TETRA TECH

Beyond Monitoring

Mapping Methane Hotspots on Landfills

Sean Buckles, P.Eng.
Nancy Nikolakakis, P.Eng.

Presentation Outline

- Landfill Gas Emissions
- Emissions Mapping Technology
- The Calgary Methane Emissions Mapping Program
- Issues and Opportunities

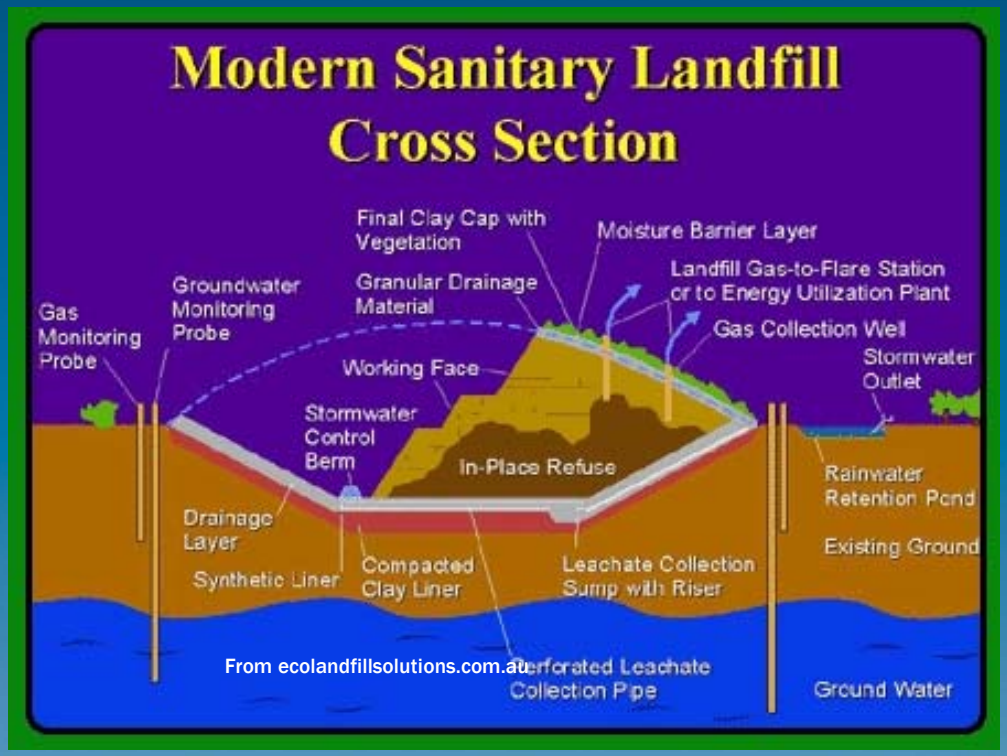
TETRA TECH

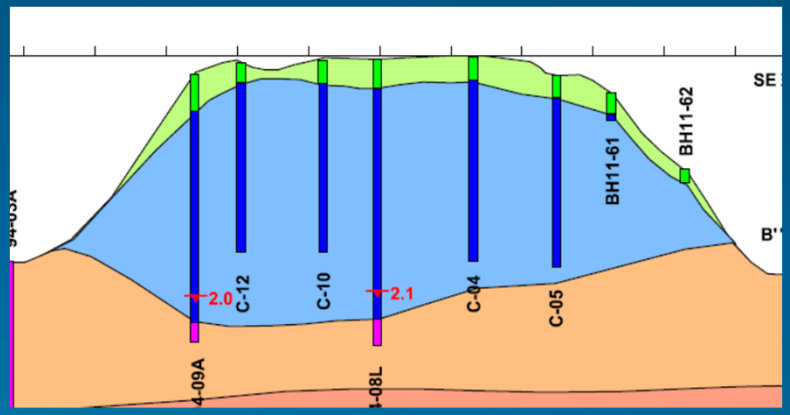
Landfill Gas Emissions

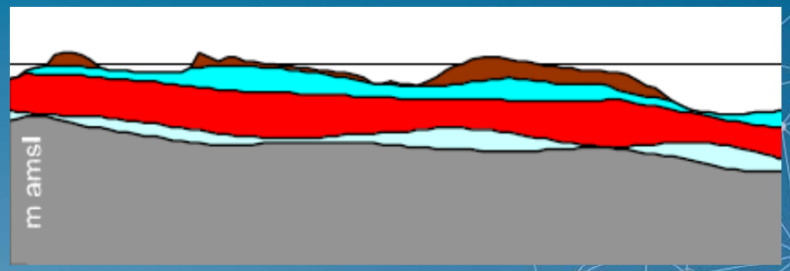
- Landfill and Cover Construction
- The Calgary Context
- Regulatory Context

