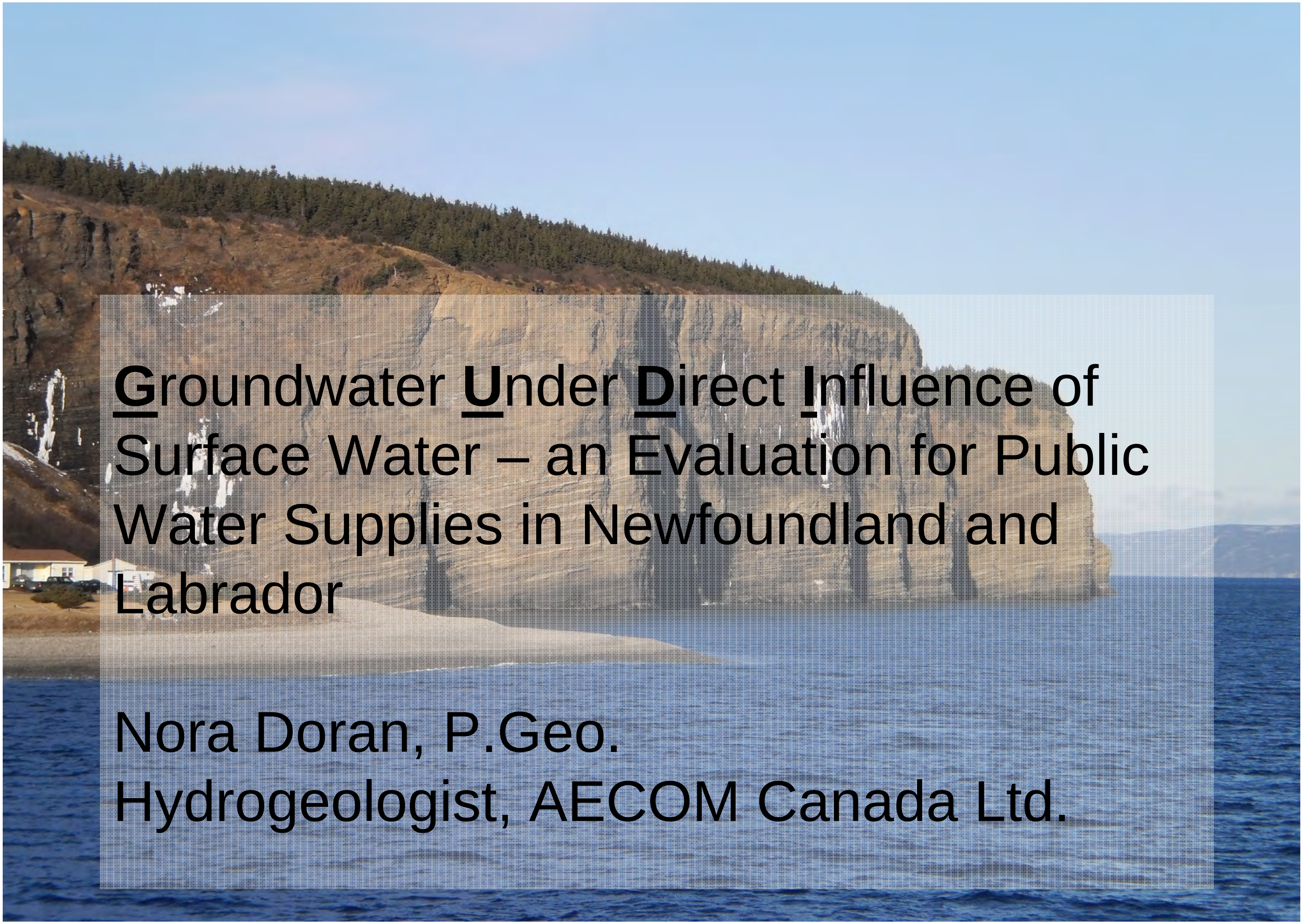

Groundwater **U**nder **D**irect **I**nfluence of Surface Water – an Evaluation for Public Water Supplies in Newfoundland and Labrador

Nora Doran, P.Geo.
Hydrogeologist, AECOM Canada Ltd.

