Monitoring Well Installation at Forestry Farm Road

Results, Conclusions and Recommendations

Presentation to Norfolk County Council

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MONTROSE ENVIRONMENTAL

Outline

1. Scope of work
2. Outcomes – what has been discovered?
3. Conclusions
4. Recommendations – In scope
5. “Ideal world” path forward

Monitoring well installation, McDowell Road

Scope

1. Install wells for measuring pressure and water quality
    - Install 2 monitoring wells at 3 locations (one each in bedrock aquifer & sand aquifer)
    - Install 7 shallow micro-piezometers at FFR and Spanjers sites (by hand to 1 m depth)
2. Install pressure loggers in wells to measure hydraulic pressure
3. Test water quality to assess potential gas well impacts at the new measurement points
4. Determine aquifer parameters (hydraulic conductivity, porosity, hydraulic gradients, etc.)
5. Report findings, including qualitative conceptual site model (CSM) update and implications
6. (Install flow measurement device at FFR – not done)
7. (Update numerical model – partially completed)

Outcomes

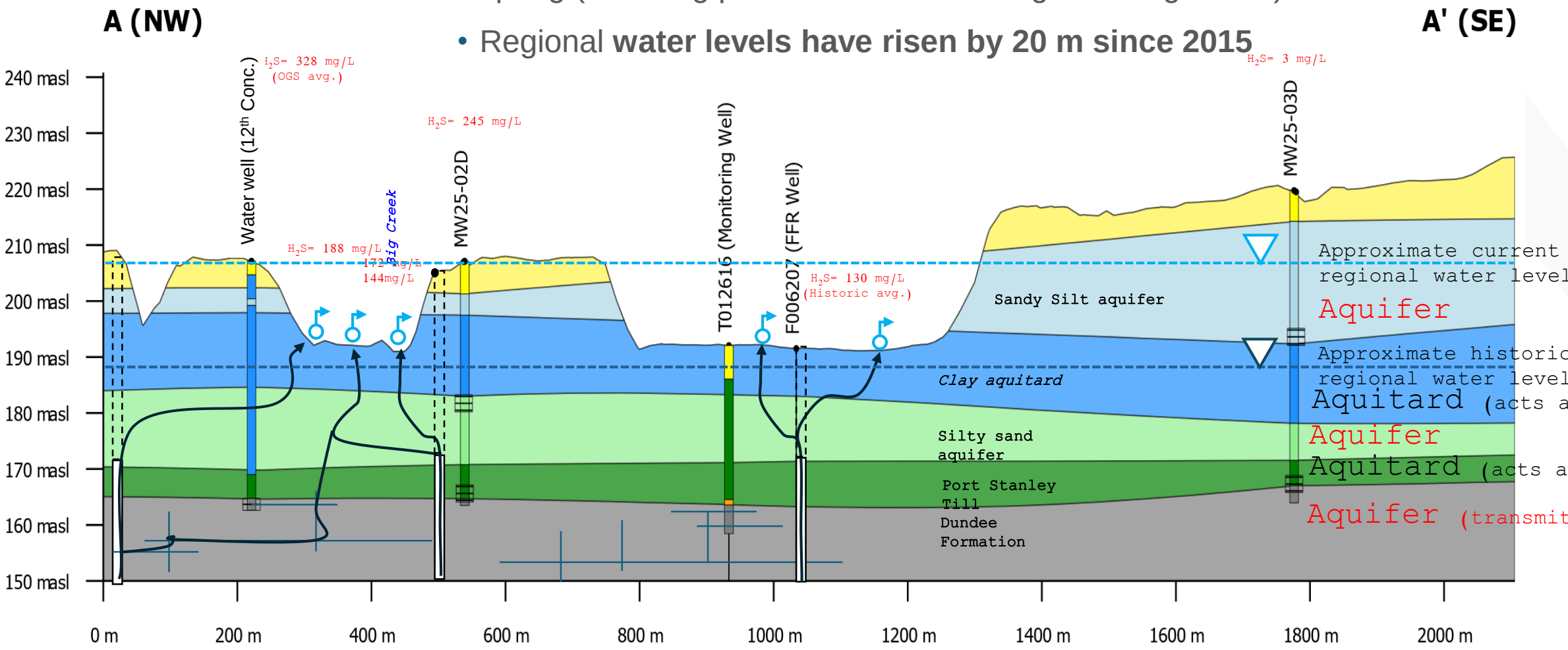
- Two monitoring wells each were installed at three locations
  - McDowell Road – MW25-03D/S
  - Forestry Farm Road (Scheer's) – MW25-02D/S
  - Concession Road 12 – MW25-01D/S

