May 23, 2025

Submitted electronically via a-and-r-docket@epa.gov

Ms. Penny Lassiter, Director
Sector Policy and Programs Division
Office of Air Quality Planning and Standards
Office of Air and Radiation
U.S. Environmental Protection Agency
109 T.W. Alexander Drive
Research Triangle Park, NC 27709

Re: Comments on Non-Regulatory Public Docket: Municipal Solid Waste Landfills
Docket ID No. EPA-HQ-OAR-2024-0453

Dear Ms. Lassiter:

The National Waste & Recycling Association ("NWRA") and Solid Waste Association of North America ("SWANA") are pleased to submit the following comments to the Non-Regulatory Public Docket: Municipal Solid Waste ("MSW") Landfills, Docket ID No. EPA-HQ-OAR-2024-0453.

NWRA and SWANA appreciate EPA's consideration of these comments and looks forward to continuing to work cooperatively with EPA to improve the standards of performance applicable to MSW landfills. Please feel free to contact the undersigned at agermain@wasterecycling.org, koldendorf@swana.org, or outside counsel for NWRA, Carol McCabe at cmccabe@mankogold.com, with any questions you may have.

Very truly yours,

Anne Germain, P.E., BCEE
Chief Technical and Regulatory Affairs

National Waste & Recycling Association

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Solid Waste Association of North America

Enclosure

A. Introduction

On October 25, 2024, as part of the United States Environmental Protection Agency's (EPA) strategy to learn more about new and emerging technologies and alternative methodologies for regulating emissions from MSW landfills, EPA opened a non-regulatory docket to gather input on ways the agency can streamline and improve the current suite of emissions regulations that cover these sources. On January 16, 2025, EPA extended the comment period for the non-regulatory docket through March 24, 2025. On March 24, 2025, EPA extended the comment period for the non-regulatory docket through May 23, 2025.

As part of this effort, and to assist with an upcoming rulemaking, EPA developed a series of white papers on new and emerging technologies, alternative approaches to regulating landfill emissions, and landfill work practice methodologies. The White papers cover the following specific topics:

1. Organic Waste Diversion ("White Paper No. 1")
2. Summary of State and Environment and Climate Change Canada ("ECCC") rules ("White Paper No. 2")
3. Landfill Size Thresholds ("White Paper No. 3")
4. Improvements in Intermediate and Final Covers ("White Paper No. 4")
5. Reducing Lag Time for Gas Control System Installation and Operation ("White Paper No. 5")
6. Aerial Monitoring ("White Paper No. 6")
7. Increasing Landfill Gas Collection Rates ("White Paper No. 7")
8. Improvements in Daily Cover Practices ("White Paper No. 8")

On December 9, 2024, EPA released two more White Papers covering the following topics:

9. Fenceline Monitoring ("White Paper No. 9")
10. Unmanned Aircraft System Technologies ("White Paper No. 10")

NWRA is a not-for-profit trade association representing private solid waste and recycling collection, processing, and management companies that operate in all fifty states. SWANA is a nonprofit professional association in the solid waste management field with more than 10,0000 public and private sector professionals across North America. Together our members own and operate MSW landfills and strive to deliver collection, composting, recycling, and disposal services in a manner that is safe, science-based, cost-effective, and protective of the environment. It is important that EPA adopt regulatory policies that allow our members to continue to deliver these essential services in this manner.

NWRA and SWANA have long been partners with EPA in developing data, methods, and best practices governing the operation of MSW landfills, including the development of emission estimates and data governing the quantification of greenhouse gas emissions associated with our members' operations. NWRA and SWANA and its members have also been active participants in the rulemaking process for MSW landfills since they were first regulated in 1996. This participation includes our's extensive comments on the rulemaking proposals leading to the