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- Multi-national professional services consulting firm
- AECOM acronym for: **A**rchitecture, **E**ngineering, **C**onsulting, **O**perations and **M**aintenance.
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    - 40 staff in Atlantic Canada
    - Offices in Halifax and Sydney, NS
    - Working towards opening a NL office
- Incorporated in 2009, AECOM Canada Ltd. is the result of the amalgamation of the following firms:
    - UMA Engineering Ltd. (established 1911),
    - Gartner Lee (established 1973),
    - Totten Sims Hubicki Associates (established 1962),
    - Earth Tech (Canada) Inc. (established 1970)

AECOM Study Team

Nora Doran, P.Geo.

Hydrogeologist and manager of Environmental Department of AECOM's Halifax, NS office. Nora has completed over 40 GUDI evaluations and 50 hydrogeological evaluations in Atlantic Canada.

Tim Lotimer, P.Geo.

In 2000, Tim Lotimer helped with the investigations into the causes of the Walkerton Water Tragedy, where 7 people died and thousands became sick from drinking water from a municipal well that was GUDI without appropriate treatment. Tim Lotimer has been a member of the review team and expert panels for development of GUDI protocols for the Ontario Ministry of Environment and Nova Scotia Environment.

Presentation Overview

1. What is GUDI ?
2. Pathogens: viruses, bacteria and parasites
3. Treatment considerations
4. AECOM's Study
   - Scope and objectives
   - Results
   - Key study findings
5. Regulatory Recommendations

What is GUDI?

<u>G</u>roundwater **<u>U</u>**nder the **<u>D</u>**irect **<u>I</u>**nfluence of Surface Water

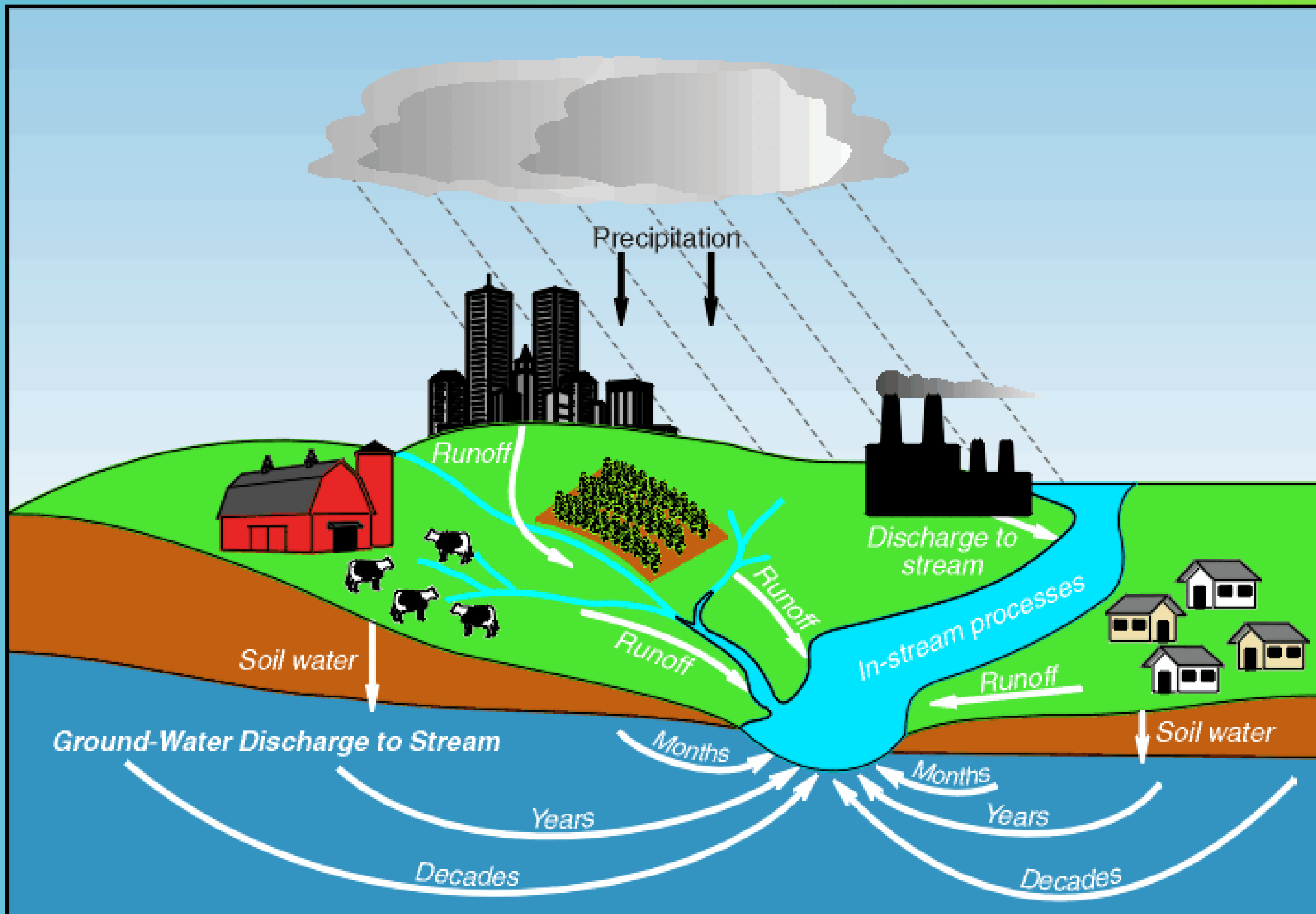
GUDI is defined by US Environmental Protection Agency as any groundwater with a significant occurrence of:

