no correlation** between vegetation vigor and ground data. Further work required.

Biological integrity classes		IDEC-Neutral
A	Reference state	]70–100]
B	Slightly polluted	]45–70]
C	Polluted	]20–45]
D	Highly polluted	[0–20]

IDEC Biological Integrity Classes

- **Stable carbon isotopes** able to detect **methane uptake** in food web, and should see effects of methane downstream compared to upstream
  - **Methane does not appear to be impacting the food web. More work is required.**



TASK 4: GROUNDWATER SAMPLING AND TRACING

Owen Sherwood

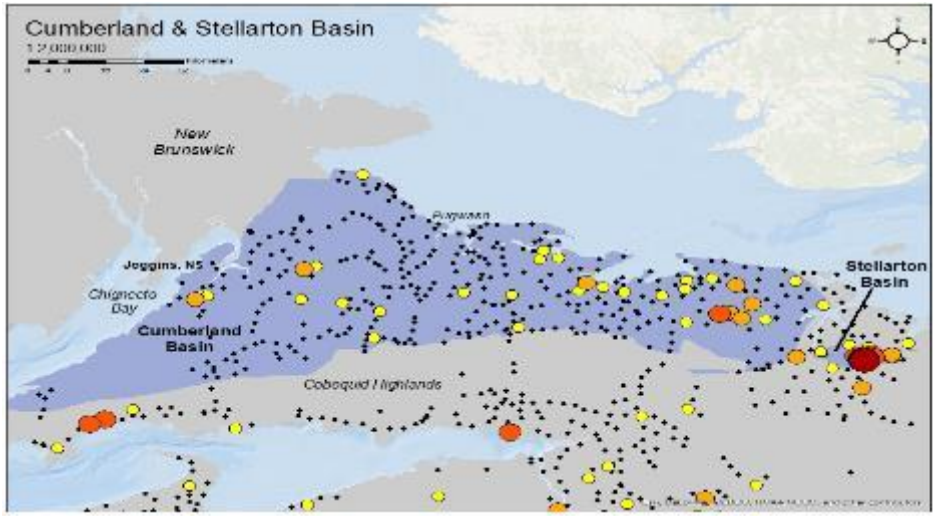
Groundwater methane (Nova Scotia): **Groundwater source tracing** using C_1-C_6 alkanes, methane carbon and hydrogen isotopes, and C_1-C_3 carbon isotopes

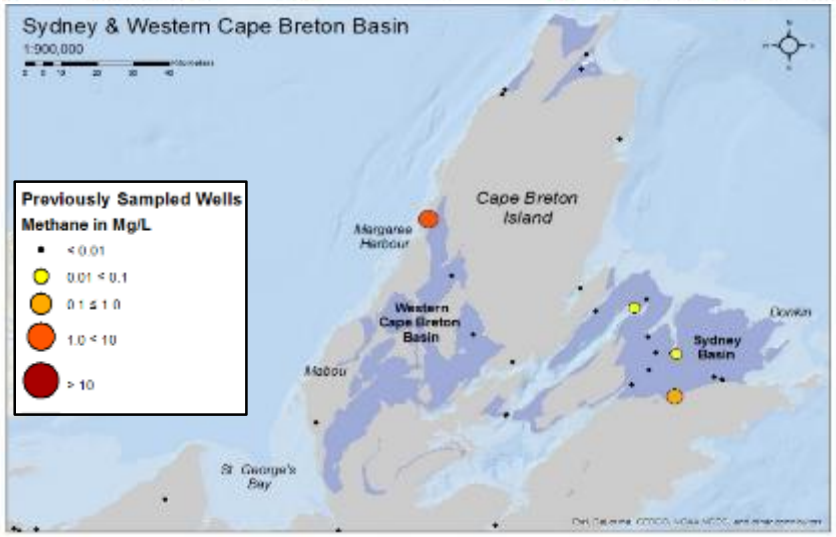
Kerry MacQuarrie

Groundwater methane(New Brunswick): First order **groundwater flow map** and methane concentration analysis; **42 water wells** sampled within a **10 km radius of Stoney Creek oil field**

TASK 4 RESULTS: NOVA SCOTIA

- **Elevated levels of dissolved methane** in Stellarton Basin
  - 10 wells with methane levels 10-28 mg/L
  - 2 wells with methane levels >28 mg/L
- **Low levels of dissolved methane** in Cumberland and Sydney basins
  - All methane levels <10 mg/L
- Methane Characterization:
  - Cumberland: Biogenic
  - Stellarton: Mix of Biogenic and Thermogenic
  - Sydney: Thermogenic
- Ongoing work to determine potential migration pathways