2016 promulgation of subparts XXX and Cf.[1] NWRA and SWANA filed a petition for judicial review and reconsideration of those rules, the latter of which EPA granted, and which led to additional rulemaking actions and clarifications.[2] However, our's petitions remain pending because EPA has not yet addressed all of the issues accepted for reconsideration. NWRA and SWANA address several of those issues herein. Since that time, NWRA and SWANA have been engaged in providing feedback to EPA relating to new and emerging technologies and alternative methodologies for regulating emissions from MSW landfills.[3] For example, in 2024, NWRA filed petitions for judicial review and administrative reconsideration of EPA's revisions to subpart HH of the Greenhouse Gas Reporting Rule,[4] 40 C.F.R. part 98, subpart HH, on the basis that EPA erred both procedurally and substantively in decreasing landfill gas ("LFG") collection efficiency values required to be used by reporting landfills under subpart HH. As explained in NWRA's petition, EPA did not provide adequate notice of this change, which we believe was based on incomplete science and conclusions advanced by climate advocacy groups.[5]

NWRA and SWANA are pleased to continue its active participation in the rulemaking process for MSW landfills by submitting comments to EPA in response to this White Paper Series.[6]

B. General Industry Comments to Federal Landfill Air Regulations

While NWRA and SWANA provide comment on each of the White Papers below, we have identified in our discussions with EPA a number of high-priority items that we ask EPA to

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[1] *Standards of Performance for Municipal Solid Waste Landfills*, 81 Fed. Reg. 59332-59384 (Aug. 29, 2016) ("Subpart XXX"), and *Emission Guidelines and Compliance Times for Municipal Solid Waste Landfills*, 81 Fed. Reg. 59276-59330 (Aug. 29, 2016) ("Subpart Cf") (collectively, the "Landfill Rules").

See EPA-HQ-OAR-2003-0215-0108 (comments on the proposed revisions to the *Standards of Performance for Municipal Solid Waste Landfills* (79 Fed. Reg. 41796, July 17, 2014) and the Advanced Notice of Proposed Rulemaking *Emissions Guidelines and Compliance Times for Municipal Solid Waste Landfills* (ANPRM EG) (79 Fed. Reg. 41772, July 17, 2014)); EPA-HQ-OAR-2003-0215-0196 (comments on the proposed revisions of the Emissions Guidelines and Compliance Times for Municipal Solid Waste Landfills (EG) (80 Fed. Reg. 52100, August 27, 2015)).

[2] The Petition for Rulemaking, Reconsideration, and Stay of the 2016 Landfill Rules is attached hereto as **Exhibit 1**. NWRA and SWANA was joined in filing the petition by Republic Services, Inc., Waste Management, Inc., and Waste Management Disposal Services of Pennsylvania, Inc.

[3] NWRA's submission in response to EPA's Request for Information on the *Use of Advanced and Emerging Technologies for Quantification of Annual Facility Methane Emissions under the Greenhouse Gas Reporting Program*, Docket No. EPA-HQ-OAR-2024-0350, is attached hereto as **Exhibit 2**.

[4] *Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule*, 89 Fed. Reg. 31802 (April 25, 2024).

[5] NWRA's Petition for Reconsideration of Subpart HH of the GHGRP was granted on August 8, 2024, and is attached hereto as **Exhibit 3**.

[6] By their nature, the White Papers do not contain specific regulatory proposals or sufficient detail for NWRA and SWANA to comment comprehensively. NWRA and SWANA are therefore responding in a similar level of detail as reflected in the White Papers and will await a more specific proposal to provide more detailed and substantive comments.

address as part of the Agency's statutorily mandated eight-year review of the Landfill Rules.[7] Incorporating these suggestions into forthcoming revisions to the Landfill Rules, which were last updated in 2016, will advance the shared goal of reducing emissions in a clear, consistent, and workable manner while recognizing the vital and irreplaceable public service provided by MSW landfills in the management of waste nationwide.