- insects,
- macro organisms,
- algae, or
- large-diameter pathogens such as *Giardia lamblia or Cryptosporidium*

and/or

- any groundwater with a significant and relative rapid shift in turbidity, temperature, conductivity or pH, correlating to surface water/ climatological conditions

Groundwater in hydraulic connection with the surface



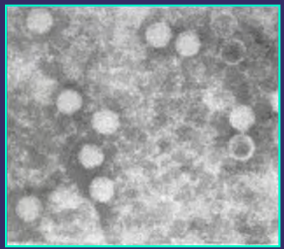
Nutrient Transport in the Groundwater System

Pathogen Threats

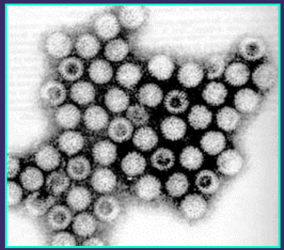
- Acute vs. chronic health effects
  - Acute = sudden and severe exposure, rapid absorption; (e.g., cholera, e-coli, carbon monoxide poisoning)
  - Chronic = prolonged exposure over many days, months, years (e.g. lead or mercury poisoning)
- Acute are most often associated with waterborne pathogens
- A waterborne disease outbreak is usually considered to be the result of acute illness affecting two or more people associated with drinking water consumption
- Enteric pathogens – multiply only in the gastrointestinal tract of humans and other animals
- Coliforms and *E-Coli* are indicators that pathogenic bacteria, viruses and/or protozoa may be present in the water supply

The pathogens

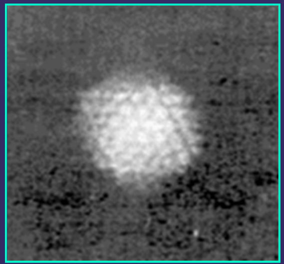
Viruses
(0.02-0.1 µm)



Poliovirus



Rotavirus

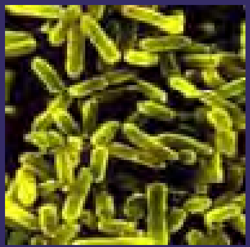


Adenovirus

Bacteria
(0.5-2 µm)