Site Features

- Three new monitoring wells
- FFR discharge
- Spanjers spring
- Updated model area
- Cross section, north to south

Conceptual Site Model

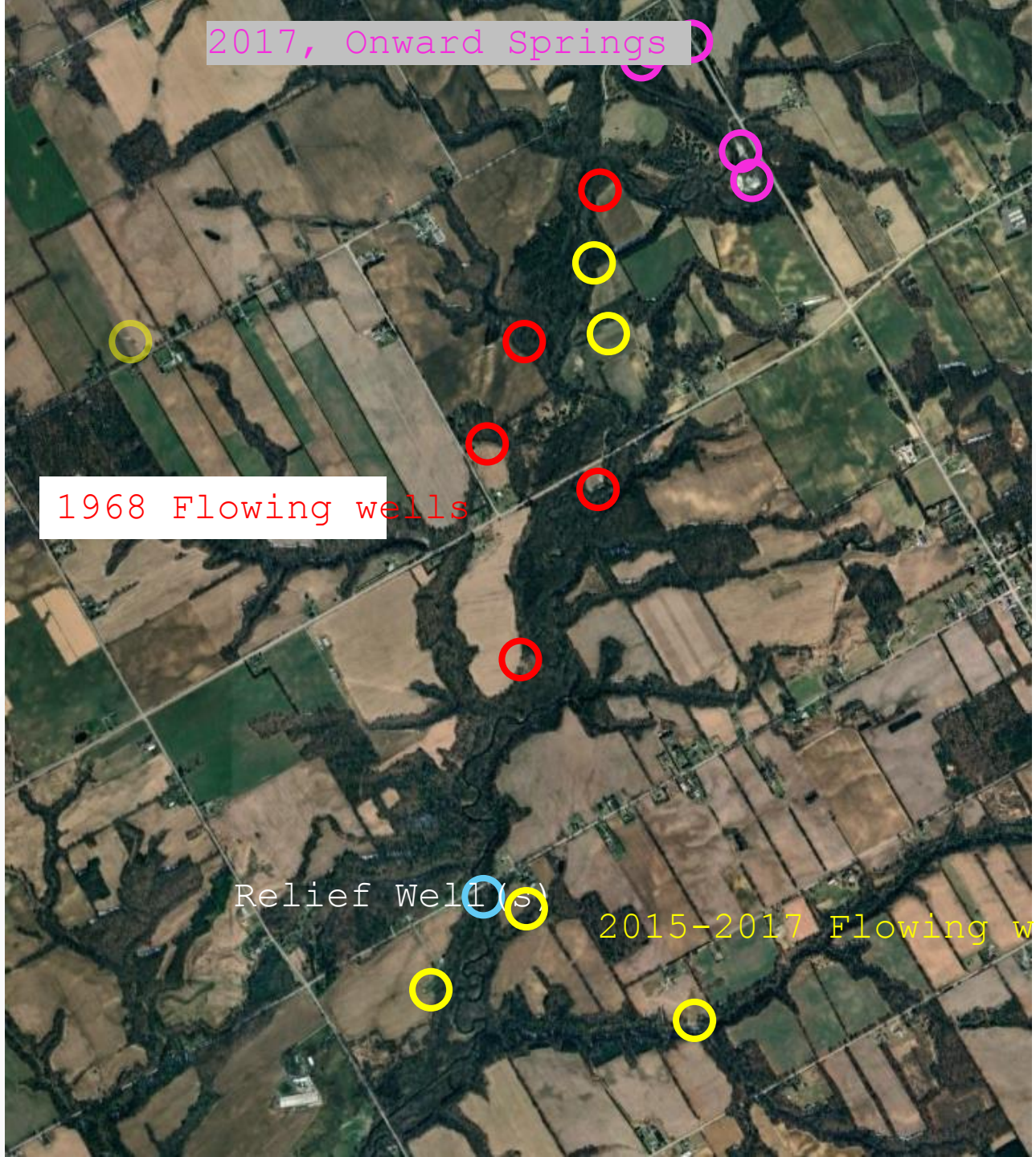
- Pressures & aquifer parameters are better characterized
- **More groundwater discharge points** at both FFR and Spanjers spring (including possible direct discharge into Big Creek)
- Regional **water levels have risen by 20 m since 2015**



