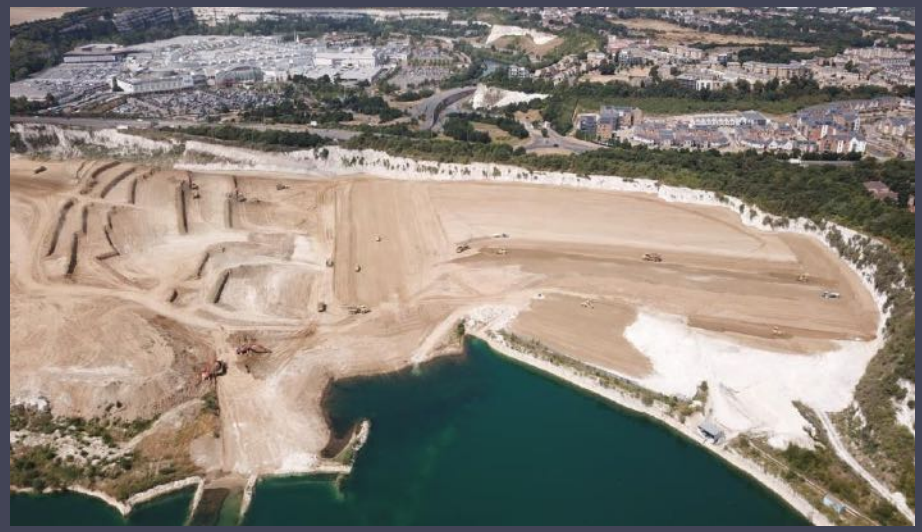
Post Earthworks Gas Monitoring in Compacted Fills – A Waste of Time



Steve Wilson and Amy Juden

www.epg-ltd.co.uk
http://ambisense.net

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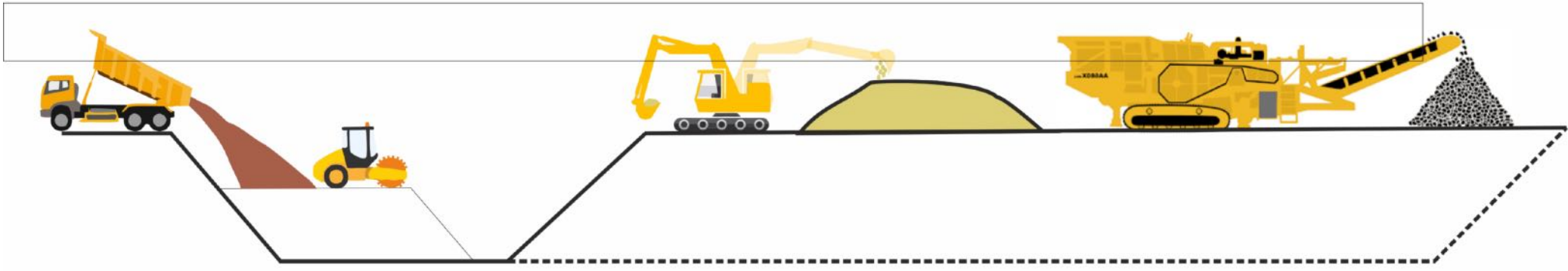
91,000m^3 of material

3. Placed

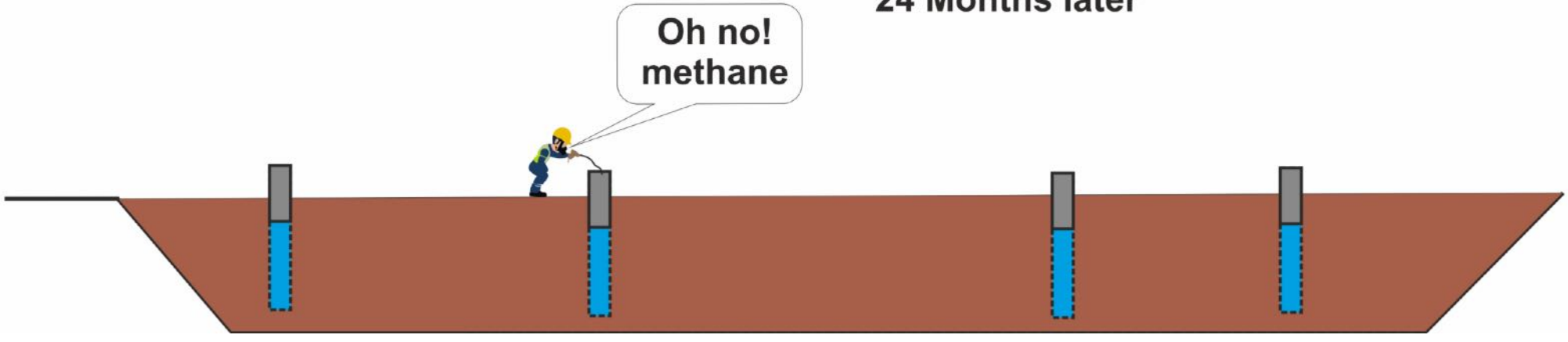
4. Compacted

1. Excavated

2. Processed



24 Months later



Gas monitoring in boreholes

- In the words of Frankie Goes to Hollywood – "*What is it good for? Absolutely nothing*" - well not quite!

- It is useful for monitoring off site risk during the works (if there is a pathway for gas migration)
- It is not useful for determining surrender when the wells are installed in recently placed compacted fill materials

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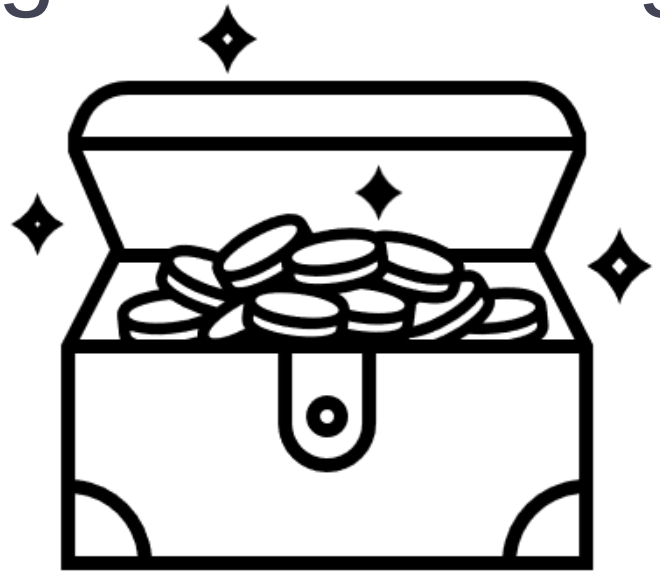
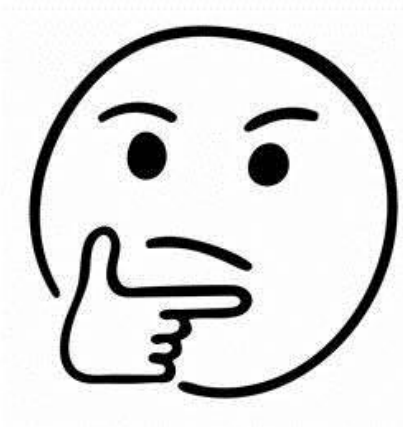
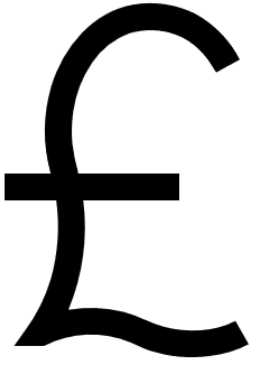
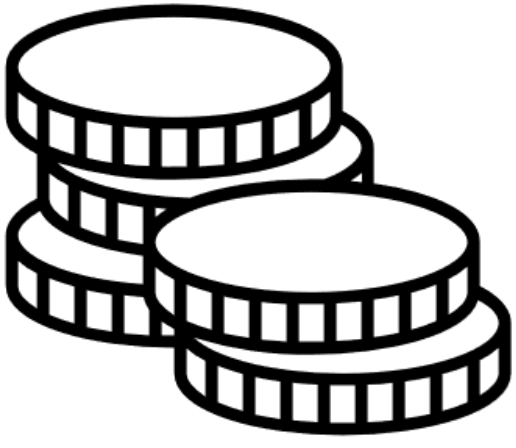
So why do consultants recommend gas monitoring?









