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South Coast Air Quality Management District
21865 Copley Drive
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Subject: Response to Additional Information Request For A/N 650025 and 650026 HOVs Request for Chiquita Canyon Landfill (FID 119219)

Dear Dr. Chen:

As you are aware, SCS Engineers (SCS) submitted, on behalf of Chiquita Canyon, LLC (Chiquita), a Title V Revision Application for Temperature Higher Operating Values (HOV) pertaining to the Chiquita Canyon Landfill (CCL), dated January 26, 2024. One fundamental purpose of this application is presented in Section 3.1 of the document, which states:

> *"Because of the ongoing [Elevated Temperature Landfill (ETLF)] conditions and the continuously changing wells that are influenced by the ETLF, CCL requests approval of an alternative permit condition that establishes a blanket temperature HOV for current as well as future wells in the ETLF area."*

A critical revision to the language in Permit Condition 5.E that is being requested is noted in Section 3.3 of the application, which states:

> *"ALL WELLS INFLUENCED BY ELEVATED TEMPERATURE EVENTS ARE ALLOWED TO OPERATE AT A HIGHER TEMPERATURE, UP TO 220 DEGREES FAHRENHEIT."*

The South Coast Air Quality Management District (SCAQMD) is aware that a discrete portion of the waste mass at CCL is experiencing ETLF conditions. ETLF conditions can generally be characterized as when the typical waste decomposition processes and corresponding methanogenesis associated with anaerobic digestion of organic solid waste materials disposed in a landfill are impeded because of heat accumulation. As a result, certain abiotic (non-biological) processes and chemical reactions within the buried wastes occur instead.

In February 28, 2024 e-mail correspondence, SCAQMD requested that Chiquita provide the following:

- Provide the past one year record of CO concentration in the wellhead for all the wells that requesting HOV, in an Excel format.
- Please also provide the High Temperature Wellfield Data (Appendix B of the original submittal) in an Excel format.

- Provide a summary of all the data collected and a discussion supporting the position that the elevated parameter (220 F) does not cause a fire, is not the result of a fire or subsurface heating event, and does not significantly inhibit anaerobic decomposition by killing methanogens.

- Provide detail information and discussion of the steps taken to correct the well temperature.

Along with this letter, SCS is submitting two Excel documents responding to the first two bullets (see Attachments 1 and 2, respectively). The following discussion provides responses to the third and fourth bullets.

SUMMARY OF DATA COLLECTED

There are extensive field measurements being conducted and recorded at CCL that are relevant to the request for a temperature HOV at select LFG wellheads and useful for evaluating the basis for approving this request. The most pertinent data includes LFG composition and quality measurements recorded at the wellheads, both using field instrumentation and via laboratory sampling and analysis. It is SCS's understanding that SCAQMD is in possession of this data.

ELEVATED LANDFILL GAS TEMPERATURE DOES NOT CAUSE A FIRE AND IS NOT THE RESULT OF A FIRE

A discrete portion of the waste mass in the northeastern portion of the waste footprint is exhibiting classic symptoms of an ETLF, as opposed to a traditional subsurface oxidation (SSO), which consists of local subsurface landfill fire events. The ETLF conditions at CCL, and the resulting elevated landfill gas (LFG) temperatures measured at the wellheads, are the result of atypical subsurface chemical reactions. The potential causation of the ETLF conditions was investigated and discussed in SCS's report titled "Elevated Temperature Landfill Causation Investigation Report," submitted to SCAQMD on December 8, 2023. This report addressed heat generating reactions that could be present in any municipal solid waste landfill, such as anaerobic exothermic metal corrosion and oxidation reactions, hydration and carbonation of certain oxides/hydroxides, and acid-base neutralizations. As stated therein, the causes of the ETLF conditions at CCL cannot be definitively identified. It is likely that the heat generated within the waste mass from typical anaerobic digestion processes accumulated to a point that inhibited the second stage of fermentation, acetogenesis, and methanogenesis processes, and was replaced by abiotic chemical reactions affiliated with ETLFs that became self-sustaining.