1. *A well-designed and well-operated gas collection system with a control device capable of reducing NMOC by 98 percent continues to be the best system of emission reduction.*

Under Section 111 of the Clean Air Act, 42 U.S.C. § 7411, EPA is required to promulgate regulations establishing standards of performance applicable to stationary sources that "cause[], or contribute[] significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare."[8] The "standards of performance" govern emissions of air pollutants and reflect the "degree of emission limitation achievable through the application of the best system of emission reduction," otherwise known as "BSER."[9] With respect to MSW landfills, since the inception of the Landfill Rules, EPA has defined BSER to be "a well-designed and well-operated gas collection system" and "a control device capable of reducing non-methane organic compounds ("NMOC") in the collected gas by 98 weight-percent"—collectively, the "gas collection and control system," or "GCCS."[10] In its evaluation of the Landfill Rules in 2016, EPA acknowledged that BSER had not changed.[11] The same conclusion is again warranted in the context of EPA's statutorily mandated 8-year review of subpart XXX; a well-designed and well-operated GCCS remains the best system of reducing emissions from landfills. EPA should reaffirm this conclusion in the context of the pollutants subject to regulation under the Landfill Rules, which are NMOCs (i.e., MSW landfill emissions as a whole), rather than methane.[12]

2. *EPA must streamline the relevant rules applicable to MSW landfills.*

As currently configured, there are multiple overlapping, redundant, and sometimes inconsistent regulations governing MSW landfills. NWRA and SWANA ask EPA to streamline these rules to establish one set of clear and consistent standards for the MSW landfill sector. By way of background, in the original 1996 rulemaking under Section 111 of the Clean Air Act, EPA created 40 C.F.R. part 60, subparts WWW ("1996 NSPS") and Cc ("1996 EG"). In 2003, EPA also established new standards for the regulation of hazardous air pollutants emitted for

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[7] CAA § 111(b)(1)(B); 42 U.S.C. § 7411(b)(1)(B).

[8] CAA § 111(b)(1)(A), 42 U.S.C. § 7411(b)(1)(A).

[9] CAA § 111(a)(1), 42 U.S.C. § 7411(a)(1); *see Standards of Performance for New Stationary Sources and Guidelines for Control of Existing Sources: Municipal Solid Waste Landfills*, 61 Fed. Reg. 9905, 9907 (Mar. 12, 1996).

[10] *See Standards of Performance for New Stationary Sources and Guidelines for Control of Existing Sources: Municipal Solid Waste Landfills*, 61 Fed. Reg. 9905, 9907 (Mar. 12, 1996).

[11] Subpart XXX, 81 Fed. Reg. at 59341.

[12] *See* 61 Fed. Reg. 9905, 9912 (Mar. 12, 1996).

landfills in the National Emissions Standards for Hazardous Air Pollutants for Municipal Solid Waste Landfills ("Landfill NESHAP"). [13]

More than ten years later, in 2016, EPA decided to create additional NSPS and EG subparts within Part 60—subparts XXX and Cf, respectively—rather than modify WWW and Cc. The promulgation of the 2016 EG likewise prompted the development of state plans and the Federal Plan in 40 C.F.R. Part 62, Subpart OOO. These five subparts, together with Landfill NESHAP, have created a complex web of overlapping rules that are not entirely consistent with each other and that pose significant implementation challenges for affected facilities, state and local permitting agencies, and EPA regions. By virtue of EPA's creation of entirely new subparts in 2016, every landfill in the country now necessarily meets the applicability criteria of two sets of NSPS and EG subparts—one from 1996 and one from 2016—as well as the Landfill NESHAP[14]:

Landfills that were last constructed/modified …	Emissions Guidelines for 111(d) "Existing Sources"		NSPS for 111(b) "New Sources"	
	Cc (1996)	Cf (2016)	WWW (1996)	XXX (2016)
… before May 30, 1991	X	X		
… on or after May 30, 1991 and before July 17, 2014		X	X	
… after July 17, 2014			X	X
Subject to Landfill NESHAP	X	X	X	X

A subsequent 2021 Landfill NESHAP rulemaking attempted to address some of the most obvious disparities among the various rules, [15] but significant inconsistencies in the application of these rules and remain, even among state and federal agencies. For example, California

[13] *National Emission Standards for Hazardous Air Pollutants: Municipal Solid Waste Landfills*, 68 Fed. Reg. 2227 (Jan. 16, 2003), codified at 40 CFR Part 63, Subpart AAAA ("Landfill NESHAP").