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Environment Agency Surrender

- Environment Agency Surrender Guidance – Completion Criteria are based on Hazardous Gas Flow Rates being below the limit for Characteristic Situation CS2
- BS8485 is based on the Wilson and Card Approach to ground gas risk assessment (Ground Engineering 1999)
- It was developed to inform risk assessment for built development over landfill and other sites with ground gas present. It is over conservative because it is relative easy to incorporate gas protection into new buildings
- It was developed based on understanding of landfill and ground gas in the 1990's when the factors that influence borehole gas monitoring were not understood
- Also based on gas generation being the only influence on gas concentrations in wells
- Processes occurring in freshly placed deposits of fill, such as consolidation and changes in pore-water pressures, render borehole measurements highly unreliable and other lines of evidence should take precedent in such cases to inform an assessment of risk.
- Historic dissolved methane in pore water also influences the results and gives high concentrations in wells that do not reflect the risk of surface emissions

Legal test for surrender

- The legal test for surrender is – ‘that the necessary measures have been taken –
  - (a) to avoid a pollution risk resulting from the operation of the regulated facility; and
  - (b) to return the site of the regulated facility to a satisfactory state, having regard to the state of the site before the facility was put into operation.’
- There are better ways than gas monitoring to do this on landfill reclamation projects

- The sensible way is to make sure that there are robust waste acceptance criteria applied
- The primary line of evidence with respect to gas generation should be Forensic Description and TOC tests to demonstrate that the material cannot generate excessive volumes of gas

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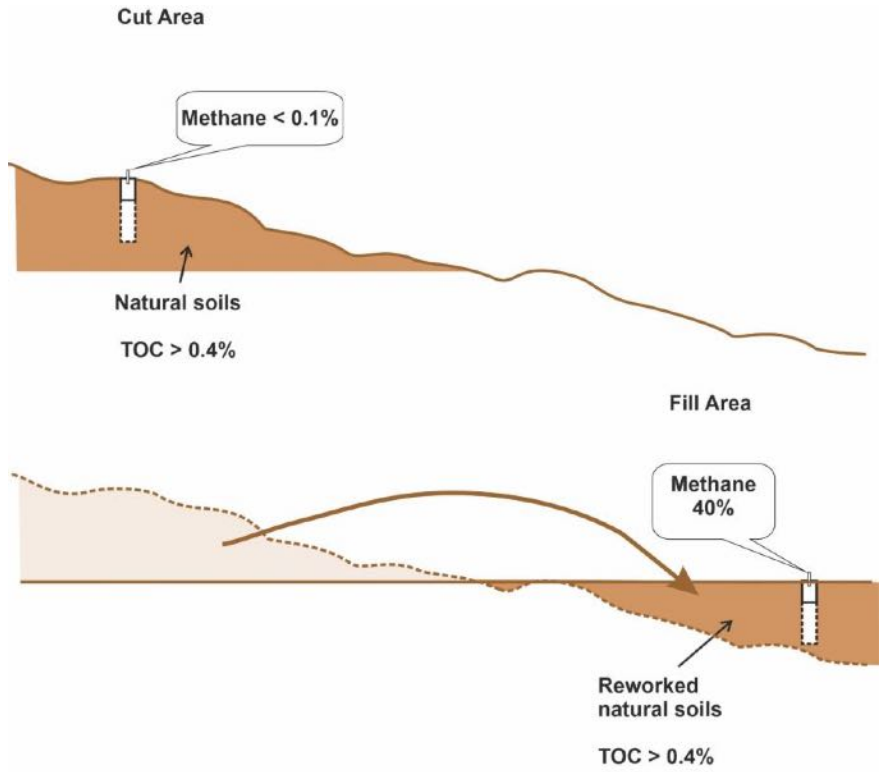
Ground Engineering 2019

- Refers to extensive studies by San Diego County in the USA on the presence of biogenic methane in engineered fill
- Methane testing on hundreds of sites over two years indicated cut areas were devoid of methane but fill areas contained high concentrations
- Organic content as low as 0.4% in soils can produce high methane concentrations in monitoring wells
- Concluded the presence of methane did not pose a risk to the developments built on the fill because:
  - Gas not under pressure
  - Gas was limited to fill soils and not undisturbed soils
  - Volume of gas was small (even though concentration is high in monitoring wells)
- The same should apply to fill materials used below development platforms in landfill reclamation



