# The WAG: An Innovation in Landfill Gas Data Analysis

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Historically, since the first data were collected and recorded from landfill gas (LFG) wells on landfills, people have tabulated, reviewed, and analyzed the data collected; looking for not just regulatory compliance parameters, but also for gas production changes, trends, and other insights, both positive and negative, to LFG system operation and the state of the landfill.

The history of LFG data analysis has ranged from tables, to single-parameter graphs, and eventually to multi-parameter graphs. In order to evaluate the trends that happen on a site, these multi-parameter graphs can span years at a time.

While these types of graphs have become the standard for LFG wellfield data analysis, the difficulty in the review is that one has to review this type of graph for every well in a wellfield. And wellfields can range from 20 to over 1,000 wells. Assuming even a minute per graph, it would take 16 hours to review a 1,000 well field.

There has to be a better way.

**The Wellfield Analysis Graph (WAG)**

Faced with the difficulty of evaluating multiple, multiple-parameter graphs to evaluate the health/compliance of a wellfield, we evaluated alternatives to the standard multi-parameter line graphs and developed a multi-parameter, multi-well ternary scatter plot, providing multiple parameters of data for an entire wellfield, on a single graphs (refer to **Figure 1**).

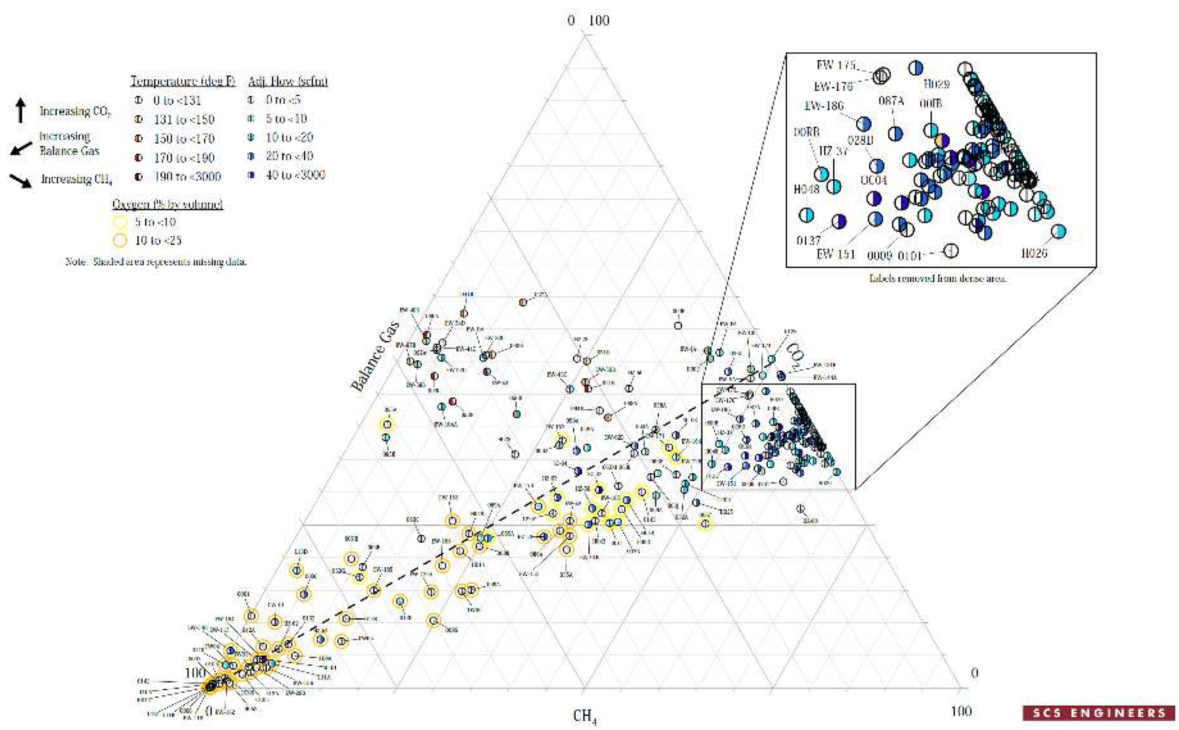


**Figure 1. Wellfield Analysis Graph**

The benefits of the wellfield analysis graph (WAG) include:

- One graph for all wells on a given site
  - Presentation of up to six parameters per well
    - Methane ($CH_4$)
    - Carbon Dioxide ($CO_2$)
    - Balance Gas (Bal)
    - Oxygen ($O_2$)
    - Flow
    - Temperature
- Multi-Use (both wellfield and wellhead) analysis

In developing the WAG, we borrowed from the ternary graphs that are typically used in groundwater minerals analysis. Each of the 3 axes of the ternary graph represents the normalized gas composition for each of the three parameters chosen for the graph. $CH_4$ is presented on the X-axis, $CO_2$ is plotted on the Y-axis, with Bal plotted on the Z-axis. By merging the axes into a triangular arrangement, you can plot the relative composition of each well on a single graph in relation to other wells from the same data set (e.g., round of readings) (refer to **Figure 2**).

