# EXHIBIT C

**Emissions estimates based on analysis of EPA's GMAP observations of $H_2S$ concentrations around the New Indy plant on 24-27 April 2021**

Prepared by Steven Hanna 23 December 2021

Hanna Consultants, Kennebunkport, ME, USA

***Main conclusion – EPA measurements of $H_2S$ concentrations on four days in April, 2021, downwind of the New Indy plant, allow calculations of $H_2S$ emissions to be made. The calculated emission rate is 105.7 g/s, which can be extrapolated to an annual emissions rate of 3322 metric tons or 3650 English tons per year.***

There is a need to better determine the $H_2S$ emissions from water treatment ponds at the New Indy containerboard plant in Catawba, SC. This task is made easier by the detailed observations of $H_2S$ concentrations taken by the EPA (2021) downwind of the ponds during the 24-27 April period. The data are about equally divided between day and night periods. The EPA used their Geospatial Monitoring of Air Pollution (GMAP) van, which is driven back and forth on roads at various distances from the ponds. The observations that are reported are high resolution (a few seconds), thus providing detailed information. The figure below (from EPA, 2021) is an example of a resulting concentration pattern, for 27 April, on a road about 500 to 1000 m downwind of the pond edge. The aeration pond, with many white circles, is seen at the bottom of the photo. The height of the red bars is proportional to observed concentration. The $H_2S$ concentration in the middle of the plume is about 400 ppb. Plume center concentrations were determined for 27 April at several distances (x) downwind: 1000 ppb at x = 0 (pond edge), 400 ppb at x = 1 km, 120 ppb at x = 6 km, and 40 ppb at x = 9 km.

There is now great interest in the atmospheric pollution modeling community in using concentrations, such as those measured at NI, to calculate emissions (Hanna 2017 provides a review). Combined with observations of wind speed and direction, transport and dispersion models can be "reversed" so that, instead of calculating concentrations from emissions, they calculate emissions from concentrations. This "reverse" or "inverse" modeling, often called Source Term Estimation (STE), has been widely applied to calculations of methane (a greenhouse gas) emissions at oil and gas production facilities. For example, Harriss et al. (2015) give an overview of the Barnett Shale methane study, where it was shown that industry-reported methane emissions were much less that those determined using the STE methods.

In fact, the EPA has developed and applied STE methods that make use of their GMAP observations of concentrations and winds (EPA, 2015). The methodology, which they call Other Test Method 33A (OTM33A), uses a simple Gaussian plume model as a transport and dispersion model, and recommends that the method should be applied to van concentrations taken when the wind is steady and when the van is likely to be in the middle of the plume. We note that the EPA (2021) did not report an application of OTM33A to the GMAP data taken at NI. One reason may be that the NI source is known to be a broad area source (a pond 500 m in diameter), rather than the point source required by OTM33A in its Gaussian plume model.

Consequently, we use the main principles of the EPA's GMAP OTM33A STE procedure, but employ a basic science area source model (Hanna et al., 1982). Also, because the van-measured wind speeds and directions are not in the EPA (2021) NI report, we used observed winds from the Rock Hill airport weather station, located about 14 miles NW of NI. Since the terrain in the area does not have significant variations, the wind data from Rock Island are likely representative of those at NI. One reason for choosing 27 April as the first test case was that winds were fairly steady out of the SSW, with a speed of about 3 m/s.

To apply the basic science area source model, we use the EPA's 27 April observations along the N edge of the pond, where 11 sampling periods suggest a median concentration of about 1000 ppb. Assume that it is a two-dimensional problem, since the pond width (about 500 m), exceeds the width of any plume from a point source that travels 500 m. The slab dispersion model that we use is $C = Q_aL/HU$, where $Q_a$ is the mass release rate per unit area ($g/m^2s$), L is the alongwind pond dimension following the wind (assume 500 m), and H is the cloud depth at the downwind edge of the pond (assume 50 m for daytime and 20 m for nighttime; see Hanna et al., 1982). Thus Q (g/s) = $Q_a$ * (pond area) = (CUH/L) * (pond area). The observed pond area of 271,000 $m^2$ is used. We calculate Q = 105.7g/s (9.1 ktons per day) for H = 50 m (daytime), and Q = 42.3 g/s (3.7 ktons/day) for H = 20 m (nighttime).

These emissions calculations (Q) are further confirmed by the EPA (2021) C observations of 400 ppb at 1 km, 120 ppb at 6 km, and 40 ppb at 9 km. The daytime estimate of Q = 105.7 g/s is used in the area source slab model equation C = Q/(UWH), with U = 3 m/s. Assume that cloud depth H = 50 m + 0.05 x and cloud width W = 500 m + 0.1 x, where x is distance from the downwind pond edge (Hanna et al., 1982). This gives the result:

At x = 1 km, predicted C is 450 and observed is 400 ppb
At x = 6 km, predicted C is 70 and observed is 120 ppb
At x = 9 km, predicted C is 38 and observed is 40 ppb

It is concluded that the observed EPA (2021) GMAP concentrations at the edge of the pond and at 1, 6, and 9 km downwind on 27 April are consistent with the slab dispersion model-predicted concentrations, assuming a source term Q of 105.7 g/s (equivalent to 3322 ktons or 3650 English tons per year).

The GMAP observed concentrations in the EPA (2021) report and the Rock Hill reported winds for the other three days of testing (24, 25, and 26 April) were generally within a factor of two of those observed on 27 April and analyzed above. Consequently, it is expected that the emissions estimate, Q, for those days will also be within a factor of about two.

The basic science model used in the above analysis is known to have an uncertainty of about a factor of two. However, since the NI-reported $H_2S$ emissions are more than a factor of 100 less than those that we calculate, there would be a large emissions underestimate by NI even if the model has a factor of ten uncertainty.

EPA, 2015. Draft Other Test Method 33A: Geospatial Measurement of Air Pollution, Remote Emissions Quantifications – Direct Assessment, 91 pp, http://www.epa.gov/ttn/emc/tmethods.html#CatC/

EPA Region 5, 5 May 2021: GEOSPATIAL MONITORING OF AIR POLLUTION REPORT FOR NEW INDY CONTAINERBOARD – CATAWBA, SC, 107 pages.

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