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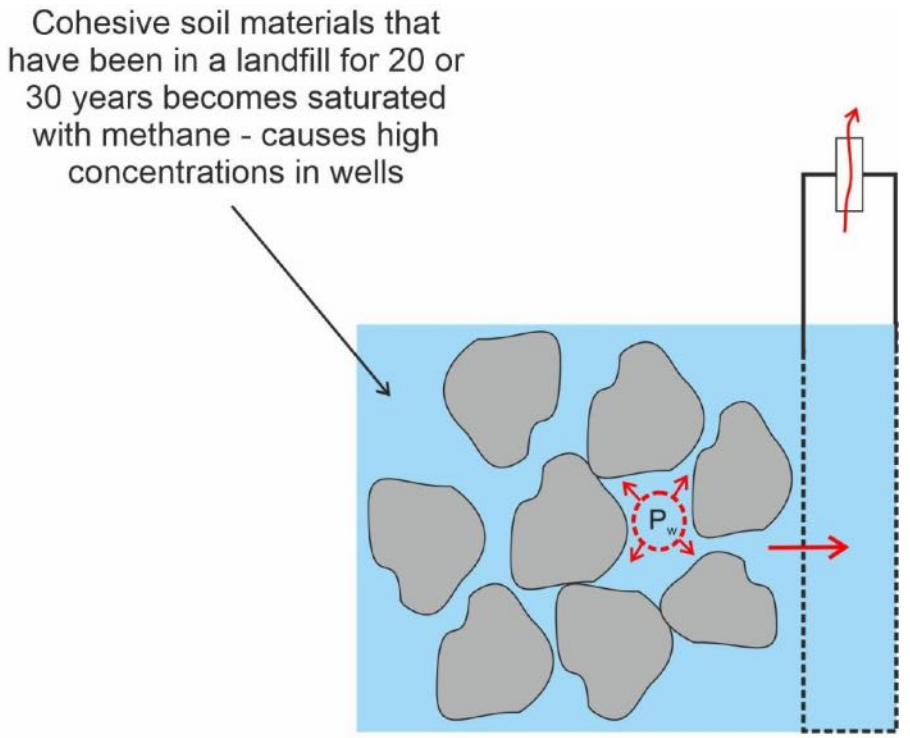
Post earthworks gas monitoring - the issues in waste

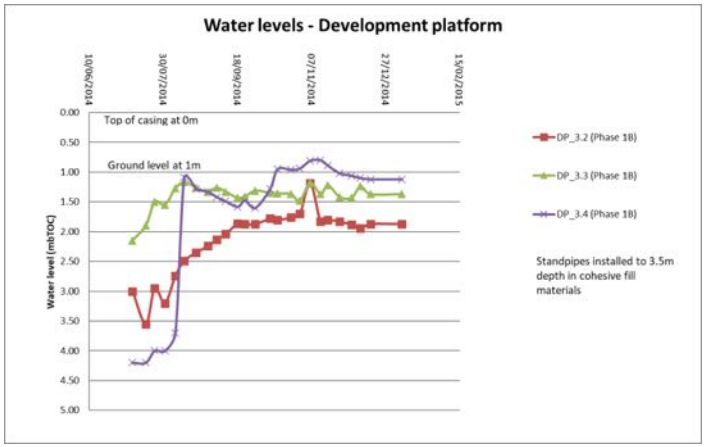
- You do not know if you have been successful until you have completed the job
- The timescales for gas monitoring after completion can be long and it is quite likely that the Environment Agency completion criteria will take **at least** one year to achieve if not longer
- In compacted cohesive fills pore water that has excess compaction pressures dissipates into the gas monitoring wells and floods them causing unrepresentative flow rates
- Other data (flux chambers, surface emissions, TOC on placed material, underfloor void monitoring) is all used to demonstrate that the gas monitoring well data is not representative of gas risk

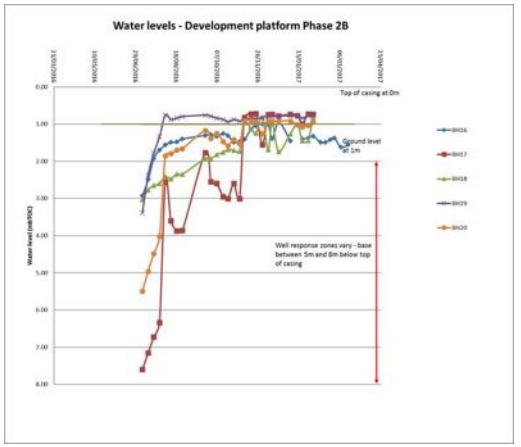


Excess pore pressure from compaction, P_w is dissipated via water flow to gas monitoring wells which floods them and causes unrepresentative flow rates

Flooded wells – effect on results

- Wells installed in compacted cohesive fill – gradual increase in water level over time
- This indicates pore water pressure in clay – it is not a free water table
- There is no water in the adjacent excavations
- The flooded wells give artificially high flow rates and artificially high gas concentrations
- Do not use data from flooded wells to calculate hazardous gas flow rates (on any site)





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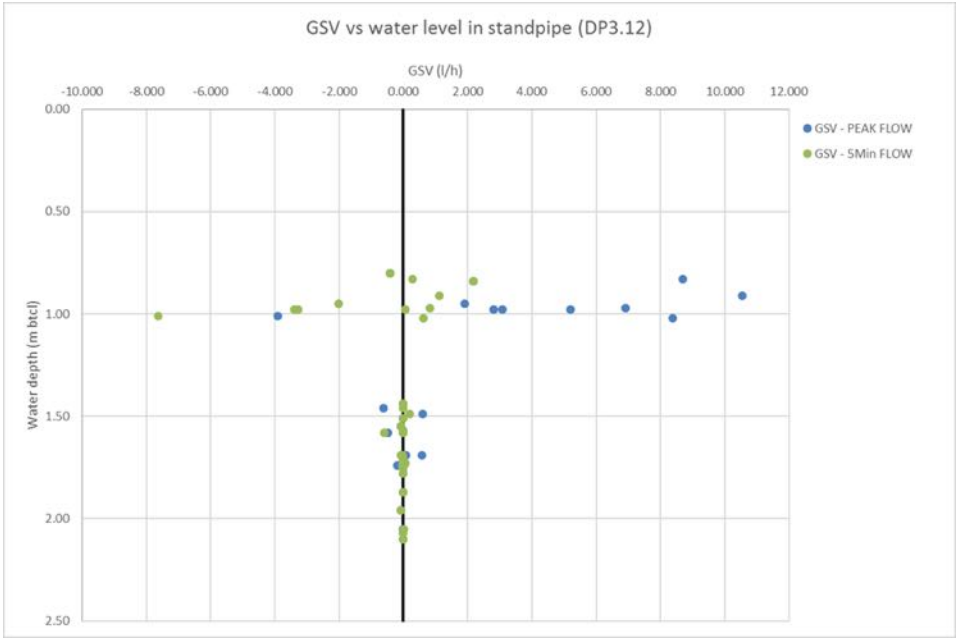
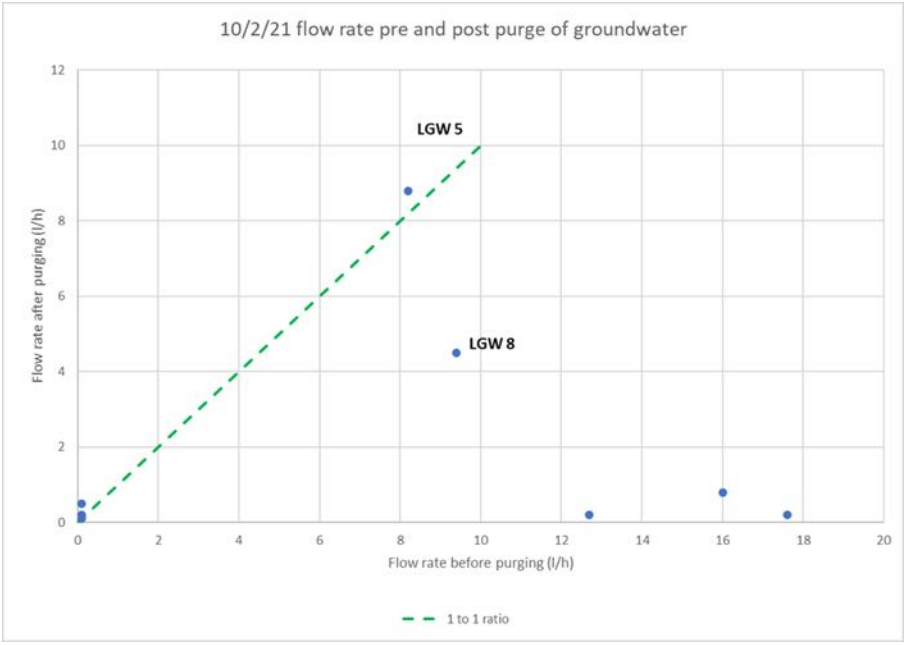
Influence of pore water on results