Enabling LFG that has been heated (even to temperatures up to 220°F) within the buried waste mass to be extracted by the LFG collection system would not cause or result in an SSO or fire since the environment continues to be anoxic and there is no oxygen present within the reaction zone to enable combustion of the waste materials. Similarly, based on the collective experience and empirical data of the landfill industry, as well as the available ETLF research literature, the ETLF reaction is not a subsequent result from a fire event. The basis for this distinction as to the cause of the heat accumulation (ETLF vs. fire) is as follows:

- While persistent and widespread elevated subsurface and LFG wellhead temperatures are present in both ETLF and SSO circumstances, the heat observed at CCL is attributed to ETLF

processes and reactions and not attributed to an SSO because of the absence of charred waste, burning odors, and smoke (which is different from water vapor).

- Poor gas quality (defined as substantially low methane, e.g., less than 30 percent) in conjunction with methane-to-carbon dioxide (CH_4:CO_2) ratios less than 1.0 and elevated carbon monoxide (CO) concentrations is present in both ETLF and SSO circumstances. However, the diminished methane content, inverted ratio, and elevated CO in the LFG at CCL is attributed to ETLF processes and reactions and not attributed to an SSO because the LFG has measurable oxygen concentrations. Measurable oxygen concentrations are not expected with SSO events because the oxygen is typically fully consumed by the waste combustion.

- While there is settlement in the northwest area of CCL, SCS does not characterize this settlement as rapid localized subsidence that is typically affiliated with SSO events. Landfill fires and SSO events usually produce a depression of approximately 10 to 30 feet in diameter that forms over a few days or less; whereas, ETLF settlement affects multiple acres and occurs over months and years.

- On-site personnel have noted an unusual increase in leachate quantities as well as instances of pressurized liquids emitting from CCL's surface from boreholes during drilling and from LFG wells in the northwest portion of the waste footprint. The production of excess liquid quantities and the presence of pressurized liquids are common for landfills with ETLF conditions and are atypical of SSO events because the stoichiometry of combustion (thermal oxidation) of wastes does not yield water as a byproduct.

- The concentration of hydrogen (H_2) in the LFG at more than 25 wells and collectors has been measured in the range of 1 to 20 percent by volume. Hydrogen content in LFG at concentrations generally greater than 5,000 parts per million (ppm), which is equivalent to 0.5 percent by volume, is affiliated with ETLFs, not SSO events because the stoichiometry of combustion (thermal oxidation) of wastes does not yield hydrogen as a byproduct. Landfills with subsurface fire events do not produce hydrogen.

- The presence of dimethyl sulfide (DMS) in the LFG at concentrations in the range of 100 ppm has been recorded at CCL. Elevated DMS concentrations, with respect to other reduced sulfur compounds, is typical for sites experiencing ETLF conditions, not SSO events.

- The odors originating from the northwest section of CCL have been described as "chemical-like" (consistent with correspondence from Los Angeles County, dated September 1, 2023) and have been observed by Chiquita and SCS personnel to be notably and distinctly different from typical LFG or landfill working face odors. This is a common observation at ETLF sites, not SSO events, because the combustion of wastes associated with landfill fires does not yield the malodorous constituents possessing the distinctive ETLF odor character, such as volatile organic acids (acetic, butyric, propionic, etc.), reduced sulfur compounds (dimethyl sulfide, etc.), ketones, aldehydes, and select volatile organic compounds (benzene, etc.).