complex world | CLEAR SOLUTIONS™

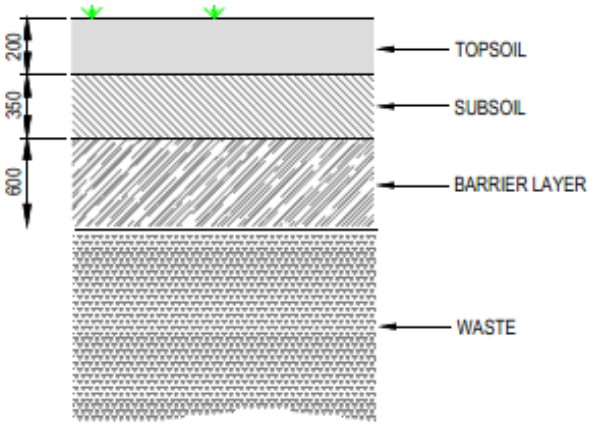
Landfill and Cover Construction



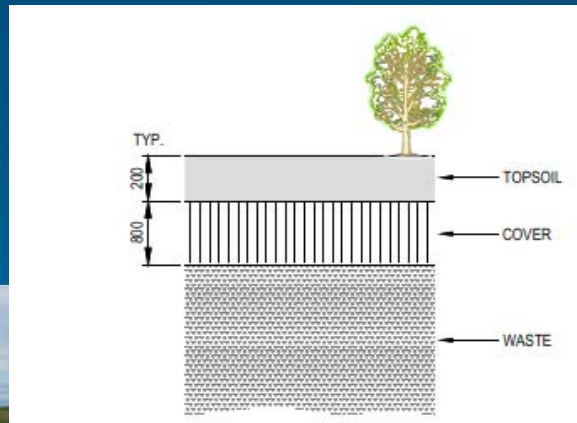




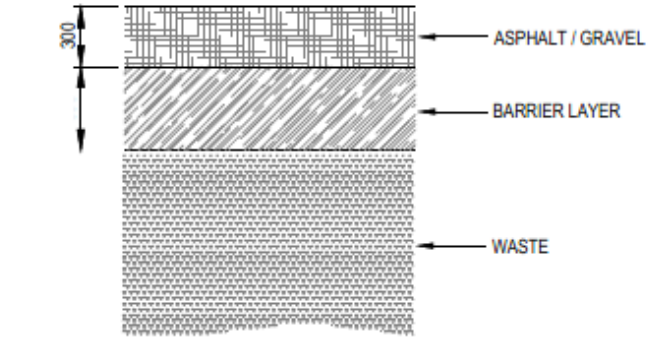
Landfill and Cover Construction



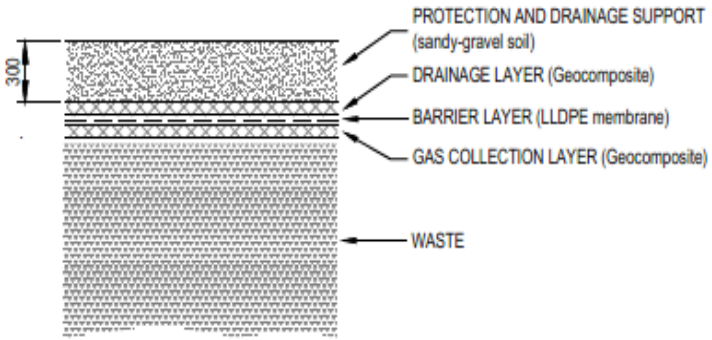
CONVENTIONAL COVER



TYPICAL EVAPOTRANSPIRATIVE COVER



PAVED and GRAVELLED SURFACES



TYPICAL GEOMEMBRANE COVER

The Calgary Context

- Calgary has a net evapotranspirative climate – less moisture getting to the waste.
- Wastes frequently undergo minimal degradation, though gas generation timeframes can be longer.
- Cross-section of cover types – active vs inactive cells.
- Cross-section of land use – restricted access vs. ball parks.
- Cross-section of wastes – C&D vs. residential.