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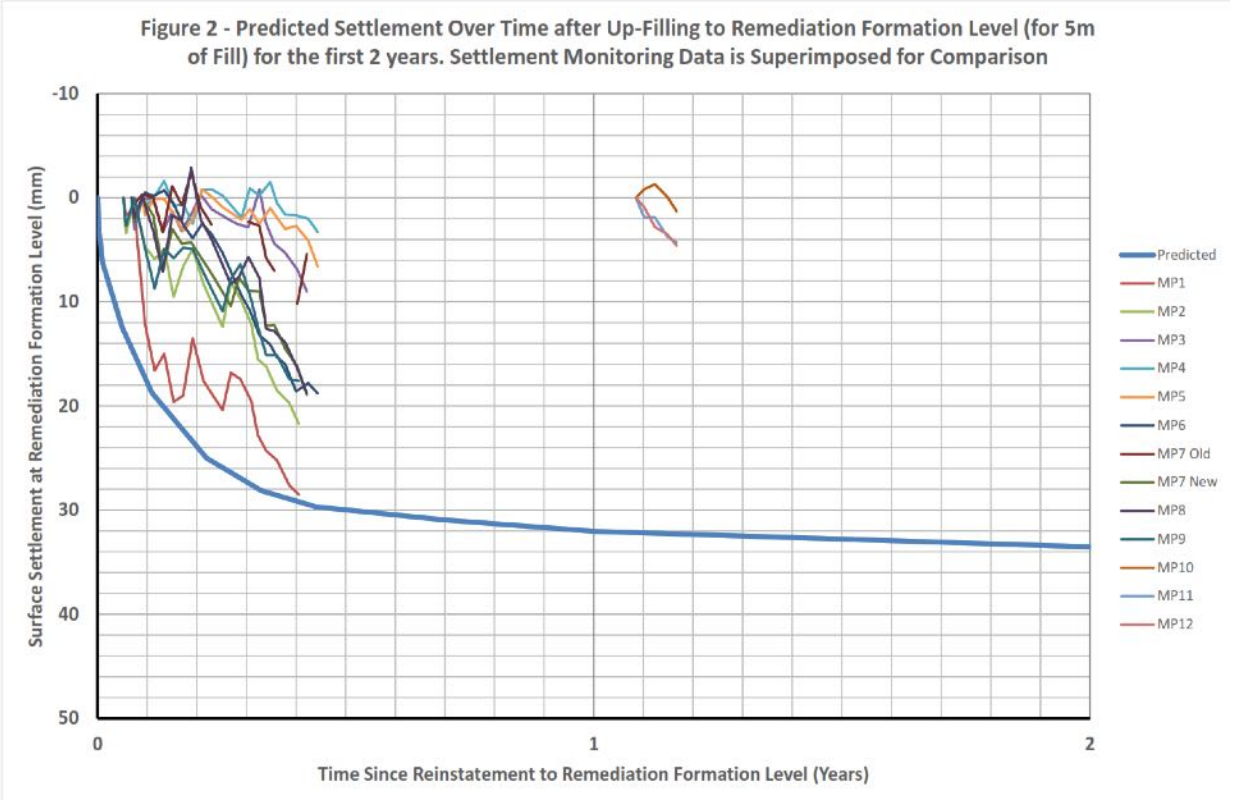
Managing earthworks using TOC

- The geotechnical performance is a line of evidence for the ground gas assessment
- Compare predicted settlement with actual and compare to performance if there was excessive organic material (adjust settlement parameters to those for organic fill)
- Material with excessive organic material will not achieve engineering requirements
  - Settlement
  - Compaction
  - Shear strength
  - CBR



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Managing Earthworks

- Use TOC criteria (amongst others) to manage materials that could be re-used on site.
- Should be part of a comprehensive earthworks specification and assessment
- Gas generation tests on material – bespoke test specification and analysis developed by EPG (Drum Tests) – to replicate site conditions
- Extensive bespoke monitoring of wells and surface emission surveys using various methods – adjust monitoring to what you see
- Understanding groundwater chemistry and Redox – indicators of gas generation process – is it anaerobic degradation?
- Robust analysis of results – it is not all about the TOC!

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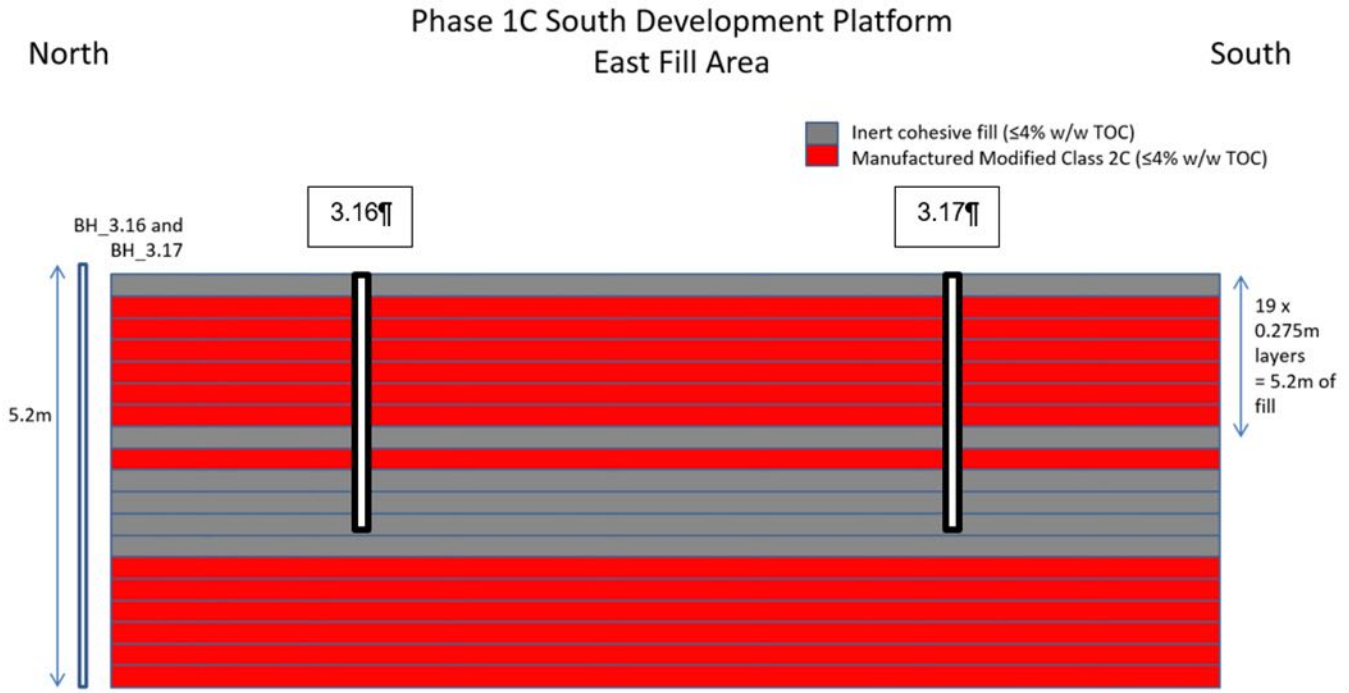
Compliance testing