The conditions at CCL resemble an ETLF event and do not suggest other types of landfill heating events, such as a subsurface fire. Landfills with subsurface fire events do not produce liquids, ETLFs do. CCL is producing hydrogen and liquids as well as exhibiting a methane to carbon dioxide ratio

indicative of an ETLF. The settlement at CCL's surface in the area of the CCL affected by the landfill reaction is broad and pronounced, rather than in discrete and isolated portions. In addition, over multiple months, personnel involved in daily operation at CCL experienced odors of a different character than odors produced from a landfill fire event. In fact, the September 1, 2023, correspondence from Los Angeles County cites "chemical-like odors," which characterizes the odors as distinctly different than the odor characteristics usually noted at landfills experiencing subsurface fires.

ELEVATED LFG TEMPERATURE IS THE RESULT OF A SUBSURFACE HEATING EVENT BUT NOT A FIRE

The NSPS/EG regulations were developed in the early 1990s (ultimately becoming effective on March 12, 1996) which was over a decade before the first known ETLF event at a landfill in the U.S. occurred around 2008. Thus, the authors of the NSPS would have had no understanding of the potential for a subsurface heating event (such as the chemical reactions that are affiliated with ETLF conditions) that is not synonymous with a landfill fire. In fact, the Enabling Document (EPA-453/R-96-004, dated March 1996) incorrectly states, *"An elevated LFG temperature is an indicator of subsurface fires and aerobic conditions within the landfill,"* and repeats this inaccurate position in numerous locations throughout the document. The solid waste industry and the federal and state regulatory agencies have since learned that this is an inaccurate statement because elevated LFG temperatures are <u>not</u> exclusively an indicator of subsurface fires and aerobic conditions when such temperatures are the result of chemical reactions associated with ETLF conditions, as is the case with CCL.

SCS and Chiquita acknowledge that the elevated LFG temperatures at the LFG wellheads are associated with a subsurface heating event, but this is different from a fire or an SSO. We strongly advocate that this provision of the NSPS Rule not be relied upon as a basis to judge the merits of the subject temperature HOV request. After over 15 years of implementing corrective measures at more than 20 ETLF sites, the solid waste industry has demonstrated to federal and state regulatory agencies that the best management practices to temper the reaction are to extract heat from the waste mass through aggressive removal of hot fluids, both gaseous phase (LFG) and aqueous phase (leachate).

ELEVATED LFG TEMPERATURE DOES INHIBIT ANAEROBIC DECOMPOSITION, BUT EXTRACTING LFG IS NECESSARY TO RESUME TYPICAL DECOMPOSITION

The conditions at CCL include elevated temperatures measured in the LFG and liquids, high pressures, an inversion of methane to carbon dioxide ratios, an increased generation of gas and liquids, increased concentrations of hydrogen and DMS, accelerated settlement, and unusual and increased odors. These conditions occur at ETLFs, not landfills undergoing typical biological anaerobic digestion conditions.

SCS and Chiquita acknowledge that the methanogenic microbial communities are distressed and impaired by the elevated temperatures caused by the subsurface chemical reactions. However, based on recent and historical methane concentrations recorded at numerous wellheads within the area of CCL affected by the landfill reaction that exhibited temperatures in excess of 145°F, which demonstrate some measurable methane concentrations greater than zero, methanogenic bacteria

are continuing to accomplish some degree of anaerobic decomposition of organic waste materials in conjunction with a periodic increase of other decomposition byproducts, such as hydrogen.

While select organisms classified as methanogens are mesophiles and achieve optimal function in temperatures less than 120°F, certain methanogens function in anaerobic environments with sustained temperatures above 180°F. (Barlaz, M.A., Sadri, A., Luettich, S. Characterizations of Biological Activity in Refuse Samples Excavated from the Waimanalo Gulch Sanitary Landfill.)

There is extensive information in the scientific literature pertaining to the effect of temperature variations on both hydrogenotrophic and acetoclastic methanogens, some of which addresses landfill biological and ecologic processes, and some of which specifically addresses elevated temperature landfills. We refer the following scholarly research articles to your attention:

- Meyer-Dombard, D.R., Bogner, J.E., Malas, J. (2020, June 3). A Review of Landfill Microbiology and Ecology: A Call for Modernization with "Next Generation" Technology. Frontiers in Microbiology, 11.