Regulatory Context

- **GHG Emissions Reduction**
  - Many jurisdictions require landfills to capture/control LFG emissions (generally size-based, while others are required at least to report).
  - Guidance (e.g.. EPA 2015) generally looks at surface emissions monitoring to determine if active extraction is required.
- **Public Safety**
  - Many jurisdictions have requirements for monitoring of subsurface gas concentrations at site perimeters (probes), in onsite buildings; sometimes surface emissions.
- **Our Program**
  - Due diligence – public safety and operational/maintenance support for long term care of these sites.

TETRA TECH

Emissions Mapping Technology

complex world | CLEAR SOLUTIONS™

Emissions Mapping Technology

- **Handheld/FID Approach**
  - Site walkover/drive-over with a flame ionization detector (FID) or similar instrument.
- **Infrared Technologies**
  - FLIR Camera (forward looking IR – thermographic camera, looks for IR radiation).
- **Laser Techniques**
  - Tunable diode laser absorption spectrometry (TDLAS), LiDAR.
- **Others?**
  - Optical remote sensing, flux boxes, etc.
  - Quantification technology not fully there, many variables…

TETRA TECH

The Calgary Methane Emissions Mapping Program

- The City of Calgary's Landfills
- Emissions Program Objectives and Scope
- Quality Assurance and Control
- Data Evaluation and Results

The Emissions Mapping Program

The City of Calgary's Landfills

- **Active Landfills – Annual Program**
  - 3 sites, 100 ha to 140 ha survey areas (3-5 days/site).
  - Program focus on closed cells, operated between ~1970s and 2000s.
  - Various cover/closure systems – modern engineered covers vs soil caps.
- **Inactive Landfills – Bi-Annual Program**
  - 5 sites, 9 ha to 40 ha survey areas (<1 to 2 days/site).
  - Operated between ~1930s and ~1970s.
  - Various cover/closure systems – non-engineered, with improvements over time.

The Emissions Mapping Program

Program Objectives and Scope

- **Surveys undertaken to:**
  - Help determine the condition of cover systems in closed landfill cells.
  - Help determine where/how surface emissions are occurring.
- **Outcome:**
  - Identification of locations of greatest generation and emissions ('hot spots').
  - Understanding of potential temporal changes in emissions.
  - Targeted locations for remedial efforts, if required.

The Emissions Mapping Program

- **Detection Technology**
  - TDL (tunable diode laser absorption spectrometry).
  - Wide detection range – 1 ppm to 100% volume.
  - Selective to methane – laser diode adjusted to the absorption wavelength of methane – when methane molecules present, laser beam partially absorbed.
  - Insensitive to other HC gases, water vapour, chemicals.
  - Instant response time, less frequent calibration.
  - 1 to 2 ppm sensitivity – multipass cell.
- **Reconnaissance and Secondary Survey**
  - Boreal Laser GasFinder with integrated GPS - UTV mounted TDL with 1 m length induced sample.
  - Gazomat LMD - Handheld methane detector with wand.
  - Both logging readings at 1 second intervals.
  - Readings tagged with GPS, sub-meter accuracy.

