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Steve Cassulo
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Subject: **Chiquita Canyon Landfill – Response to Los Angeles County Public Works Letter Dated September 20, 2023 – Explanation of 15 Percent Increase in LFG Generation and Interim Measures to Increase Control Capacity.**

Dear Mr. Cassulo:

On September 20, 2023, Los Angeles County Public Works (PW) provided Chiquita Canyon, LLC (Chiquita) with additional comments on Chiquita's initial Condition 69 report. PW's requests included Chiquita "elaborate on how the 15% LFG generation [due to the reaction] was estimated, including all assumptions made." Another request asked to "elaborate on the Landfill's interim effort to bridge the gap in its flaring capacity while waiting for [permanent] flare permits."

SCS Engineers (SCS) has prepared this response letter providing the requested information.

BASIS FOR AN ESTIMATED 15% INCREASE IN LFG GENERATION:

As you are aware, landfill gas (LFG), is produced as a byproduct of anaerobic digestion of organic waste materials by microbial colonies in municipal solid waste (MSW). This process is referred to as, "methanogenesis" due to the significant generation of methane, which is one of the primary components of LFG, which is well understood within the solid waste industry. As a result of this well-known process in MSW, various algorithms and models have been developed as tools to estimate the quantity (both mass-based and volume-based quantities) of LFG that will be generated by the decomposition of wastes with a known composition.

The United States Environmental Protection Agency's Landfill Gas Emissions Model (LandGEM) is an example of such a tool, which can be utilized to estimate the quantity of individual constituents of landfill gas (such as methane and carbon dioxide), as well as the quantity of the LFG mixture. In the context of designing LFG equipment and infrastructure and documenting the rated capacity, the LFG flowrate is often expressed in volume-based quantity per unit time, such as cubic feet per minute (cfm).

However, the production of gas within a landfill in which a discrete portion of the waste mass is exhibiting multiple characteristics that are consistent with elevated temperature landfill (ETLF) or reaction conditions, is not as well understood. Under ETLF conditions, the typical waste decomposition processes (i.e., methanogenesis) associated with anaerobic digestion of MSW are impeded, due to heat accumulation. As a result, certain abiotic (non-biological) processes and reactions within the buried wastes are present instead. For purposes of this discussion, the gas produced within an ETLF by abiotic processes will be referred to as “Reaction Gas” (RG) to distinguish it from typical LFG produced by traditional methanogenesis.

The exact processes and reactions involved in production of RG are not well-documented within literature, and corresponding algorithms and models to estimate the quantity of RG are not readily available (especially any models that have been empirically confirmed by field measurements). The use of a first-order decay model similar to LandGEM to estimate projected RG flowrates may not be appropriate because under these conditions, microbes are not metabolically synthesizing the waste as during traditional methanogenesis.

Accordingly, engineering design exercises for sizing equipment to combust a gas stream that is a composite of LFG and RG typically consider the following:

- ETLF circumstances increase composite gas (LFG + RG) quantities (on a volumetric flowrate basis) because the increase in temperature expands gas volume in accordance with the ideal gas law (pV=nRT), where p represents pressure, V volume, n amount of substance, R ideal gas constant and T for temperature.

- ETLF circumstances decrease LFG quantities (on both a mass and volumetric basis) because the increased heat present within the waste matrix distresses certain species of methanogens (those that are characterized as mesophilic) and impedes their metabolic synthesis of the waste materials that produces LFG.

- RG, as a byproduct of abiotic processes and reactions, may potentially be produced in greater quantity than LFG produced by anaerobic digestion from the same unit of solid waste. While not a direct comparison, the pyrolytic gas yield of the organic fraction of MSW has been demonstrated to be significantly greater than the pyrolytic gas yield of anaerobic digestion (AD) solid residuals (digestate)[1].

For purposes of estimating the composite gas (LFG + RG) quantity that may warrant collection, management, and destruction at the Landfill, a 15 percent (%) inflation to the facility-wide LFG recovery rates, calculated using the industry-accepted algorithms and models, was applied in the flare capacity analysis to address ETLF during a 5-year period.