History

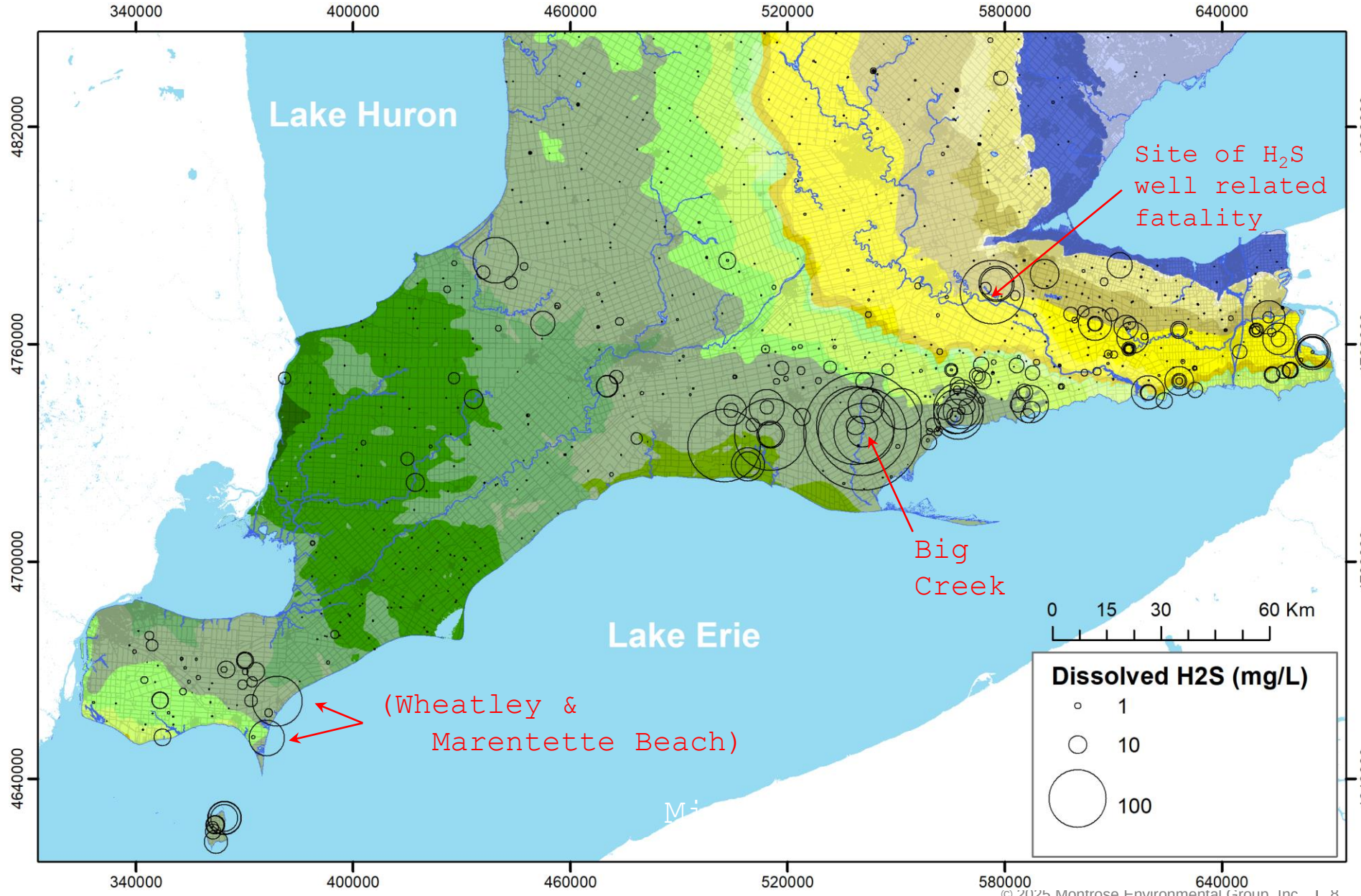
Understanding the origin of the increased pressures was not part of the scope of work, but it is necessary for the conceptual model