[14] As can be seen in this table, MSW landfills that were constructed or modified on or after May 30, 1991, and before July 17, 2014, meet the definition of both a "new" source under Subpart WWW and an "existing" source under Subpart Cf. This is an odd result, and calls into significant question whether EPA acted lawfully when it interpreted Section 111(d) of the Clean Air Act to allow it to promulgate a second Section 111(d) Emission Guidelines standard for an already-regulated set of sources that had previously been subject to "new" source performance standards under Section 111(b). *See* 42 U.S.C. § 7411(d). In addition, it is unclear whether Section 111(d) of the Clean Air Act would allow EPA to establish a set of existing source standards for source categories already regulated under Section 112 of the Clean Air Act, which MSW landfills were, starting in 2003. *See* CAA § 111(d), 42 U.S.C. § 7411(d).

[15] *See National Emission Standards for Hazardous Air Pollutants: Municipal Solid Waste Landfills Residual Risk and Technology Review*, 85 Fed. Reg. 17244 (March 26, 2020).

agencies and landfills have been subjected to a series of confusing guidance directives by EPA Region 9 that attempt to decipher the various subparts and address applicable requirements in conjunction with the California state plan requirements and permit shield implications. The region has stated that Subpart WWW continues to apply through Title V permits, even though the state and federal plans developed under Subpart Cf have now been effective for several years and Subpart WWW should have been entirely superseded.[16] This demonstrates that even regulators charged with overseeing the implementation of these rules have had difficulty in interpreting and applying them. Other regions have offered no guidance at all, leaving state and local agencies to do their best in interpreting conflicting rule language, often incorrectly or inconsistently. Given this regulatory confusion and uncertainty, it is critical for EPA ensure that any forthcoming changes to the Landfill Rules are carefully aligned and clear to reduce unnecessary administrative burden and confusion. NWRA and SWANA believe this would be best accomplished by eliminating unnecessary subparts and implementing one set of air regulatory requirements to govern MSW landfills.

3. *EPA must commit to timely review of design plans or eliminate the obligation to submit them altogether.*

NWRA and SWANA ask EPA to fix the broken rules governing submission and review of GCCS design plans. While the Landfill Rules require affected landfills to seek agency approval of GCCS design plans, they fail to require agencies to actually review and approve such plans, thereby placing unreasonable risk upon affected facilities that are nonetheless required to move forward with GCCS installation.[17] NWRA and SWANA and its members have observed very low review rates for GCCS plan submittals (estimated at around 40%) and have been caught in the middle of confusion between delegated state agencies and EPA regions as to which regulator has primary responsibility for such review. These agency failures place an unfair risk on affected landfills by requiring the design plans to reflect site-specific factors and alternative compliance systems, some of which come to light only after construction has commenced. Agency enforcement actions have exacerbated the problem, either by alleging violations based on design plans that were never timely reviewed or renewed by the Agency. Given these longstanding issues, EPA should revisit the need for agency review and approval of landfill GCCS design plans. The Landfill Rules should no longer require agency review or approval if the landfills obtain the certification of a Professional Engineer. GCCS as-builts would continue to be maintained on-site, however, and would be submitted for agency review upon request. Moreover, since expansions and additions to the wellfield are required to be listed in semi-annual NESHAP reports, this information would likewise remain available to EPA and state agencies at all times.[18]

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[16] *See Clean Air Act Landfill Requirements for California Sources,* EPA Region 9 October 25, 2023.

[17] *See* 40 C.F.R. §§ 60.767(c) and (d).

[18] These reports are widely accessible due to the fact that they are submitted electronically to EPA via the Compliance and Emissions Data Reporting Interface (CEDRI) in accordance with the relevant electronic reporting requirements. 40 C.F.R. § 60.767(i).