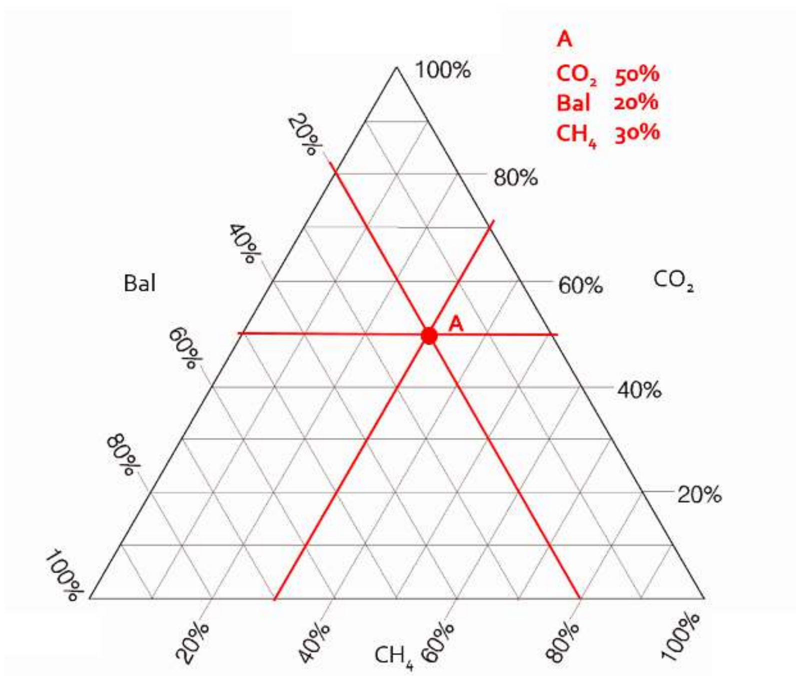


**Figure 2. Ternary Diagram of Well Composition**

Using this approach, the distribution of the composition of an LFG wellfield can be reviewed at a single glance (refer to **Figure 3**).

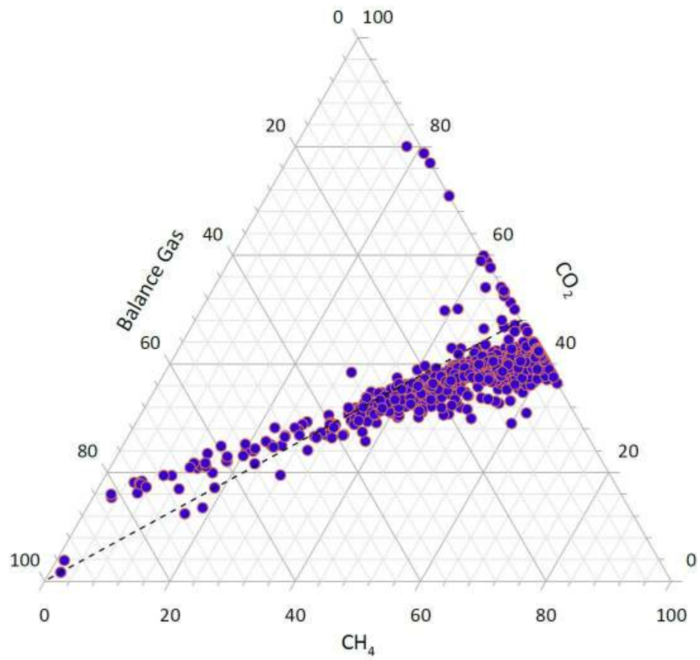


**Figure 3. Full Wellfield Analysis Graph**

In reviewing the 1,000 wells presented in Figure 4, the reviewer can see that the majority of the wells have a methane concentration of 40 to 60 percent, and a corresponding $CO_2$ concentration of 30 to 50 percent. This is generally indicative of Phase IV of typical LFG generation.

Once the basics of the WAG are understood, then the reviewer merely needs to spend time comparing the majority of the wells to the $CH_4$:$CO_2$ ratio (shown at a value of 1:1 as a dashed line in **Figure 3**) and evaluating outliers. This process simplifies the wellfield review process and reduces the time involved with detailed review of multi-parameter graphs. What the reviewer can now spend time doing, is focusing on more detailed review of outlier wells. And, when the $O_2$, flow, and temperature are added to the WAG, it can be further used to evaluate changes that may need to be made to management of the wellfield, and in the evaluation of elevated temperature landfills (ETLF).