- Early flowing from ~1910 was plugged in 1968
  - 5 gas wells began to flow and were plugged that year
  - A new relief well was drilled that year
- The “new” relief well was plugged in 2015
  - 5 (different) gas wells started to flow, at least 4 of which started within a month
- Last of the 2015 flowing wells were plugged by July 2017
  - Major flow at FFR and probably Spanjers spring began that month
  - Other springs are now known



Norfolk County Hydrogen Sulphide Problems in Context

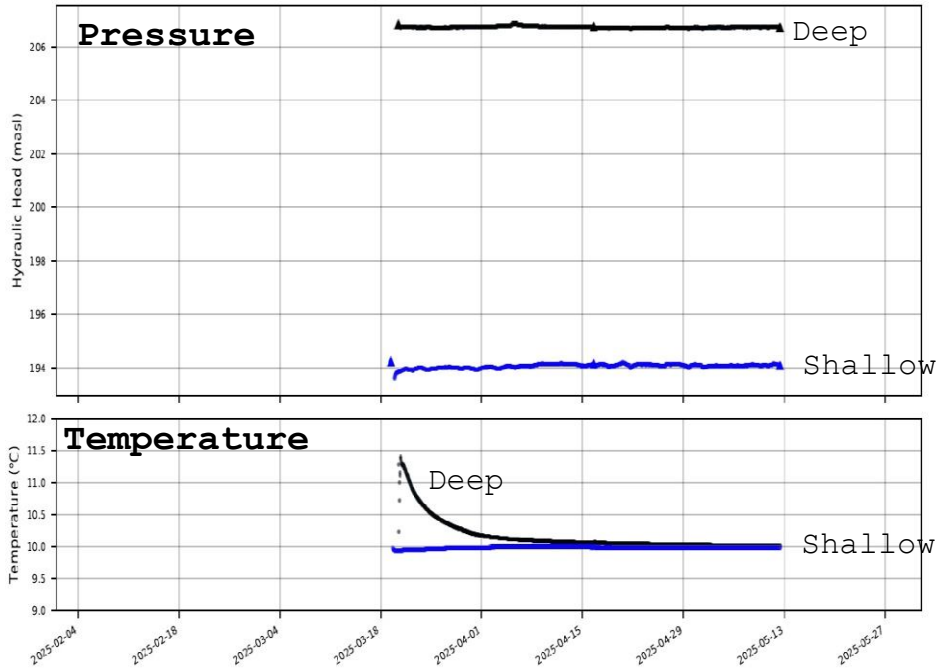
Dissolved hydrogen sulphide measurements by the Ontario Geological Survey & from Montrose's public facing projects