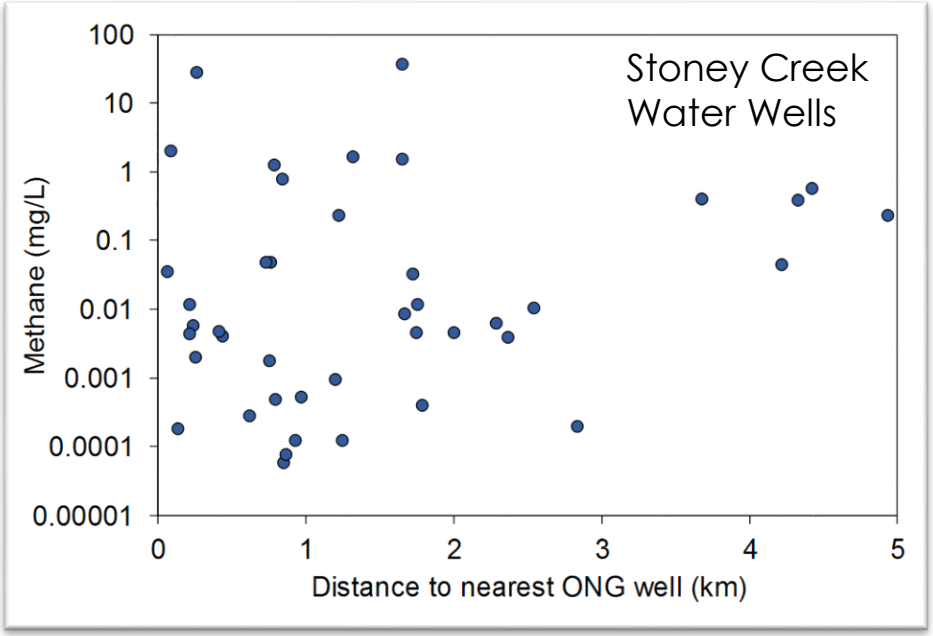
TASK 4 RESULTS: NEW BRUNSWICK

Dissolved methane detected (>0.0005 mg/L) in 81% of 42 sampled wells

- Higher frequency and higher median compared to undeveloped O&NG areas
- 2 wells with methane concentrations of between 28-36 mg/L
  - Horton Group bedrock nearer to surface, and this is an area of historic bitumous shale exploration
- Remainder of wells had dissolved methane concentrations <7 mg/L

Cannot definitively determine that Stoney Creek O&NG field is impacting private well water. **Results suggest geology in vicinity of water wells contributes more methane**.

Further work is recommended.



TASK 5: GEOLOGICAL CHARACTERIZATION

Grant Wach Geology: **Geological interpretations of coal mines in NS**, (using new datasets and existing field measurements)

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Tom Martel Geology: Historical context, field work, **characterizing geology and data interpretations**

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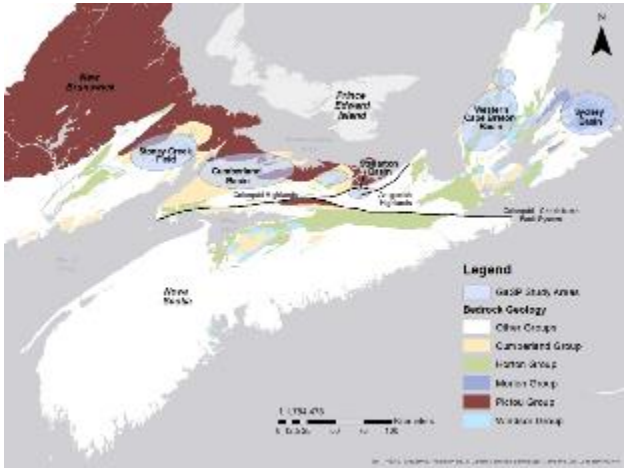
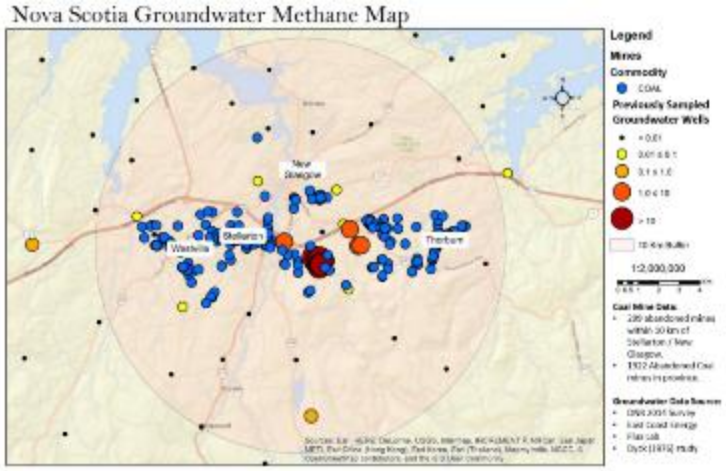
Karl Butler Geophysics: **Locate abandoned well casings**, cut off below surface, by magnetic surveys to aid targeting soil gas sampling