**Figure 4** shows the analysis of a wellfield from an ETLF site. As shown in Figure 6, while a few of the wells are located in the preferred $CH_4$:$CO_2$ ratio zone (the middle of the right-hand side of the graph), the majority of the wellfield has low $CH_4$, high $CO_2$ and high Bal. When $O_2$, temp, and flow are added to the graph, you can see that the majority of the wellfield in the high Bal:$CO_2$ area is running at high temperatures, with the wells that have the highest Bal, also having significant (e.g., greater than 10 percent) $O_2$, which is indicative of ambient air being pulled into the well.

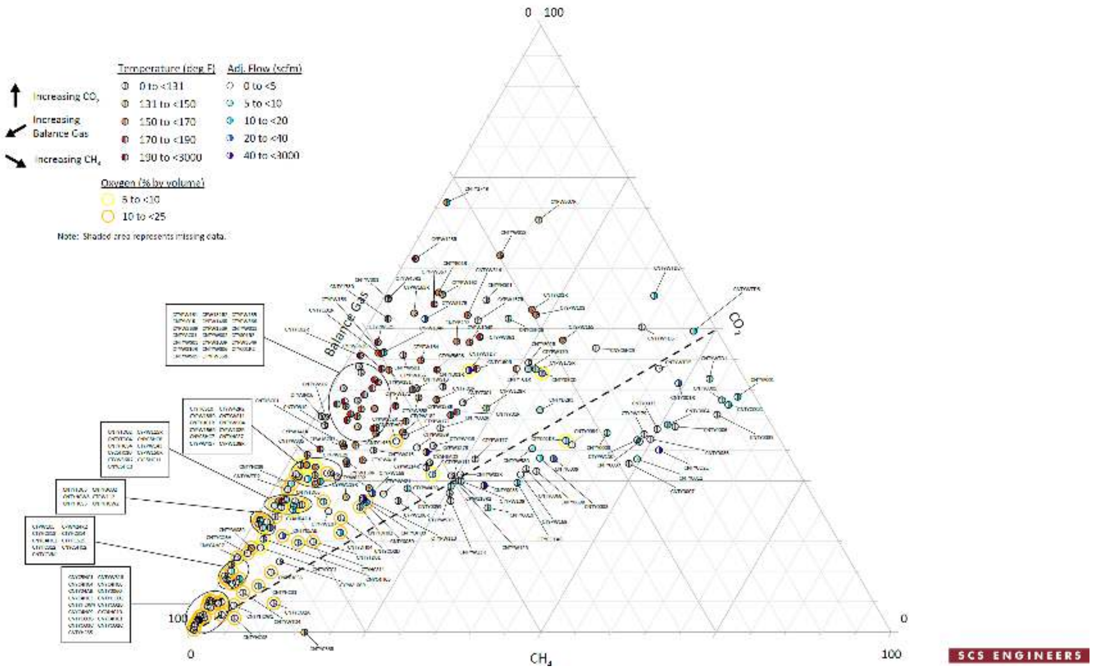


**Figure 4. ETLF Site Evaluation using WAG**

While the key benefit of the WAG is that it provides a snapshot of the entire wellfield, the WAG methodology can also be used for evaluation of individual wells over time. **Figure 5** illustrates a well at an ETLF site over time. Initial readings of the well were in the typical Phase IV CH4 and $CO_2$ ranges, whereas over time, the methane levels decreased in comparison to the increase of $CO_2$ and Bal. This reaction well ended up on the graph on the upper, left-hand side, indicating minimal to no $CH_4$ content.

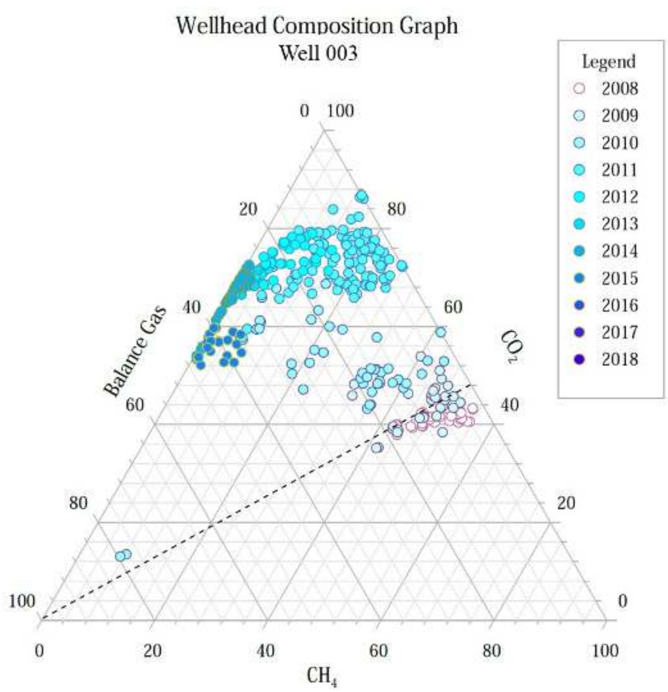


**Figure 5. Use of WAG Format for a Single Well over Time**