OGS Data from Hamilton (2021) + Montrose publicly

Conclusions

1. **Six monitoring wells & 7 piezometers were installed as planned**
   - The new monitoring network is automatically **tracking pressure trends** and will allow groundwater chemistry changes to be tracked over time.
   - Vertical hydraulic gradients **are upward** near FFR and Spanjers springs
2. **Five key hydrostratigraphic units (layers)** were identified and/or refined
3. **Water quality analysis** indicates influence from legacy gas wells at the two northerly monitoring wells, but not at McDowell Road…



Hydrograph (pressure log) and temperature log from MW25-02 (FFR, at Scheer's)

Conclusions

4. **The CSM and the numerical models were refined**
   - This has enhanced understanding of flow pathways and source of anomalies and added more confidence to predicted outcomes
   - More model calibration is required
5. Pressure data and information from previous studies show that **there are additional groundwater discharge sites** at both FFR and the Spanjers spring areas.
6. Plugging the main FFR discharge point now would pose a high risk of shifting discharge to other locations (e.g., Spanjers spring).

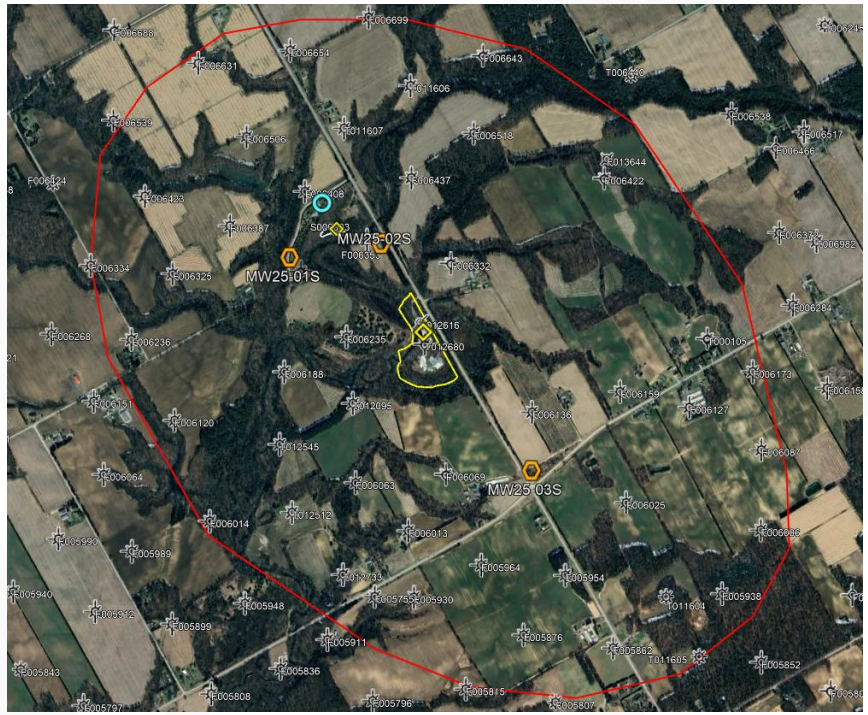
Recommendations- In Scope

1. Initial monitoring should be carried out quarterly for a year, then reassessed.
   - Monitoring would involve downloading of loggers and assessment of changes and chemical sampling
2. The existing numerical model should be further calibrated to match conditions observed at monitoring wells.
   - This will constrain the directions from which H_2S impacted water can originate
   - may help to locate the legacy gas well(s) contributing to the Spanjers spring impact.
3. Characterize **additional groundwater discharge points**, including possible discharge into the bed of Big Creek, using thermal infrared and other methods
4. Replace the existing culvert discharging groundwater at the FFR site and install a weir **flow measurement device** that has already been built as part of this scope of work
5. **We do not recommend plugging the FFR discharge site** without first reducing pressure in the bedrock and Lower Silty sand aquifer, to avoid triggering new discharge elsewhere in Big Creek valley.