UNB

Dave Keighley Geology: **Geological interpretations for Stoney Creek** oilfield, NB, using existing datasets and new field measurements

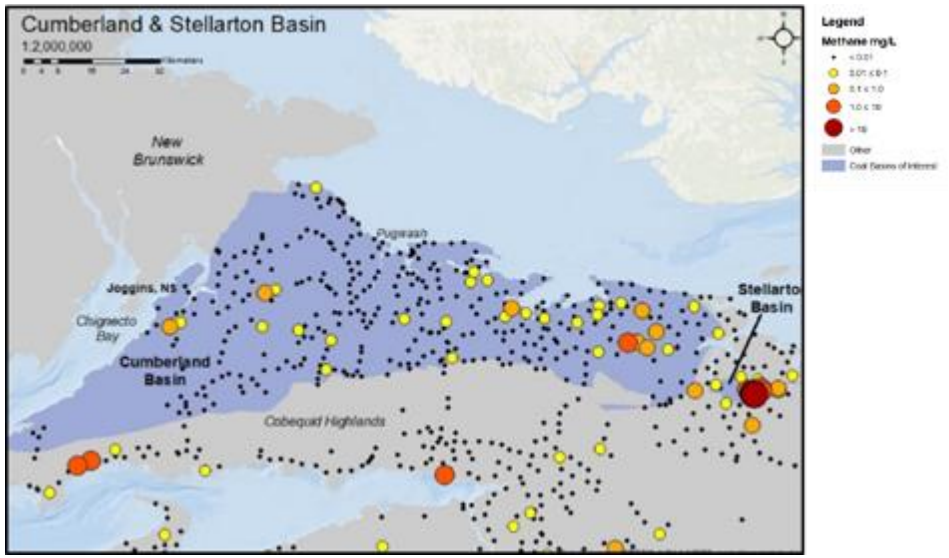
UNB

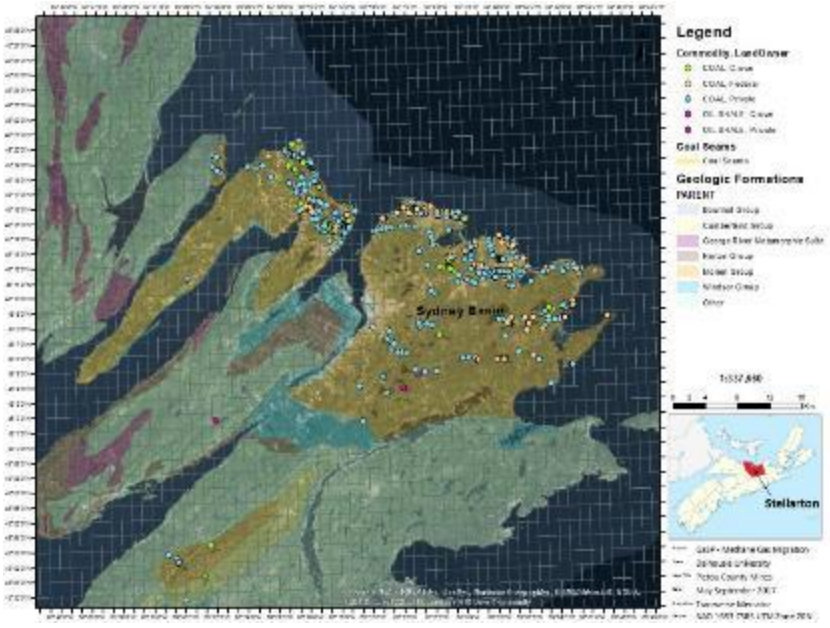




TASK 5: CHARACTERIZATION RESULTS

- **Arcmap** of new and legacy emissions and geologic data
  - Comprehensive structural and stratigraphic characterization of each basin
  - Spectrometry and soil methane sampling
  - Well water type sections
- **Magnetic surveying** through Stoney Creek **did not prove a correlation between well depth and emissions**
  - Same formation throughout, 39 well sites visited lack of access)
  - Research into drone based surveying shows promise (removes terrain barriers)