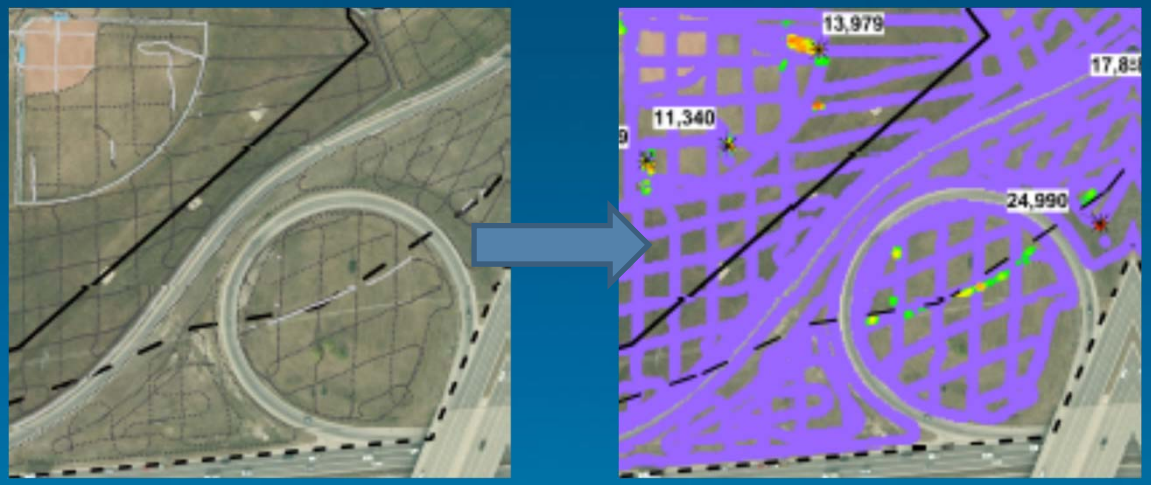
The Emissions Mapping Program

- **Quality Assurance and Control**
  - Equipment calibration and real-time QC by system and operator.
  - Evaluation of ambient/background methane concentrations (~2ppm).
  - Weather monitoring/criteria (<20 km/hr instantaneous wind speed, survey during dry periods, not within 48 hr of 5 mm rainfall or greater).
  - Field QA procedures – survey timing; evaluation of vegetation and disturbance; cover walkover; survey grid spacing (20 m or finer with handheld follow-up), LFG system operation.
  - Repeatability evaluation – repeated lines, adjacent lines, crossing points.

The Emissions Mapping Program

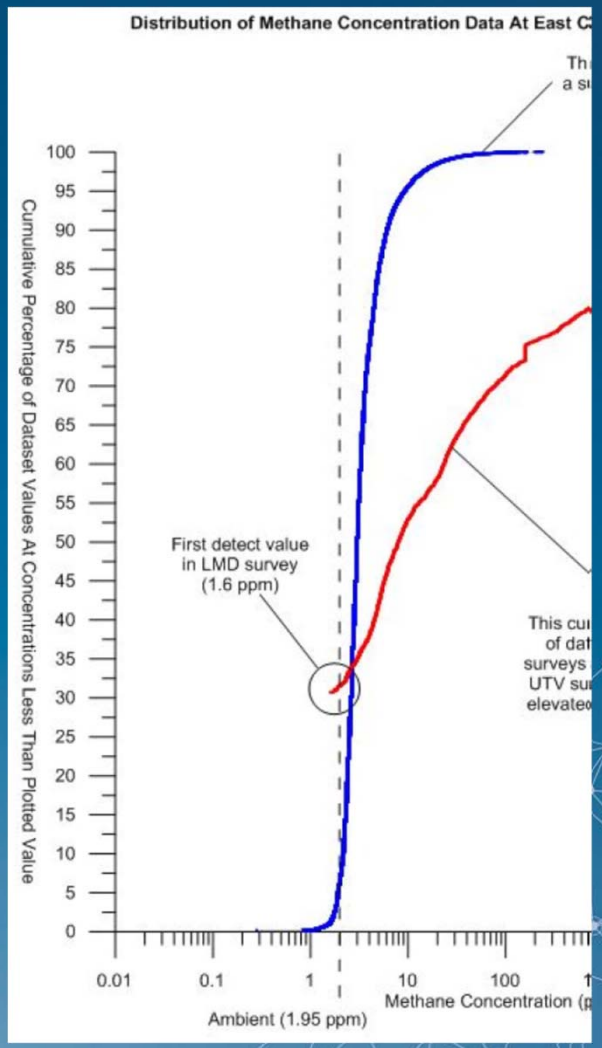
- **Data Evaluation and Results**
  - Used ‘clipped’ data to help interpret – <25ppm and >25 ppm.
  - Provided series of 2-D maps with georeferenced photos to document notable surface conditions/features detected in cover inspections.
    - Interpolated/kriged results within a search radius of 5 m to aid in visualization.
  - Provided a secondary 3-D model to aid in interpretation, including of survey grid crossovers – used to identify 3 categories of measurement.
    - Category 1 Areas – no significant methane detected on any survey passes (arbitrary selection of 100 ppm).
    - Category 2 Areas – significant methane on one pass, but not another.
    - Category 3 Areas – significant methane detected consistently on all passes.