Recommendations- Out of Scope – 1

These are offered in good faith, based on our professional opinion and are "ideal world" solutions from a purely technical point of view. We recognize they will be constrained by jurisdictional, regulatory and budgetary concerns.

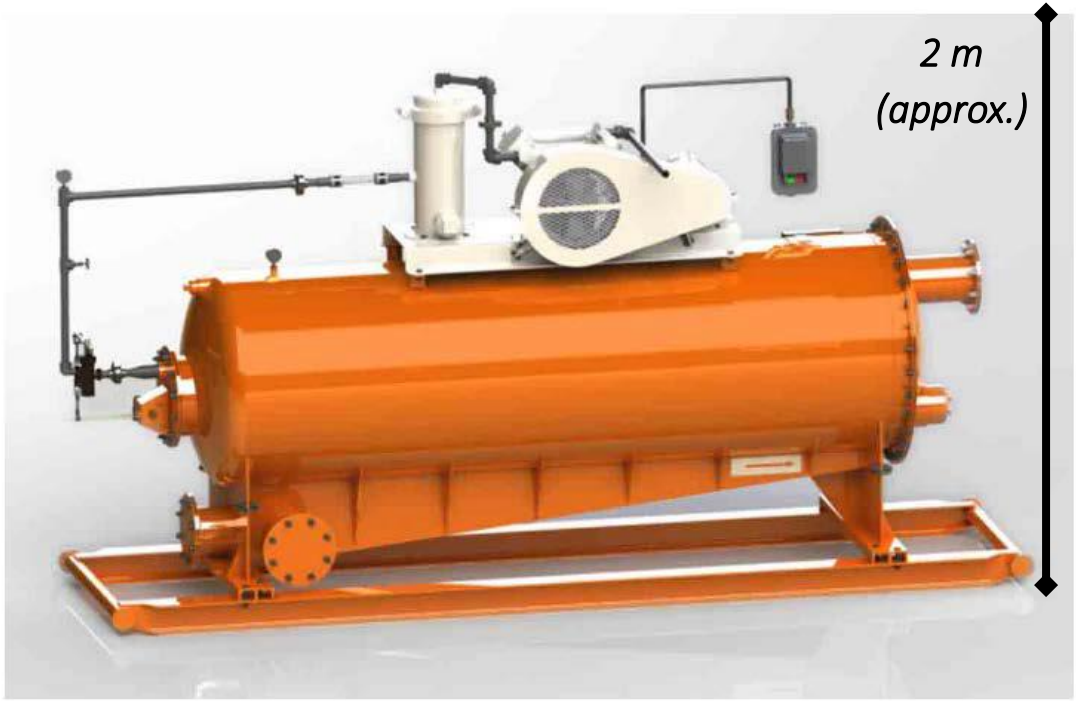
1. In the short term, focus on reducing impact at the Spanjers spring rather than FFR
   - Find the former gas wells that may be contributing to impact at Spanjers
   - Prioritize these for plugging (or re-plugging)
   - The low flows to surface at Spanjers spring suggest that finding and plugging legacy wells contributing to it would be less risky than stopping the much greater flow at FFR.
   - In case of plugging, **monitor local pressure and water chemistry in real-time** to assess impacts of interventions



Gas wells surrounding FFR site with model updated area circled

Recommendations- Out of Scope – 2

2. Reduce the smell at FFR by installing a temporary collection system and **vacuum degasser.**
   - This could both safely and (relatively) inexpensively reduce the dissolved hydrogen sulphide by at least10X and greatly reduce the smell
   - However, the water still won't meet the very stringent Ontario freshwater aquatic guidelines of 0.002 mg/L (now it is over 150 mg/L).
   - But given that the discharge would be far less harmful than it is right now, the Ministry of the Environment (MECP) should be consulted to determine if a temporary exemption to the law can be arranged