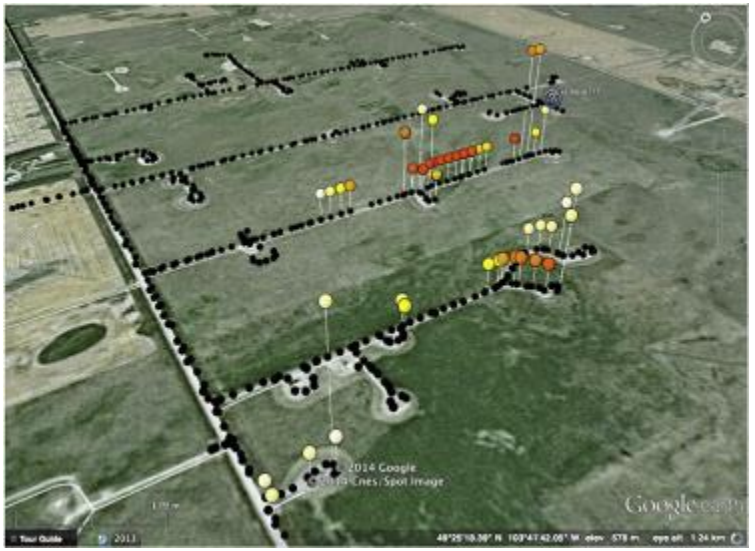
TASK 6: TECHNO-ECONOMICS AND SYNTHESIS

Maurice Dusseault

Well Mitigation: Evaluated legacy well records to determine **completion and abandonment techniques**, correlating to current observations of **well integrity loss**. Improved methods for mitigation of post-casing gas migration through literature and technical products

Patrick Withey & Robert Walsh

Environmental Economics: Preliminary estimates of abatement costs for methane across well sites, plus return costs vs abatement costs based on **varying levels of carbon pricing**