The Emissions Mapping Program

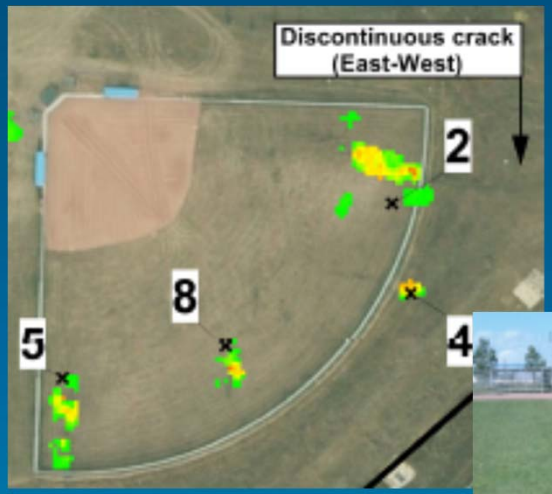


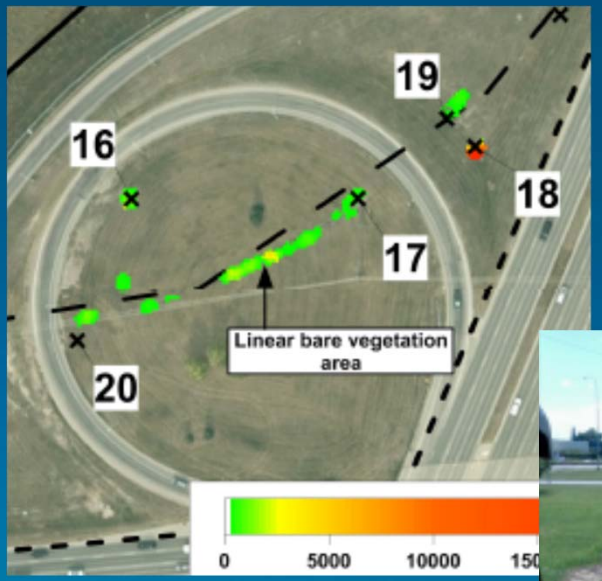
The Emissions Mapping Program

- **Data Evaluation and Results**
  - Typically find that most areas near-ambient concentrations.
  - Greatest concentrations only at a few locations, but often quite obvious features (mostly ‘category 1’ results).
  - Inactive sites often have significant concentrations.
  - Good correlation with cover inspection.
  - Relatively low concentrations (few hundred ppm) provide useful indicators of cover conditions.