4. *Surface emissions monitoring enforcement must be carried out in accordance with the regulations, and any new detection methodologies must be further reviewed and evaluated prior to their inclusion in the Landfill Rules.*

EPA should maintain and reinforce that surface emissions monitoring ("SEM") is intended to ensure that GCCS is well-operated, using an operational standard of 500 ppm methane. However, SEM is not an emission limit, nor is an exceedance of the 500 ppm operational standard a violation if timely corrective action is undertaken. Corrective actions may include repairs to restore cover integrity, tuning wells or even adding new wells. NWRA and SWANA have expressed concerns to EPA with respect to an apparent shift in SEM methodologies being adopted in agency investigations and enforcement activities – methodologies that mistakenly suggest noncompliance and that depart from the rule requirements and established industry practices. Aside from these concerns, NWRA and SWANA believe that SEM practices and effectiveness can be strengthened through the use of alternative technologies where appropriate, and to that end several industry members are actively partnering with EPA and technology vendors to evaluate drones, lasers and methane sensor technologies for near-field surface monitoring. As set forth in more detail herein, we do not believe that any of these technologies are sufficiently developed or available for mandated use through the Landfill Rules at this time, nor would they be appropriate for every site. However, NWRA and SWANA intend to work closely with EPA and other partners to evaluate the most effective technologies and we ask EPA to carefully consider how these technologies might be incorporated into the Landfill Rules in a manner that provides affected landfills with the option to use them in conjunction with traditional SEM methods.

5. *Wellhead temperature should not be used as compliance parameter, because it is not a reliable indicator of subsurface fires.*

Lastly, NWRA and SWANA and its members urge EPA to carefully evaluate the continued utility of the wellhead temperature standard in the Landfill Rules. The causes and appropriate corrective actions for increased temperature wells are frequently misunderstood by EPA and state agencies. Increased wellhead temperature (above the 131-degree Fahrenheit standard) is usually caused by site-specific waste composition and local climate-related factors affecting individual sites. The best course of action in response to rising temperature is to increase landfill gas flow to the affected well which will allow pressure, and thus temperature, to decrease. Rarely are high temperatures indicative of a subsurface fire. However, temperature-related corrective action currently requires sites to reduce landfill gas flow to the affected well, thereby decreasing system performance and increasing potential fugitive emissions. Further, attempting to address increased temperatures by expanding the GCCS with new wells can serve to exacerbate the condition.[19] Where a fire is indeed present, there are a multitude of other indications that landfill operators can closely monitor. Relatedly, the enhanced temperature monitoring requirements that accompanied the increased parameter value in the Landfill NESHAP have been ineffective in practice for two primary reasons: first, agencies appear to be reluctant to approve Higher Operating Values ("HOVs") for high temperature wells, despite

[19] Mullah-Saleh, A.; Hernandez, M.; & Mesojedec, J., *Elevated Temperatures (as High as 176 degrees Fahrenheit) Detected in Landfill Gas Wellheads!*, SWANA.

EPA's intent that enhanced monitoring would only be conducted until an HOV is approved. Second, the carbon monoxide ("CO") monitoring requirement, which is based on laboratory sample analysis, imposes a tremendous administrative burden and lag time with no corresponding benefit when compared to the much more practical field-based stain tube methodology, which EPA previously rejected but should reconsider.[20] The lag time for laboratory analysis of CO is often greater than two weeks, whereas stain tubes provide instant feedback to GCCS operators in order to make immediate adjustments to the system to address high CO readings.

In light of these concerns, NWRA and SWANA urge EPA to revisit its 2014 NSPS proposal to remove the wellhead temperature requirement altogether and instead rely on SEM and wellhead pressure as the appropriate indicators of GCCS performance.[21] NWRA and SWANA and other industry members commented extensively in favor of this proposal in 2014, and our comments continue to be reflective of our observations in the field.[22] Removal of the wellhead temperature parameter would also be consistent with the recent rule proposal released by Environment and Climate Change Canada ("ECCC").[23]

C. Specific Comments in Response to White Paper Series

NWRA and SWANA hereby submit the following comments on the individual White Papers, as summarized here and as set forth in more detail below:

White Paper No. 1. While organics diversion is an advantageous practice where feasible, NWRA and SWANA agree with EPA's prior conclusion that it does not fall within the purview of the Landfill Rules. Organics diversion would require behavioral changes amongst waste generators as well as infrastructure requirements better situated for consideration by state legislatures and solid waste management programs.

White Paper No. 2. EPA describes several proposals or regulatory requirements advanced by state agencies regarding MSW landfill emissions. Our comments on these requirements are contained in responses to other White Papers, to the extent other White Papers raise parallel or similar suggestions. In adopting requirements imposed by state agencies, EPA must consider the feasibility, costs, and potential undue labor burdens associated therewith.