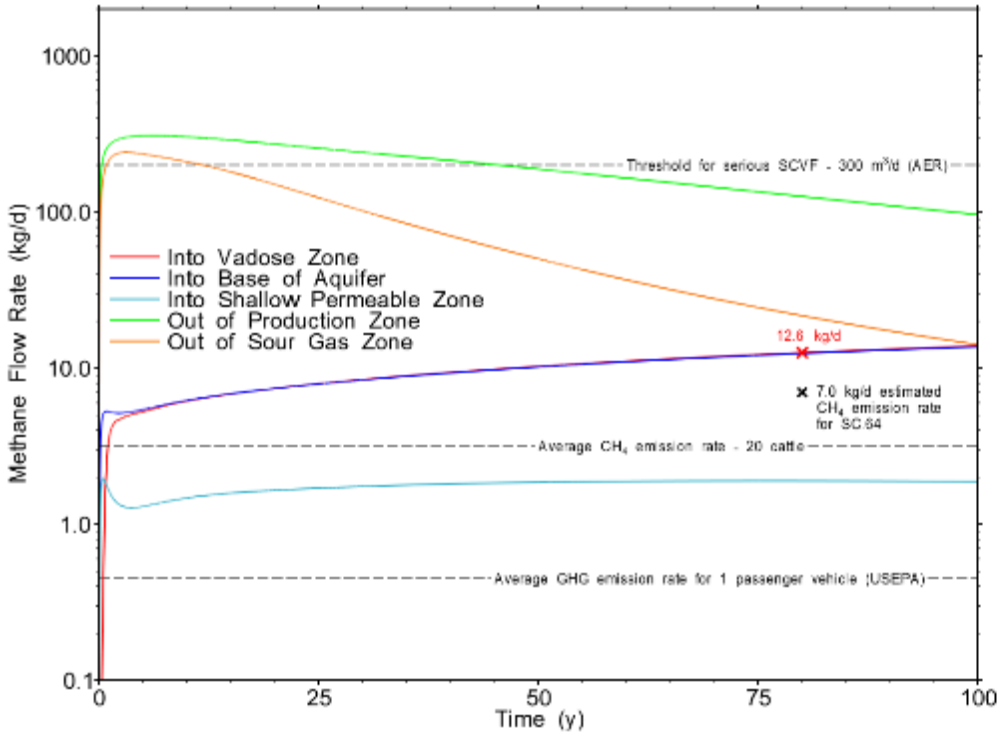


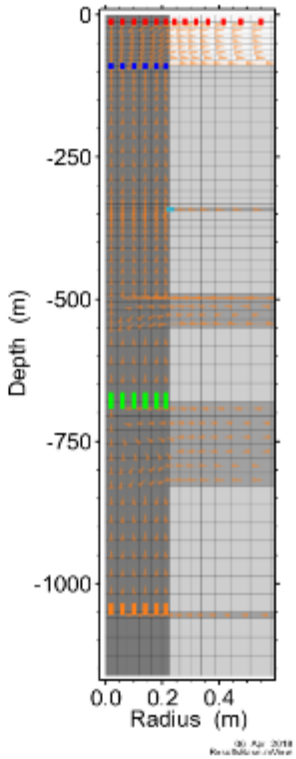
TASK 6: TECHNO-ECONOMICS AND SYNTHESIS

Stoney Creek field data (historical, provincial, GaSP) synthesized into one complete picture

- Conceptual model for subsurface natural gas movement and fugitive emissions produced
- Can be used by the GaSP team to interpret task results
- May be used to **evaluate plans** for remediation of suspended/abandoned wells **to reduce emissions**

- With **carbon pricing** and emissions regulations, **a market could develop** for economical abandonment technologies.





CONCLUSIONS

- **GaSP is a preliminary regional methane emissions study, one of the first in Canada**, to investigate fluxes of methane from source geological reservoirs, through groundwater and soil conduits, to the atmosphere
- Concentrations of groundwater and atmospheric methane showed **modest increases in the vicinity of legacy fossil fuel extraction sites** that we were able to access
- Attribution to **natural vs industrial activity** remains difficult due to limited access to legacy well sites and lack of formal cooperation with industry and government
- A multi-party geoscientific investigation of the Stoney Creek area and other legacy areas will be required **before effective policies and regulatory frameworks can be created and implemented**
- **Modest funding requirements** are needed to continue these research efforts
- Independently conducted performance assessment of mitigation technologies is needed to mitigate emissions from legacy sites at **reasonable costs**