Salmonella

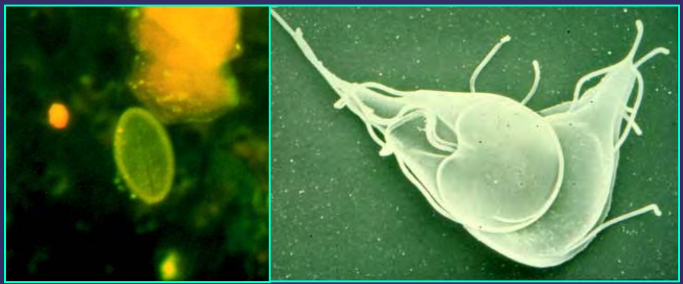
Campylobacter



E.coli O157H7

Parasites
(2 - 50 µm)

Cryptosporidium parvum (2-5 µm)



Giardia lamblia (10-12 µm)

INRS - Institut Armand-Frappier
Université du Québec

Disinfection of Drinking Water

- Health Canada recommends:
  - Minimum 3 log (99.9%) reduction or inactivation of parasites (*Cryptosporidium and Giardia)*
  - Minimum 4 log (99.99%) reduction or inactivation of viruses
- Treatment requirements depends on characterization of water source as being either:
  - Surface water, including a well that is groundwater under the direct influence of surface water (GUDI), <u>or</u>
  - Groundwater

Treatment

- Surface water treatment typically met by a combination of:
  - 1) Engineered filtration - to produce a water with low turbidity/particles that may interfere with disinfection
  - 2) Disinfection - to kill or inactivate pathogens

- "True" groundwater – water found in an aquifer where the overburden and soil acts as an effective filter that removes micro-organisms and other particles by straining.
  - Treatment typically met by primary disinfection for inactivation of viruses. Typically achieved by chlorination

Treatment (cont'd)

▪Municipal drinking water treatment providing filtration and disinfection with chlorine can reduce the risk of contracting giardiasis and cryptosporidiosis.

▪Chlorine by itself is <u>not</u> effective against *Cryptosporidium* but it can inactivate *Giardia.*

▪Recent research by Health Canada indicates ultraviolet light will inactivate both.

▪Health Canada Draft Guideline Turbidity in Drinking Water (2012) discusses how turbidity compromises disinfection process.

- For non-GUDI wells, turbidity > 1 NTU is acceptable
- If turbidity is > 1 NTU, the cause should be investigated

▪Determining whether a supply is GUDI is a complex process including evaluation of geology, hydrogeology, geochemistry, microbiology, land use and soils.

Purpose of a GUDI study:

- To identify communal wells that require treatment beyond a minimum level of primary disinfection to ensure that appropriate treatment is provided to inactivate or remove human pathogens such as viruses, bacteria and protozoa.

Overview

Scope of AECOM's study:

1) Assessment of 38 public supply wells in the Province and determine if they are in fact GUDI; and,

2) Provide recommendations to Water Resources Management Division (WRMD) for drafting guidelines regarding:
   - Designation criteria for GUDI wells including wellhead protection strategies;
   - Treatment standards for GUDI wells
   - Treatment, monitoring and management options for GUDI systems.

Focus of today's presentation:

1) Results of the GUDI study completed on 38 wells studied by AECOM
2) To provide an overview of what is GUDI and the potential human health risks if not treated properly
3) To provide recommendations for next steps

Background

Internal study completed by WRMD in 2009:

- Evaluated water quality data collected through the drinking water quality program.
- Criteria for potentially GUDI = Colour > 10 TCU and turbidity > 1 NTU

WRMD Findings:

- 9 groundwater supplies confirmed to be influenced by surface water
- 35 groundwater supplies potentially under the influence of surface water; and,
- 38 groundwater supplies potentially under the influence of surface water during periods of wet conditions.

Scope of AECOM study:

- Evaluation of 38 public supply wells identified by WRMD
- 12 locations in Western Newfoundland and 12 locations in Eastern Newfoundland
- Locations in Labrador and northern Newfoundland were identified but cancelled by WRMD upon initiation of the project due to timing of the project, weather conditions and remoteness.

Approach

Document Review

- Well log records, water quality data WRMD drinking water monitoring, surficial geology, bedrock geology.