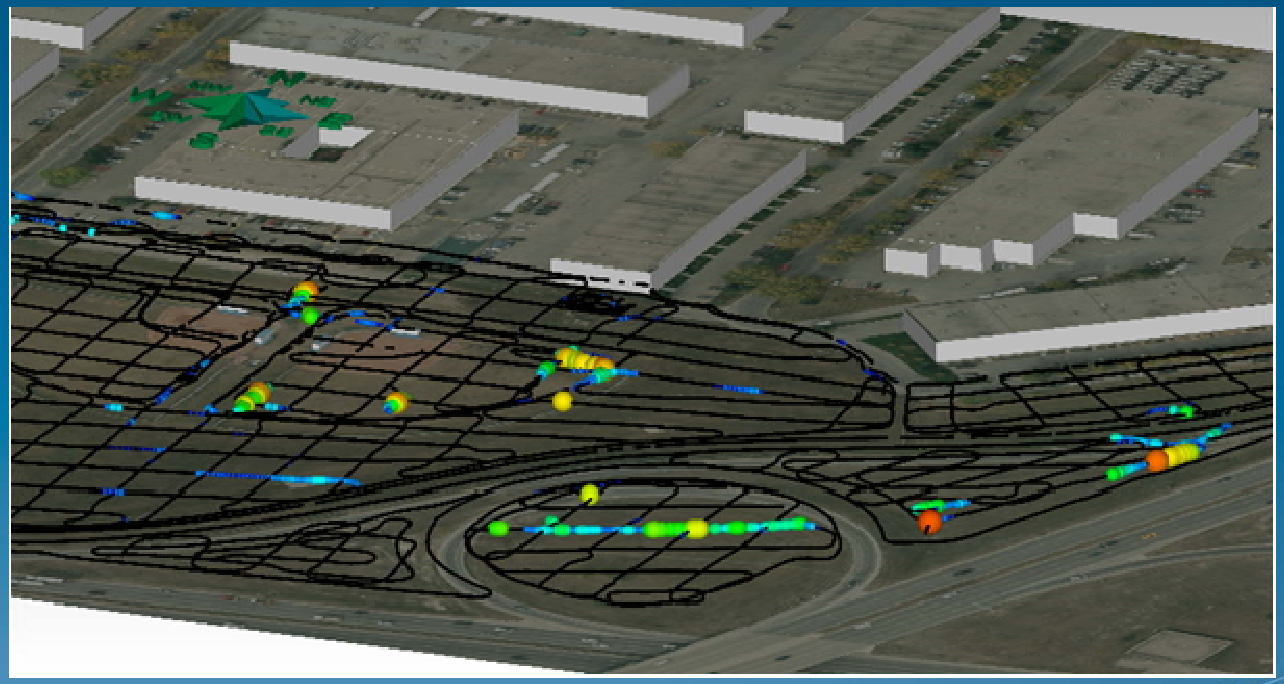


The Emissions Mapping Program

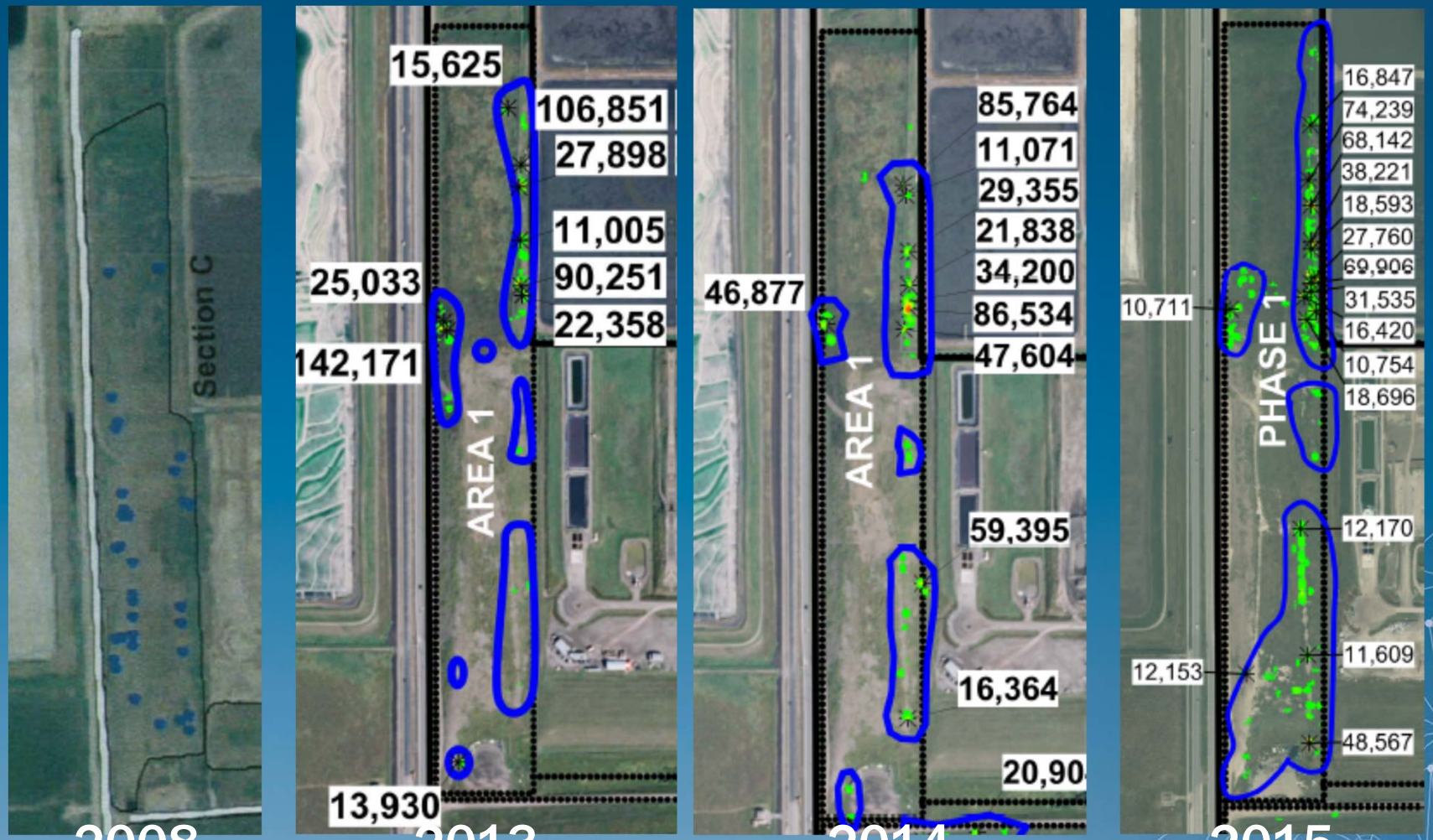




The Emissions Mapping Program



The Emissions Mapping Program



TETRA TECH

Issues and Opportunities

complex world | CLEAR SOLUTIONS™

Issues and Opportunities

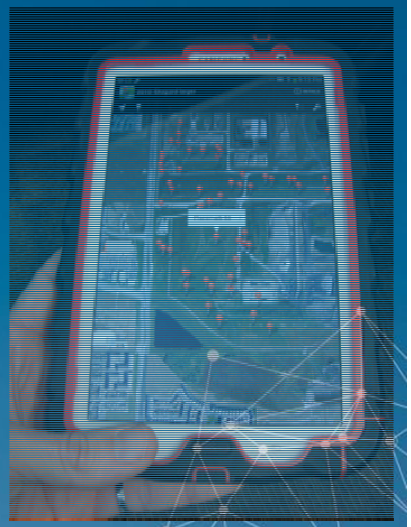
- **Key Issues**
  - Repeatability – more difficult with smaller readings/seeps and long survey windows.
  - Appropriate weather windows – need long window to cover a large area (avoid breaking up area surveys where possible).
  - Other atmospheric effects – pressure influences, such as landfill ‘burping’ and pumping hard to capture.

Issues and Opportunities

- **Key Issues (continued)**
  - Air intake on UTV over ~1m – can be affected by preferential pathways (ruts, flat vegetation, breezes), from where greater proportion of gas drawn (though conversely provides integrated data).
  - Survey coverage – significant methane variation over short distances – are we missing things with a 20 m grid? Is integrating data fair?
  - Desire to rely on absolute numbers – false sense of accuracy/precision
    - collected at one point in time.
    - survey data crossing differing terrain/vegetation.
    - Varying weather conditions (atmospheric pressure, wind, moisture, etc.).