This was derived based on the following two approaches:

[1] Refer to “Pyrolysis of raw and anaerobically digested organic fractions of municipal solid waste: Kinetics, thermodynamics, and product characterization” Yuming Wen,, Ziyi Shi, Shule Wang, Wangzhong Mu, P¨ar G¨oran J¨onsson, Weihong Yang, Chemical Engineering Journal 415 (2021) 129064, https://doi.org/10.1016/j.cej.2021.129064

1) We considered the average LFG wellhead temperature during 2020, which was estimated to be approximately 135 degrees Fahrenheit (F), and compared it to the average LFG wellhead temperature during 2022, which was estimated to be approximately 155 F. The resulting increase in temperature constitutes a 14.8% increase, which would correlate to a consistent increase in gas volume if all other parameters (pressure, number of moles, and gas constant) remain the same.

2) Separately, we determined the approximate portion of the waste mass affected by ETLF conditions and applied an RG rate of production to that portion, while maintaining the standard LFG rate to the remainder of the waste mass. The portion of the waste mass affected by ETLF conditions in the northwestern portion is believed to be less than 15% of the total waste in-place. Assuming that RG quantities produced from this area are twice that of the typical LFG that would be produced, and assuming that LFG production from this area is completely impeded by the heat, then:

   Reaction Gas (RG) in Northwestern Zone = (Facility-Wide LFG x 0.15) x 2.0 = 0.3 x Facility-Wide LFG
   Total Composite Gas = (Facility-Wide LFG x 0.85) + RG = 1.15 x Facility-Wide LFG

Clearly both approaches are subject to various uncertainties and assumptions but are deemed to offer a reasonable suitable approach and methodology in the absence of empirically verified algorithms and models for gas generation at ETLFs.

CONTROL CAPACITY DISCUSSION

The Landfill currently has a control capacity of 9,600 scfm between the two (2) existing flares (Flares 1 and 2), each at 4,000 standard cubic feet per minute (scfm), and the one (1) existing portable thermal oxidizer at 1,600 scfm (TOX 1). The third party LFG-to-energy plant also provides additional control capacity, but Chiquita aims to have sufficient flaring capacity on its own.

The Landfill is actively constructing one (1) new 6,000 scfm flare (Flare 3) that is required by the South Coast Air Quality Management District (SCAQMD) to be online by November 24, 2023. We anticipate having it online by that deadline. The Landfill will also be submitting a permit application to the SCAQMD for an additional 6,000 scfm flare (Flare 4) by October 31, 2023. Flare 4 would replace the older, existing 4,000 scfm flare. We hope to have Flare 4 online in 2025, but it will depend on the time it takes SCAQMD to process the permit application.

In the interim, the Landfill has secured an additional portable thermal oxidizer with a capacity of 4,700 scfm (TOX 2) that will be delivered to the Site on October 20, 2023, and expected to be operational by mid-November 2023. With the addition of Flare 3 and TOX 2, the short-term capacity of Site will increase to 20,300 scfm, which is in excess of the peak predicated LFG plus reaction gas flow of 15,400 scfm. Table 1 provides LFG generation including reaction gas flows and a breakdown of control capacity.

Based on the capacity numbers in Table 1, the landfill is expected to have adequate gas control capacity to handle the increased gas production from the reaction with a margin of safety, once TOX 2 and/or Flare 3 comes on-line. Until that time, the site is at a deficit for gas control.

Table 1. Control Capacity Discussion

Year		**2023 (Current)**	**2023 (w/Flare 3)**	**2023 (w/Flare 3 + TOX)**	**2024**	**2025**
LandGEM LFG Generation	(scfm)	13,400	13,400	13,400	14,000	14,500
LFG Generation (Reaction Gas increase)	**15%**	**15,400**	**15,400**	**15,400**	**16,100**	**16,700**
Flare FL-100 (Flare 1)	(scfm)	4,000	4,000	4,000	4,000	4,000
Flare FL-150 (Flare 2)	(scfm)	4,000	4,000	4,000	4,000	
TOX-1	(scfm)	1,600	1,600	1,600	1,600	
TOX-2	(scfm)			4,700	4,700	4,700
Flare FL-120 (Flare 3)	(scfm)		6,000	6,000	6,000	6,000
Flare FL-130 (Flare 4)	(scfm)					6,000
Total Flare Capacity	(scfm)	**9,600**	**15,600**	**20,300**	**20,300**	**20,700**

CLOSING

If you have any questions regarding information contained in this submittal, please contact the undersigned at 858-571-5500.

Sincerely,

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Vice President
SCS ENGINEERS

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