Development of a GUDI Questionnaire

- Well designation and location information
- Historical water quality information (interview with well operator)
- Water supply source / well type / sensitive setting
- Well construction information (e.g. depth, casing length, grout, yield, depth of water bearing fractures, etc.)
- Well condition evaluation
- Well condition versus NL Well Drilling Regulations (NL Reg 63/03)
- Aquifer characteristics
- Proximity to sources of surface water

Site Visit, well inspection and interview with well operator

- Information provided the well operators was critical to our study

Study Findings

- Majority of the 38 wells evaluated had unsanitary well heads and did not comply with the NL Reg 63/03

Unsanitary well head refers to:

- any wellhead that is not equipped with a casing that extends to an appropriate height above the surrounding ground; and/or,
- does not have an appropriately vented, watertight and vermin-proof well cover; and/or,
- is not designed to support the pumping equipment in the well.

All of these features must be in place to prevent entry of material that may impair the quality of water in the well.

Examples of Unsanitary Well heads observed during site visits

- Well seal is broken and does not seal property due to the rope coming up from the well pump;
- Well casing is < 30 cm height requirement;
- Exposed electrical wires present a threat of electrical shock;
- Poor housekeeping conditions observed in the pump house.

- No well cap;
- Saw cuts in the casing;
- Insufficient height of casing above the ground;
- Exposed electrical wires present a threat of electrical shock.

Examples of Unsanitary Well heads observed during site visits

- Unsanitary due to penetrations in the well cap
- Insufficient well casing height (< 30 cm)

- Inadequate well seal
  - Holes in well cap
  - Rope coming through well cap
- Insufficient well casing height (< 30 cm)

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Examples of Unsanitary Well heads observed during site visits

- Well is in a well pit
- Unsanitary due to penetrations in the well cap
- Well casing does not extend 30 cm above the ground surface
- Well is constructed in a manner where surface water can enter around the well head.

- Hole in casing (improper well seal)
- Insufficient casing height (< 30 cm)
- Untidy housekeeping in well house (evidence of rodents)
- Pump seems to be supported on well seal using a gear clamp, which is inappropriate.

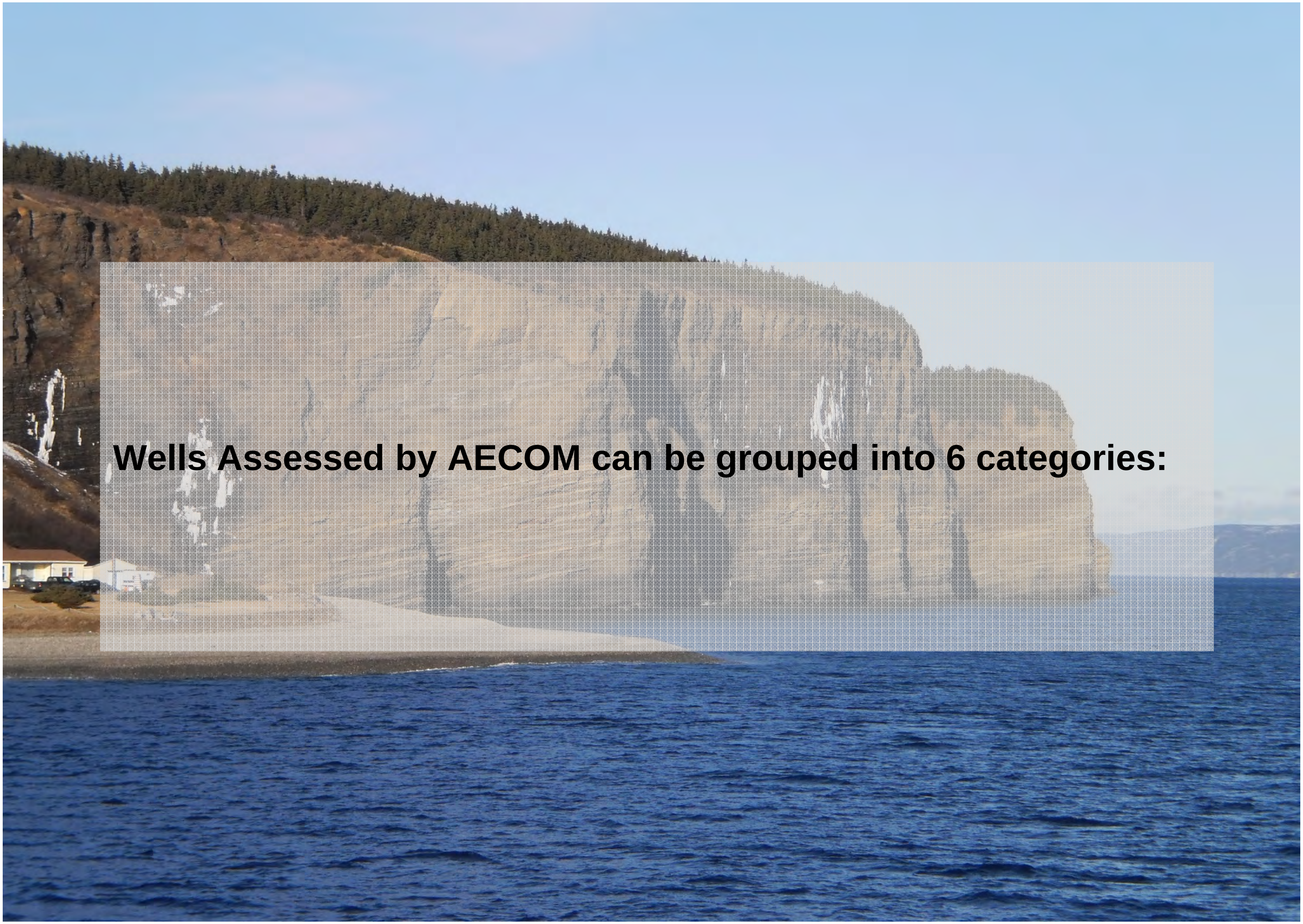
Examples of Unsanitary Well heads observed during site visits