White Paper No. 3. NWRA and SWANA recommend that EPA maintain existing requirements pertaining to the size and emission threshold for rule applicability, as the best indicator for

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[20] *See* 85 Fed. Reg. 17244 (March 26, 2020).

[21] *See Standards of Performance for Municipal Solid Waste Landfills*, 79 Fed. Reg. 41796, 41821 (July 17, 2014) ("Instead of having the landfill owner or operator conduct monthly monitoring of temperature and nitrogen/oxygen at the wellheads, the EPA is considering relying on landfill surface emission monitoring requirements in combination with maintenance of negative pressure at wellheads to indicate proper operation of the GCCS and minimization of surface emissions.")

[22] *See* EPA-HQ-OAR-2003-0215-0196.

[23] Canada Gazette, Part I, Volume 158, Number 26: Regulations Respecting the Reduction in the Release of Methane (Waste Sector).

GCCS installation is the age, rather than amount, of the waste, in conjunction with NMOC emissions. It is imperative that closed sites are not required to enter or reenter the program and that standards are not applied retroactively.

White Paper No. 4. NWRA and SWANA agree with EPA that final cover requirements are regulated under RCRA subtitle D, while intermediate cover requirements are considered best management practices rather than components of BSER. The use of biocovers, MOLs, and GDLs in intermediate cover cause operational burdens that tend to result in increased fugitive emissions and decreased GCCS efficiency, while assuming the availability of materials irrespective of landfill geographic location.

White Paper No. 5. EPA should not reduce the time provided for landfill operators to install or expand GCCS because the existing time periods provide sufficient time to develop, permit, and construct GCCS. Moreover, EPA's assertion that earlier installation of GCCS will increase gas capture fails to consider that the gas generation rate of composite waste streams are not known to a high degree of certainty; therefore, the current NMOC emission rate factors consider uncertainty and overestimate NMOC emissions already. EPA should not use a methane-based destruction efficiency criteria or ban the use of open-flares because doing so would provide no appreciable emission reductions while inhibiting site-specific flexibility and beneficial gas utilization projects.

White Paper No. 6. NWRA and SWANA support the continued research and evaluation of aerial and satellite measurement technologies for future incorporation into the Landfill Rules. These technologies do not currently provide reliable results, are not cost-effective, and do not utilize open-source, transparent, standardized methodologies for detection or quantification purposes. Further, their use in regulations applicable to oil and gas facilities is not readily transferrable to MSW landfills.

White Paper No. 7. EPA should allow landfill operators and engineers to choose the materials used in GCCS components on a site-specific basis. NWRA and SWANA support to implementation of a robust decommissioning procedure to improve LFG management during the beginning and back end of the generation curve. With respect to liquids management, NWRA and SWANA members have found that wellhead pressure and SEM adequately indicate where excessive liquids in wellheads impedes gas collection, without the need for additional technology. While automated wellheads pose some operational benefits, the technology is underdeveloped, increases operator labor burdens, and does not comport with other aspects of the Landfill Rules—namely, corrective action deadlines and oxygen calibration standards.

White Paper No. 8. Daily cover is influenced by a host of site-specific factors and geographically available material and is properly situated for regulation under RCRA, subtitle D. Any daily cover regulations under the Landfill Rules should be performance-based to allow for site-by-site flexibility. To reduce working face emissions, NWRA and SWANA support the use of interim GCCS in ways which recognize the need for operational flexibility, but does not support a working face size limitation or the use of fixed sensors, as neither initiative would comport with the dynamic, rapidly changing aspects of the working face.

White Paper No. 9. Fixed fenceline sensors require additional development before they should be considered for implementation into the Landfill Rules, and in any event, do not capture emissions across the entire surface of landfills. Fenceline sensors have typically been used for site-specific concerns relating to H_2S emissions for odor reduction purposes, which is not an appropriate consideration under the NSPS.