- Krakat N., Westphal A., Schmidt S., Scherer P. (2010). Anaerobic digestion of renewable biomass: thermophilic temperature governs methanogen population dynamics. Appl. Environ. Microbiol. 76 1842–1850.

The important conclusion on this point is that it is critical to extract the hot fluids (gas and liquid) from the subsurface reaction to reduce the temperatures within the waste mass in an effort to encourage the reestablishment of more complex methanogenic communities in order to resume typical anaerobic digestion processes within the Landfill. The resiliency of methanogens when subjected to temperature variations is addressed in the Meyer-Dombard paper, which states *"Importantly, the populations of both hydrogenotrophic and acetoclastic methanogens were resilient when temperatures were dropped from 60°C to 55°C, and then increased back to 60°C (Krakat et al., 2010). However, experimentation at higher temperatures under landfill environmental conditions specifically have not been performed."*

EXTRACTION OF ELEVATED TEMPERATURE LFG IS IMPERATIVE TO MITIGATING AN ETLF

Previous experience at other ETLF landfills demonstrates that landfill reactions and resulting odors have been mitigated by best management practices, including increased gas extraction and liquid removal (e.g., through expanding systems and providing adequate LFG control capacity and leachate disposal capacity). Implementing these measures will help slow the reaction and mitigate impacts. The landfill industry has embraced several approaches to "contain and manage" the reaction area as outlined below:

- Enhanced gas collection and control infrastructure to remove reaction gases, reduce landfill pressures, reduce malodorous emissions, and remove heat.

- Enhanced liquids removal to improve gas collection efficiency and remove heat through the installation of in-well dewatering pumps. Removing landfill liquids removes heat, as well as allows gas to be collected from greater depths in the landfill, and the increase in temperature

is often a necessary side-effect of pumping operations that remove heat from these portions of the waste mass.

- Enhanced interim or final cover installation to further enhance gas recovery and reduce surface emissions and resulting odors.

Measures typically introduced to reduce LFG temperatures at the wellhead include adjustment of the wellhead control valve to reduce the applied vacuum, sealing of the soil/pipe interface at the well riser pipe penetration at the landfill surface, and checking for liquids accumulation in the well. All of these measures were attempted by LFG system operations personnel and proved insufficient to remediate the elevated temperatures prior to the recognition of ETLF conditions within the reaction area.

As a practical matter, obtaining HOVs for wells exhibiting elevated temperatures due to abiotic chemical reactions versus subsurface oxidation is an absolute imperative to enable the Facility to achieve its goal of removing heat via gas extraction. There are no measures available to Chiquita to instantly cool the hot LFG originating from the reaction area. Throttling the wellhead to a closed position as a response to the NSPS/EG temperature threshold is absolutely the wrong strategy as an ETLF remedial action because it prevents the beneficial removal of heat from the buried wastes.

As demonstrated at the other landfills that have experienced widespread ETLF heating events during the past approximate 15 years and in SCS's report titled "Elevated Temperature Landfill Causation Investigation Report," submitted to SCAQMD on December 8, 2023, Chiquita and SCS are confident that implementation of the best management practices developed by the landfill industry to contain and manage the reaction, which is accomplished in part via extraction of LFG with elevated temperature measurements, will succeed in slowing the propagation of the reaction area, result in cooling of the buried wastes, enable methanogenesis to ultimately be re-initiated within a large section of the affected waste mass, and mitigate and abate the detrimental impacts, such as odors, being experienced by surrounding off-site communities.

Please contact either of the undersigned if you have questions or require additional information.

Sincerely,

Robert E. Dick, PE, BCEE
Senior Vice President
SCS Engineers

Patrick S. Sullivan, BCES, CCP
Senior Vice President
SCS Engineers

cc:

Steve Cassulo, Chiquita

James Kim, SCS

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