- Extensive compliance testing
- Including TOC and forensic description tests
- Main aim was to manage the material to limit gas potential before it was placed rather than rely on post construction gas monitoring (which is too late!)
- Testing may include the following (depends on the site and materials)
- TOC
- DOC on leachate where appropriate (if TOC exceeds target)
- Redox
- Chemistry – Volatile Fatty Acids, etc
- Gas generation tests – laboratory BMP and bespoke site Drum Tests
- Temperature measurements of fill materials in various locations

- It is not easy!

Good understanding of the materials around each well



Figure·1.7··Layers·of·fill·material·below·Phase·1C·South·–·East·Fill·Area¶

Post construction testing

- Gas monitoring in wells has been completed (against EPG advice and at insistence of regulators and other consultants)
- Then the following testing has then been completed to show the borehole monitoring is not reliable
  - Flux chamber testing
  - Surface emission surveys
  - Groundwater testing (inc dissolved gases)
  - Extended gas monitoring and pumping tests in wells
  - Underfloor void monitoring

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Warning!

- The following graphs are examples of data from various different sites or parts of sites
- Provided to show complexity – standard GSV approach is not applicable – although we refer to it in our reports because that is what regulators and client's consultants understand, we do not rely on it at all
- There is no one size fits all explanation of the results or correlations that can be assumed

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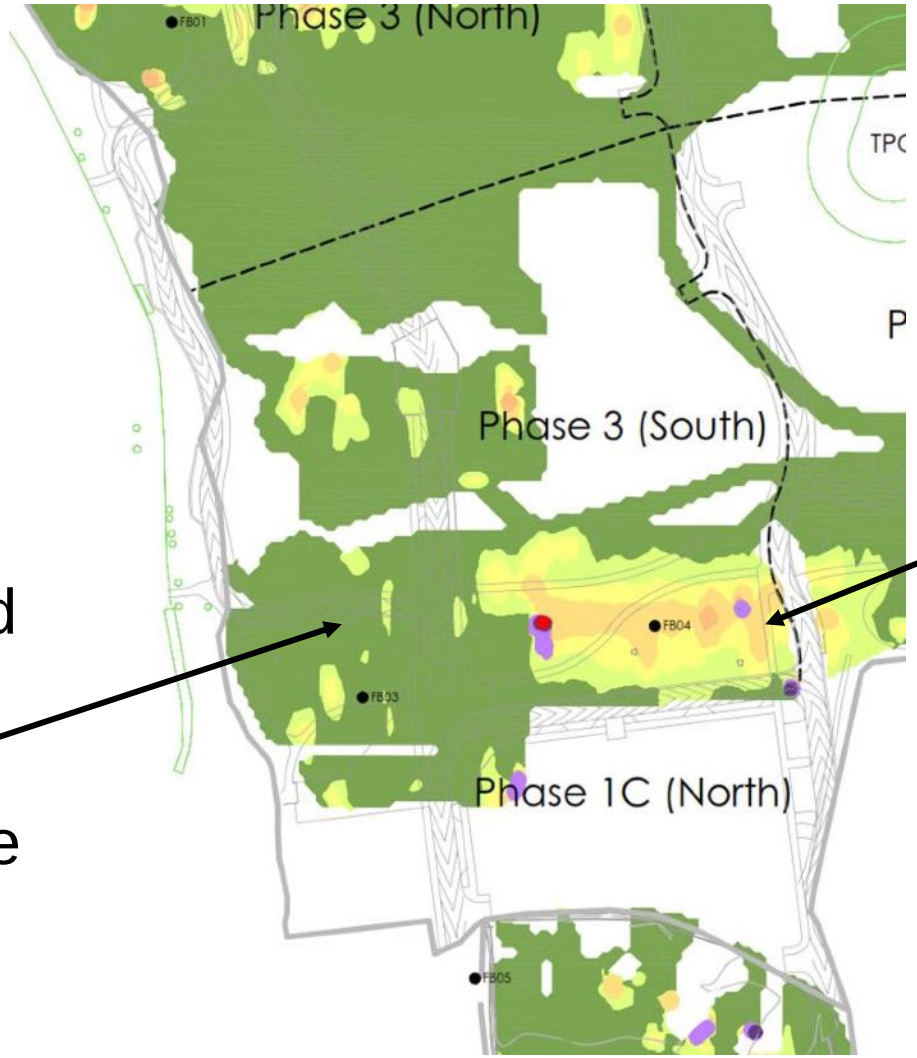
Influence of compaction on gas emissions



Not compacted and surcharged to reduce settlement – minimal surface emissions

Compacted to reduce settlement – Elevated surface emissions (measured directly on fill)