White Paper No. 10. EPA should continue to evaluate UAS technologies under the existing OTM/ALT review process to ensure that open-source, transparent, and standardized methodologies exist prior to mandating their use for SEM in the Landfill Rules. NWRA and SWANA agree that these technologies could resolve several issues posed by walking SEM; however, interval spacing should not be reduced until reliable, standardized detection methodologies exist, and EPA allows operators to choose among all approved methods without limitation.

1. *MSW Landfill Organic Waste Diversion Alternative Compliance Mechanism (October 2024)*

Organics diversion and source separation can be advantageous practices where feasible, particularly where the organic materials are used to produce beneficial products such as renewable biogas for energy or fuel or high-quality compost material for enhancing soils. However, EPA has acknowledged the complexities of incorporating organics diversion into BSER, and has concluded that the practice is best situated for state, local, and Federal solid waste management authorities.[24] In particular, EPA notes the following barriers with respect to the inclusion of organics diversion practices in the Landfill Rules:[25]

- the complexity and local nature of waste management;
- limited processing and transfer capacity for organic wastes;
- the multifaceted and regional nature of the solid waste management industry; and
- behavioral changes that would be needed among waste generators (individuals, businesses, and industries) to divert their organic waste from landfills.

NWRA and SWANA agree that organics diversion is not appropriate for inclusion within the Landfill Rules because it would require changes to solid waste management programs and the buildout of significant infrastructure. Indeed, state agencies implementing solid waste programs at the behest of their state legislatures are better situated for administering organics diversion programs. For example, the Maryland Department of Environment implements the Organics Recycling and Waste Diversion Program, [26] as directed by the state legislature.[27] A federally-mandated organics diversion program would not only usurp the authority exercisable

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[24] *See* 2016 Response to Comments (RTC), at 46, EPA-HQ-OAR-2014-0451-0191, Excerpt 8.

[25] *Id.*

[26] *See* Md. Code Regs. § 26.04.13.

[27] 2021 Maryland Laws Ch. 439 (H.B. 264) Solid Waste Management—Organics Recycling and Waste Diversion—Food Residuals, 2021 Maryland Laws Ch. 439 (H.B. 264); Md. Code Ann., Envt § 9-1724.1.

by states, but it would also likely be considered an impermissible exercise of agency authority under the Clean Air Act.

In determining that BSER is a well-designed and well-operated GCCS,[28] EPA has never attempted to alter the waste streams accepted by MSW landfills to exclude a certain type of municipal solid waste because, as EPA acknowledged in this White Paper, doing so would necessitate behavioral changes on an individual basis—entirely outside the control of landfill operators. Such an exercise of discretion was not contemplated by Congress in enacting Section 111(b); in any event, organics diversion is not a "technology-based approach," but rather is dependent on the existence of off-site infrastructure to accommodate composting or anaerobic digestion of organic waste. [29]

In any event, an organics ban would undermine the protective measure provided by landfills when other waste management avenues fall short. In the event that organic waste becomes contaminated, cannot meet the standards or established end markets, is rejected by processing facilities, or must be diverted due to unforeseen system upsets, MSW landfills may provide a secure destination. For example, when a rendering plant in Delaware temporarily shut down, organic waste was diverted to landfills until rendering operations could resume, making landfills a necessary backstop for organic waste disposal.

Although organics diversion is not appropriate or practical for regulation under the Clean Air Act, NWRA and SWANA encourage EPA to consider whether organic waste diversion could be otherwise acknowledged through the Landfill Rules, such as via the reduction or removal of requirements for low-organic and low landfill gas-producing sites. In conjunction, it would be appropriate for EPA to revise the mandatory landfill gas generation estimation factors to reflect site-specific organic waste reduction practices, where appropriate.

2. *Review and Comparison of Existing State Rules and Proposed Canadian Rule to MSW Landfills NSPS/EG (October 2024)*

This White Paper largely contains topics addressed in the other White Papers in the series. To avoid confusion, please see the comments in the other White Papers regarding the following topics:

- *Size Threshold: See* comments on White Paper No. 3 (Landfill Size Threshold).
- *Emission Threshold: See* comments on White Paper No. 5 (MSW Landfill Gas Collection and Control System (GCCS) Installation Lag Time and Nonmethane Organic Compound (NMOC) Destruction Efficiency).