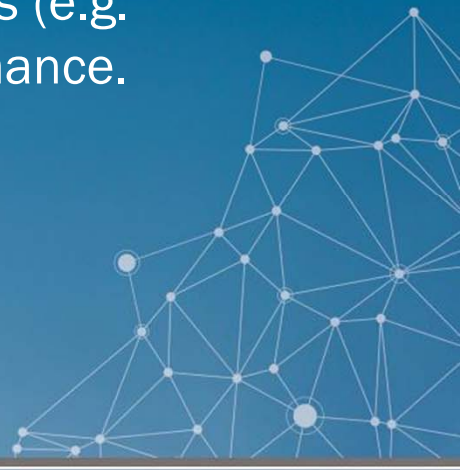
Issues and Opportunities

- **Benefits and Opportunities**
  - Combined approach (UTV survey + foot survey + surface inspection) minimizes chance of missing emission points.
  - Can be used to target remedial efforts (e.g. minor cover improvements, oxidative covers, active extraction).
  - Helps operators to focus on numerous long term maintenance elements:
    - LFG emissions.
    - Gas generation.
    - Leachate generation.
    - Cover erosion.
    - Cover ‘health’.
    - Requirements for active extraction.



Issues and Opportunities

- **Benefits and Opportunities (continued)**
  - Focus on relative concentrations (rather than absolute numbers) helpful in minimizing external factors such as weather.
  - Increased QA to evaluate repeatability would be useful to document short term temporal effects (e.g. repeat small grid multiple times over course of day/days).
  - Combining approaches with quantitative measurements (e.g. flux chambers) may help evaluate overall cover performance.



TETRA TECH

Acknowledgements

The City of Calgary – Jaroslaw Kuczynski, P.Geol.
Gas Recon Inc. – Steve Lepp

Presenter Contacts:
Sean Buckles, P.Eng. -Sean.Buckles@tetratech.com
Nancy Nikolakakis, P.Eng. – Nancy.Nikolakakis@tetratech.com