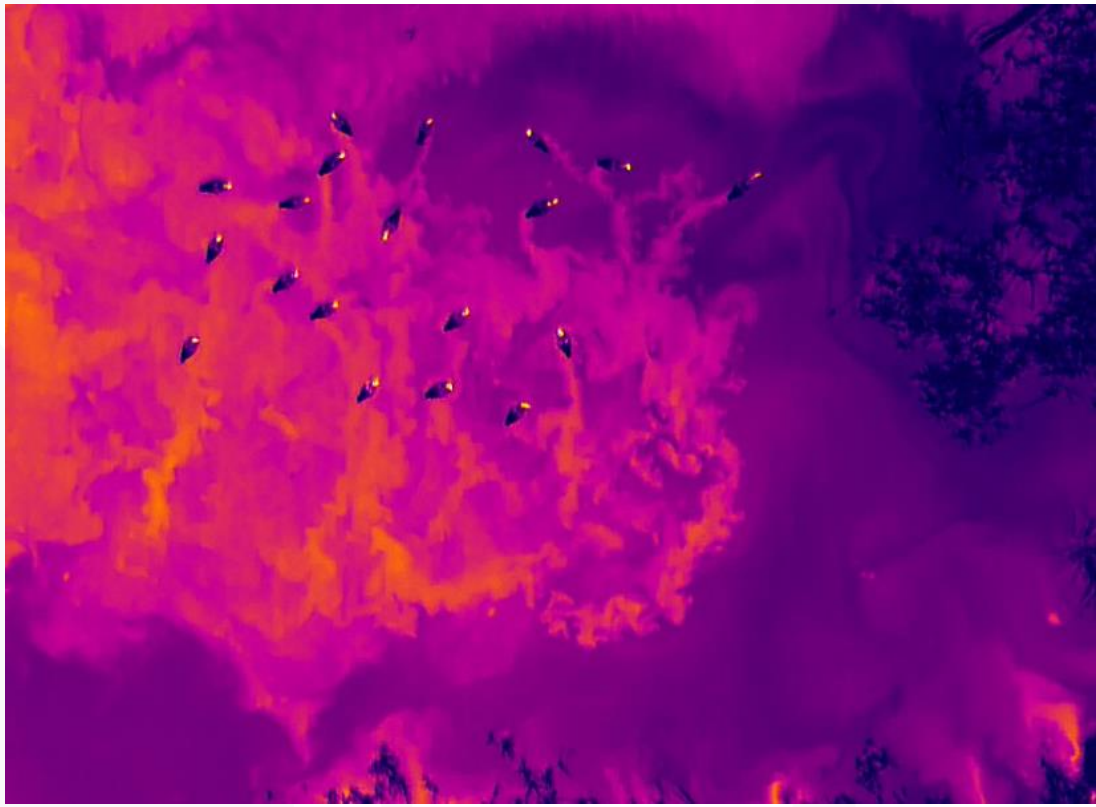
Vacuum degasser

Byproduct of H_2S + absorbent

- **NOTE, the proposal to use a vacuum degasser is by Frank Kuri and is reproduced here for the Council's convenience. Please see that proposal for details and costs**

Recommendations- Out of Scope – 3

3. Arrest the ongoing erosion at the current FFR discharge site by **installing a nearby pressure relief well**, the discharge of which should be connected to the vacuum degasser.
4. Initiate a technical working group with MNR, MECP, MOH, and Norfolk County to work toward **a long-term solution**.
    - With the new and improved information, it is now possible to consider permanent solutions.
    - Subject to the committee's input and oversight, initiate an **Environmental Assessment (EA)** RFP to address the potential treatment and discharge of groundwater into Big Creek and the air and water quality requirements thereof.
    - In the assessment, we recommend that the status quo be considered as a benchmark **by which to assess the outcomes of any proposed**



Ducks on a pond during early morning thermal infrared survey