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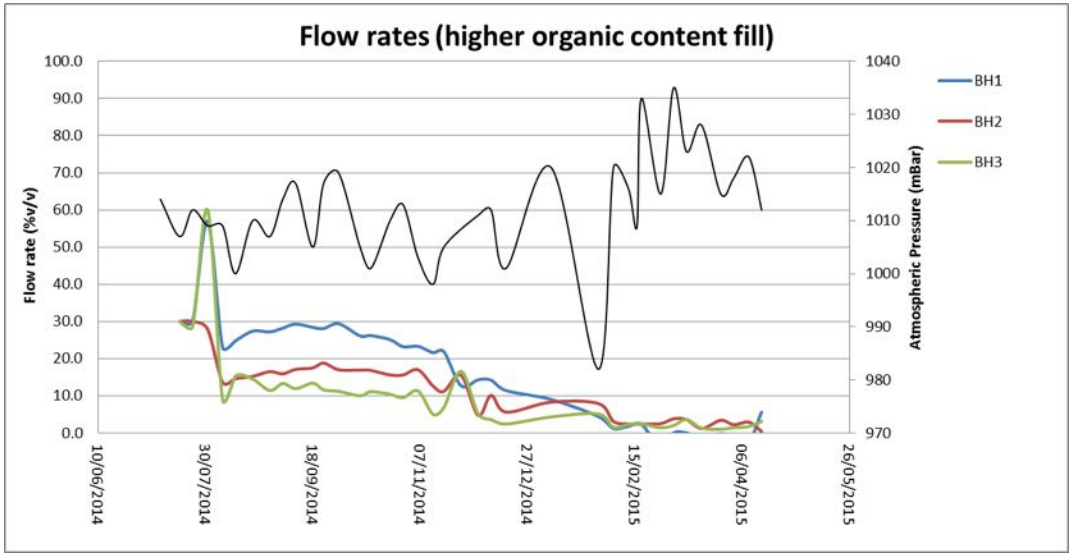
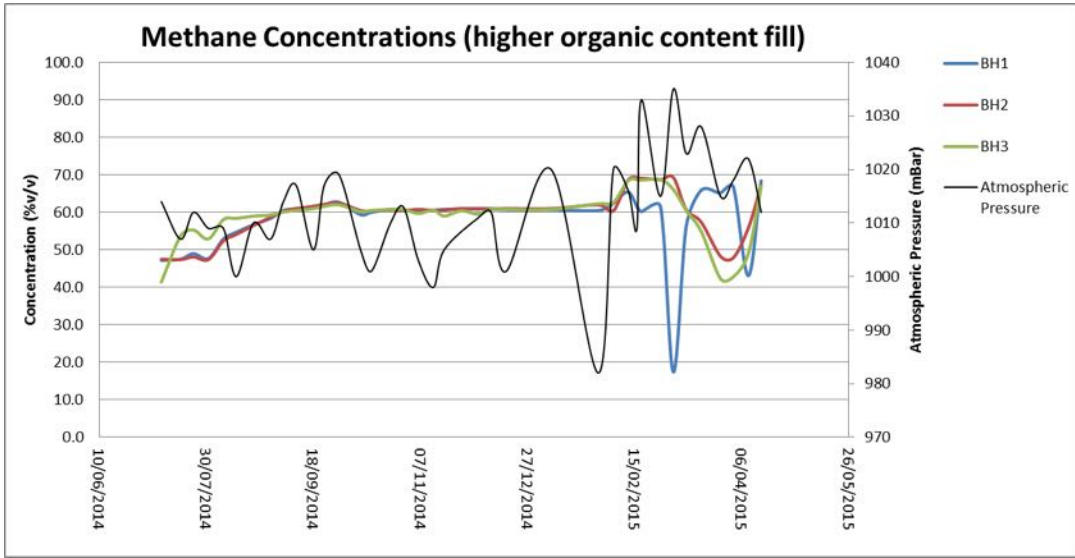
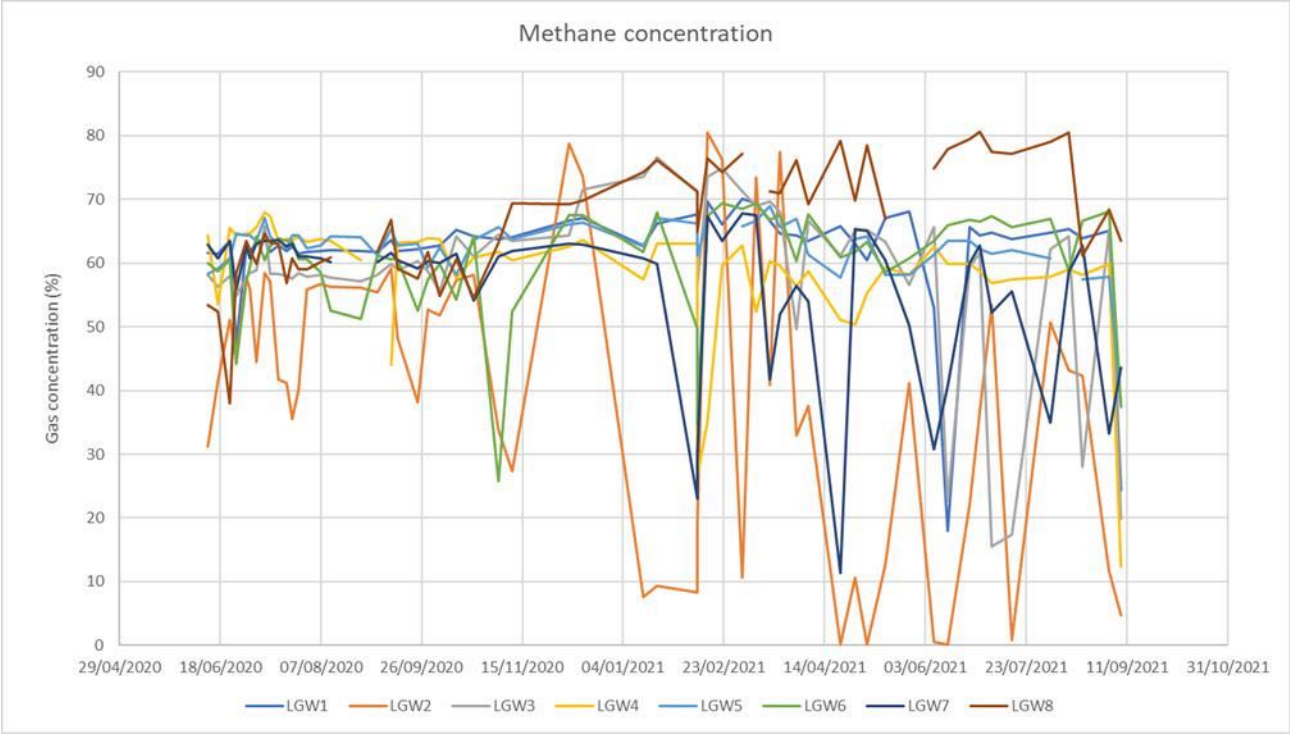
Example monitoring well results

- Using maximum or worst case values is not appropriate as the trend is for a reduction over time
- Once flow rates became very low gas concentrations became highly variable
- Reports of bubbling in the wells stopped once flow rates became low – so there is some gas generation but the volumes are small
- Combined effects of compaction and gas generation need to be considered on a well by well basis





- On this site some gas generation for first five months (consistent methane) then other factors become dominant
- Variability increases with time
- Gas generation is a short term effect and volumes are very low