- Penetrations in the well cap;
- Well seal is not properly vented;
- Well casing stick-up is not > 30 cm above the ground surface;
- Pump seems to be supported on the well seal using a gear clamp, which is inappropriate.

- Improper well camp (not vermin proof or vented)
- Insufficient well casing height (< 30 cm)
- Pump seems to be supported on the well seal using a gear clamp, which is inappropriate.

Example of a Properly Sealed Bedrock-Sourced Groundwater Supply Well

- Appropriate length of steel well casing sealed into competent bedrock;
- Affixed with drive shoe having an annular space (e.g. resulting gap between pilot drill hole and well casing) filled with an appropriate sealant from the bottom end of the well casing at the drive shoe extending upward the full length of the casing to a point just below the pitless adapter.
- Well casing extends > 30 cm above the highest point on the ground surface within 3 metres radially from the outside of the casing and above the 100 year storm level.
- Well cap is vermin-proof, is vented and secure



Wells Assessed by AECOM can be grouped into 6 categories:

"Type 1" Wells (3 of 38)

"Type 1" wells include dug wells or shallow overburden wells that are clearly under the influence of surface water as they are very shallow and in a sensitive hydrogeological setting.

Clearly GUDI wells.

“Type 2” Wells (12 of 38)

“Type 2” wells are drilled wells with clearly unsanitary wellheads.

Examples include :

•wells equipped with a well cap that is broken;

• well casing stickup is less than 30 cm above grade;

• the top of the well is equipped with a well cap that does not provide a waterproof or vermin proof seal of the well;

•wellheads where there are holes cut into the casing for various reasons (e.g. rope coming out of the casing to secure the pump) or other poorly sealed penetrations into the cap.;

•wells where the pump appears to be supported on the well seal using a gear clamp that causes the well seal to come apart or fail.