Dr. Richard Jackson

Dr. Michelle Gray

Dr. Patrick Withey

Dr. Diana Loomer

Dr. Kerry MacQuarrie

Fred Baechler

Dr. Robert Walsh

Dr. Karl Butler

Dr. Grant Wach

Dr. Owen Sherwood

Dr. Maurice Dusseault

Dr. David Risk

Elliot McLauchlan

Amy Rowe

Jack Evans

Benjamin Plazek

Mitch Grace

Mohammad Oyarhossein

Fiona Henderson

Kim Taylor

Chelsie Hall

Dr. David Keighley

Natasha Morrison

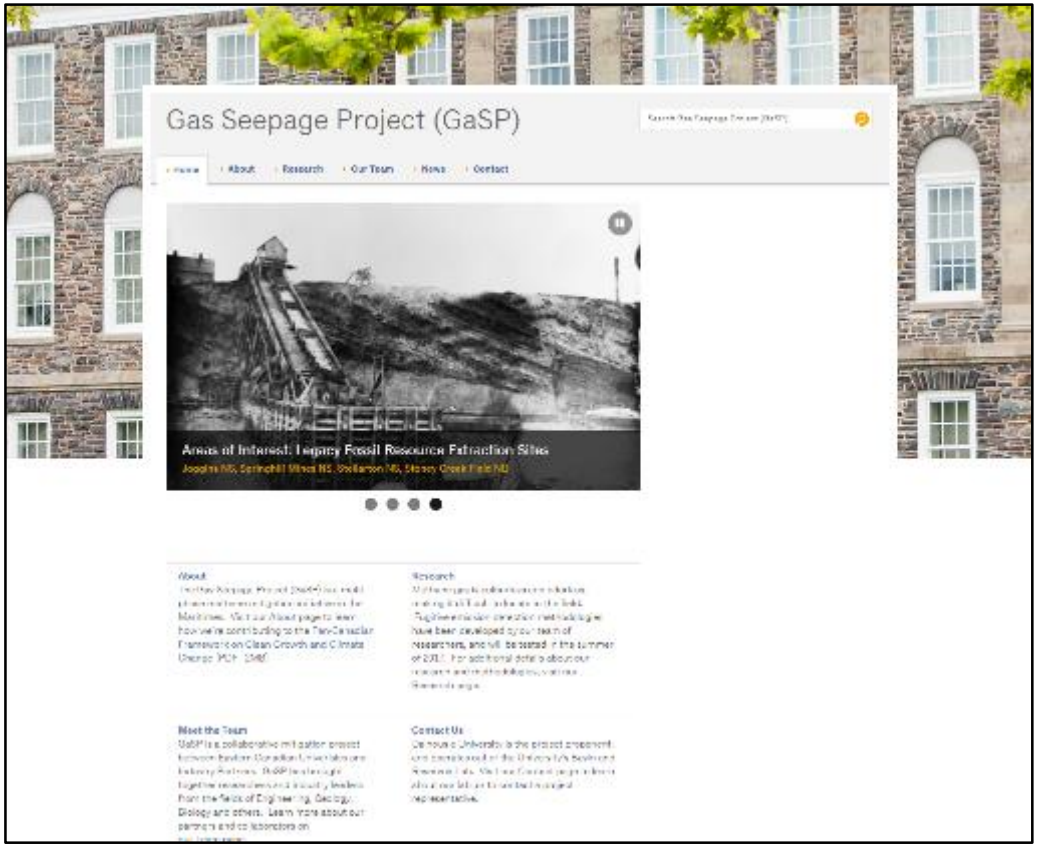
James Williams

Chelsea Fougere

Colin McKenzie

Not Pictured
Edwin Macdonald
Colin Macadam
Tom Martel
Dr. Muki!

WEBSITE AND REPORTING

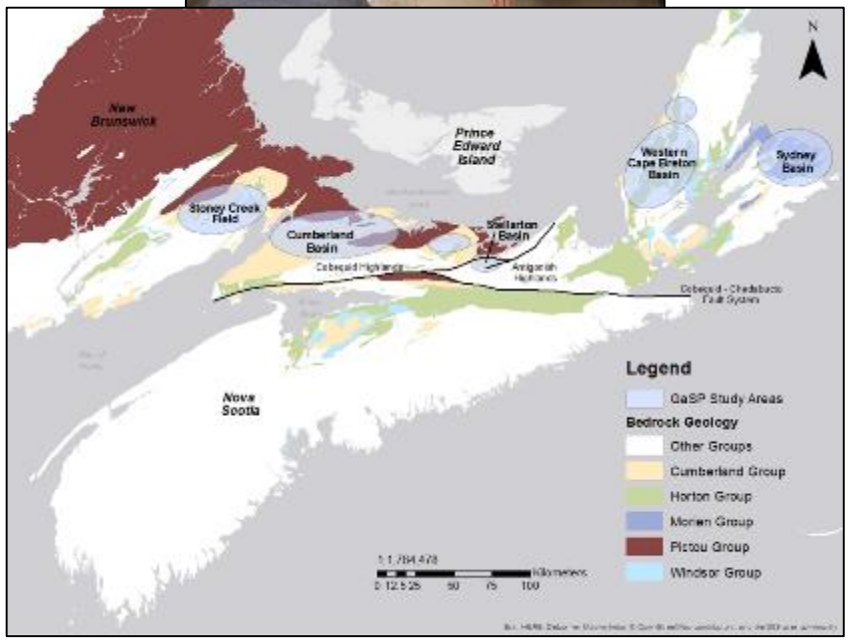


www.dal.ca/sites/gasp.html

Nova Scotia:
Department of Natural Resources

New Brunswick:
Energy and Resource Development

GRADUATE RESEARCH POSTERS



Methane Emissions from Legacy Infrastructure at the Stoney Creek Oilfield, New Brunswick

James Williams, David Risk

Sources of Groundwater Methane in Proximity to Legacy Coal Mines in Nova Scotia

Kimberley Taylor, Owen Sherwood

Geologic Characterization and Historic Mining Data Analysis of Abandoned Coal Mine Sites in Nova Scotia

Fiona H. Henderson, Elliot McLauchlan, Grant Wach

QUESTIONS?