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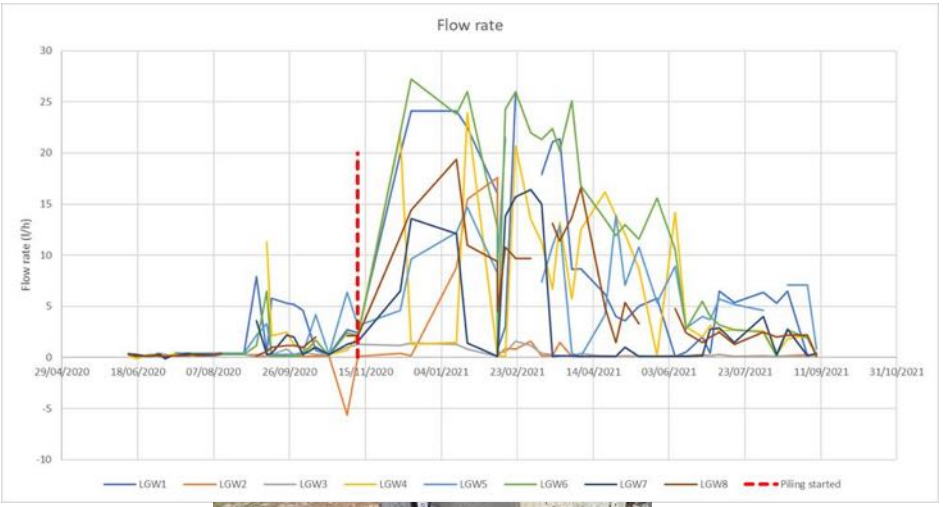
Flow rate over time

- On this site wells purged regularly for first five months
- When purging stopped flow rates increased because wells were flooded
- Driven piles increased flow rate further (and also pore pressure)
- Reduced over time – temporary effect – but no evidence of gas flow up the piles themselves or of any off site migration
- The piles are not acting as a preferential pathway



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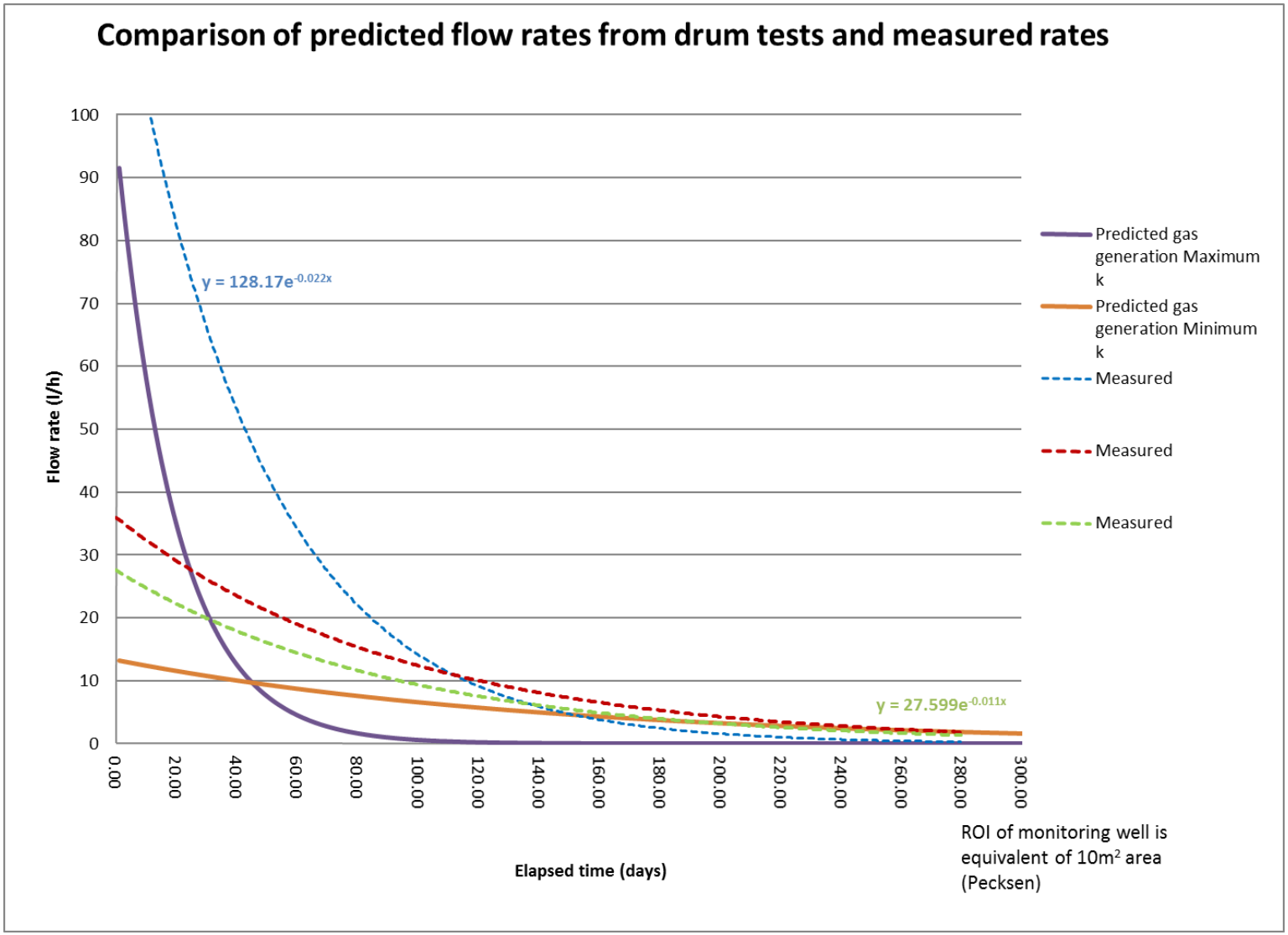
Correlation with gas generation tests