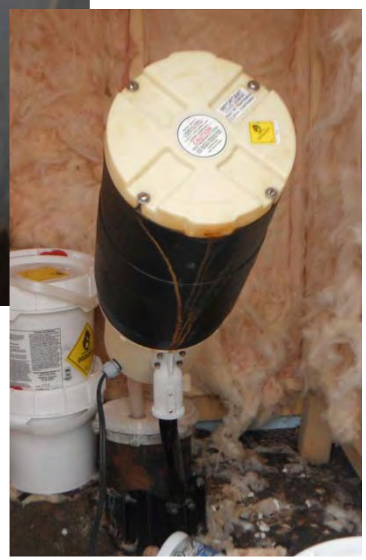
“Type 2” wells are Potentially GUDI

“Type 3” Wells (9 of 38)

“Type 3” wells are drilled wells with wellheads that appear to meet regulatory requirements, however, there is no information about the well’s construction or setting.

- No well log available for Type 3 wells;
- No information about the well depth, casing length, drive shoe, properly sealed annular space surrounding the well casing, thickness and nature of the overburden.

“Type 3” wells are Potentially GUDI



"Type 4" Wells (4 of 38)

"Type 4" wells are wells having unsanitary well heads, however they are not as bad as Type 2 wells.

For example:

- wells where the top of well casing is < 30 cm above ground surface.
- wells with old-style well cap

"Type 4" wells are Potentially GUDI

“Type 5” Wells (3 of 38)

“Type 5” wells are wells where water quality data or anecdotal information provided by the well operator suggests there is a connection to surface.

e.g. “the water becomes cloudy after it rains”

Type 5 wells are GUDI

“Type 6” Wells (2 of 38)

“Type 6” wells are wells where water quality or other indicators provided by NLDEV suggests a connection to surface.

Type 6 wells are GUDI

Summary of Findings

- 6 confirmed GUDI wells and 32 potentially GUDI wells
- 28 of 38 wells (73%) were not in compliance with NL Well Construction Regulations (NL Reg 63/03)
  - Non-compliance well conditions may be a contributing factor to observed poor water quality.
  - Implementation of a sampling program to further characterize GUDI conditions of these wells likely to be biased by well conditions.
- There is a significant lack of well construction information for all 38 wells assessed by AECOM.
- There is a general lack of bacteriological groundwater quality data for raw groundwater samples (i.e. before any treatment).

Findings – 38 Wells in AECOM's Study

- Unsanitary conditions of many of the examined wells prevents reliable interpretation of any pathogen indicators in water samples and ultimately poses a public health threat.
- For the 32 wells classified as Potentially GUDI:
  - All wellheads should be upgraded to a sanitary condition ASAP
  - Testing program should be undertaken to determine if well casing is sealed at the point of contact with bedrock and the location of water producing zones in each well should be identified.
- For the 6 wells classified as GUDI:
  - Scoped hydrogeological evaluations should be conducted.
  - Conduct a treatment needs evaluation to determine additional treatment requirements based on risk established for each system.

Fundamental Criteria to be established during GUDI evaluation:

1. Assessment of whether viable pathogens may reach the well.
   - Under what environmental conditions will they do so; and,
   - At what levels are they likely to be found in the well; and,
2. Assessment of whether turbidity or particulate matter could reach the well, or be produced by the well, that would interfere with disinfection.

Regulatory Recommendations

- Shallow casing depth and absence of annular seal makes wells vulnerable to surface water contamination.
- Government of Newfoundland and Labrador should consider updating NL Reg 63/03 to include a minimum casing length, requirement for grouting and requirement for a vermin-proof well seal.
- Elements of a future GUDI evaluation process recommended for the Province of Newfoundland and Labrador should be completed under a 3 step process:
    1. Step I GUDI Screening
    2. Step 2 Hydrogeological Evaluation and Threat Assessment
        a. Well Characterization Assessment
        b. Water Quality Sampling Program
        c. Time of Travel Determination
        d. Microscopic particulate analysis
    3. Step 3 Treatment Needs Assessment

Final Thoughts

- According to 2011 Annual Drinking Water Report, there are 187 public groundwater supplies in the Province.

  - AECOM assessed 38 of 187 wells; what about the remaining 149?

  - Unsanitary conditions of wells assessed is a serious threat to public health.

  - Costs of fixing the well heads is peanuts compared to money required for treatment conversion.


Thank you
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