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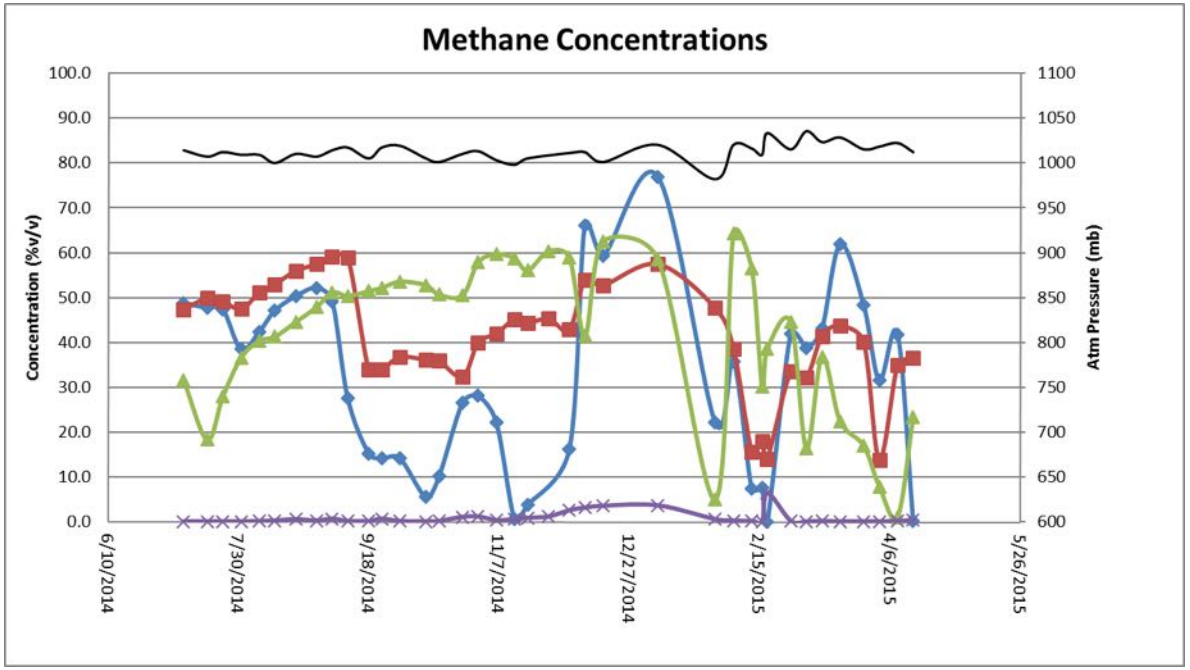
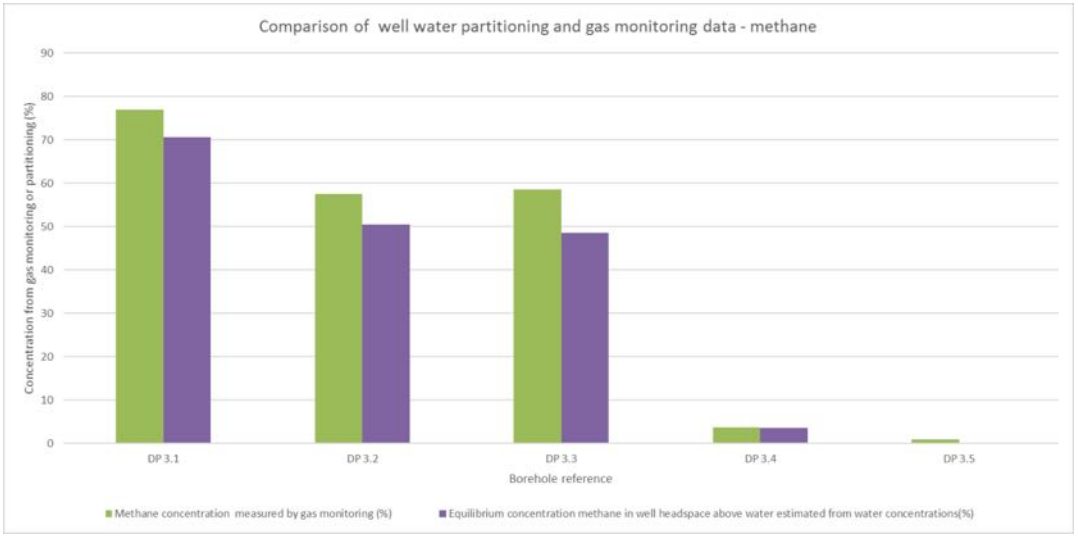
Comparison of well with emission data

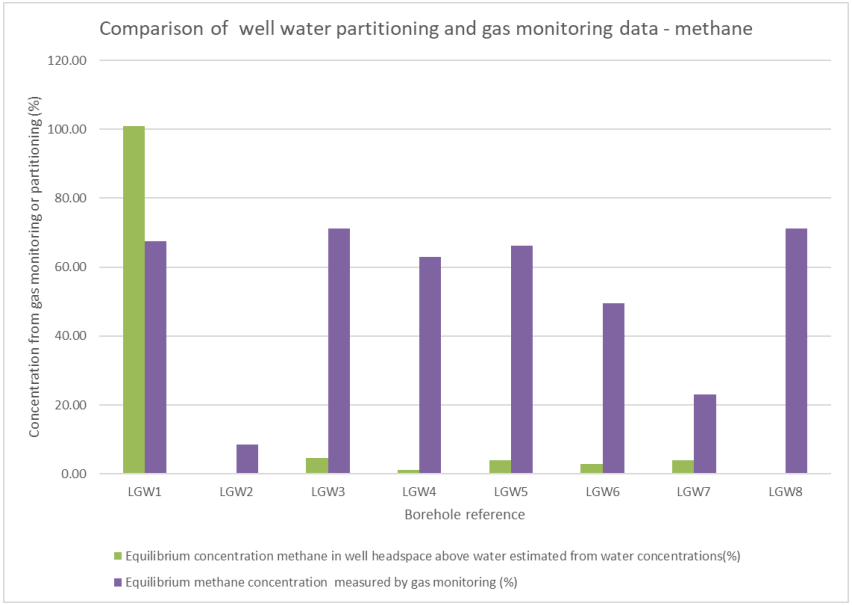
- Sporadically high methane concentration in wells
- Surface flux in boxes is negligible (tests on several occasions)
- Surface emission survey TLD – negligible concentrations (tests on several occasions)



Groundwater monitoring

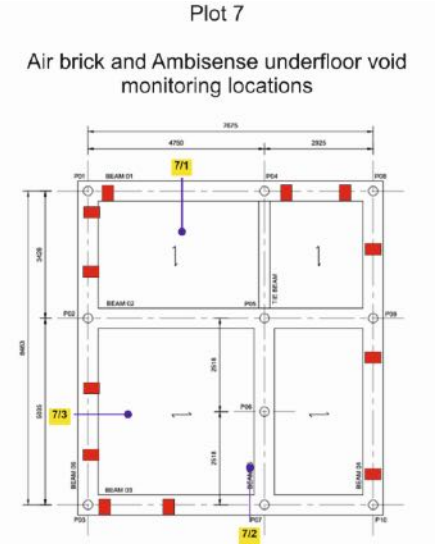
- Dissolved gas in pore water may or may not be an influence
- On top graph wells that are dry have no gas and good correlation between dissolved gas and gas monitoring
- Bottom graph – margial influence from dissolved gas





Void monitoring

- Three plots built in advance for the sub floor monitoring
- Should be continuous gas monitoring with linked weather data to each result
- Need to monitor in some dead spots – Follow the method in CL:AIRE Technical Bulletin TB16



Conclusion – moving forwards

- 2013 – installed gas monitoring wells after completion of filling but made it clear other lines of evidence were more important
- 2018 – installed in waste but the results were for design of venting to houses - surrender of recovery permit did not rely on gas monitoring data
- 2020 – post filling gas wells/monitoring not required or specified and compliance/surrender is based on TOC data of fill
- 2020 Post fill verification limited to flux chamber testing at surface
- Permit surrender based on waste acceptance testing not gas monitoring

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Thank you

- I will be pleased to discuss the presentation and answer any questions

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