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[28] *Standards of Performance for New Stationary Sources and Guidelines for Control of Existing Sources: Municipal Solid Waste Landfills*, 61 Fed. Reg. 9905, 9907 (Mar. 12, 1996); *Standards of Performance for Municipal Solid Waste Landfills*, 81 Fed. Reg. 59332, 59341 (Aug. 29, 2016).

[29] *See, e.g.*, *West Virginia v. EPA*, 597 U.S. 697 (2022). In *West Virginia*, the Supreme Court held that CAA Section 111(d) did not allow EPA to require "generation-shifting"—*i.e.*, subsidizing increased generation by natural gas, wind, or solar—as part of BSER for existing power plants because Congress did not implicitly "leave to 'agency discretion' the decision of how much coal-based generation there should be over the coming decade" and generation-shifting did not constitute an applicable "technology-based control." *Id.* In promulgating Section 111(d), Congress intended a technology-based approach. *Id.* at 726 (citing 40 Fed. Reg. 53343 (1975)).

- *GCCS Design and Installation*: *See* comments on White Paper No. 5.
- *Surface Emissions Monitoring: See* comments on White Paper No. 10 (Unmanned Aircraft Systems (UAS) Technologies for Landfill Methane Monitoring).
- *GCCS Removal: See* comments on White Paper Nos. 5 and 7 (Increasing Landfill Gas Collection Rates).

EPA must review existing state rules with the understanding that certain requirements contained therein are suited for the particular geographic locations and climactic conditions unique to the relevant state enforcing the rule. For example, MSW landfills in Colorado are subject to drastically different conditions and resource availability than MSW landfills in Oregon. To the extent EPA intends to adopt provisions of certain of these state rules, EPA must do so in a way that acknowledges that differing characteristics of MSW landfills falling within the national purview of the Landfill Rules. Further, EPA must not blindly adopt provisions of proposed or effective state regulations without evaluating and considering technical feasibility and cost effectiveness, to avoid creating unnecessary financial burdens and undue labor burdens associated with monitoring and recordkeeping.

3. MSW Landfill Size Threshold (October 2024)

The current federal regulations require MSW landfills with a disposal capacity of 2.5 million megagrams (Mg) and 2.5 million cubic meters (m^3) or more and that are estimated to generate greater than 34 megagrams per year (Mg/yr) of nonmethane organic compounds (NMOC) or have surface emissions of methane exceeding 500 ppm through use of the Tier 4 method to install a GCCS within 30 months of the first emission rate report showing that the landfill's NMOC emissions exceed 34 Mg/yr. 40 C.F.R. § 60.762(b)(2)(ii)(A), (B). EPA's White Paper on this topic explores alternative thresholds for applicability, including a waste-in-place ("WIP") threshold, and a methane-based emission threshold. In advancing these potential regulatory changes, EPA broadly assumes that "landfills exceeding a revised size threshold would also exceed the methane-based emission threshold and would be required to install and operate GCCS."[30] This White Paper primarily evaluates assumed emissions reductions associated with a 450,000 ton WIP threshold, but "does not attempt to recommend a specific methane emission threshold" for rule applicability because "it is assumed that exceeding a size threshold" "would likely result in exceeding a methane-based emission threshold."[31]

First and foremost, in considering any changed applicability threshold EPA must ensure that already-closed landfills do not become subject to the Landfill Rules. Closed landfills either did not meet the applicability criteria of the Landfill Rules, or otherwise met the stringent requirements for shutdown or removal of GCCS. Accordingly, the potential for landfill gas generation and emissions are low. These landfills no longer accept waste or generate revenue, and therefore would not be able to meet the substantial cost burden associated with the Rules, and would generate very little benefit, if any, from applicability of the Landfill Rules. EPA expressly acknowledged and agreed with this concern in its 2016 rulemaking, when evaluating a

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[30] White Paper No. 3, at 2.

[31] *Id.* at 4.

potential change in the capacity threshold for the Landfill Rules from 2.5 million m^3 to 2.0 million m^3:

> *The EPA also notes that closed landfills may have limited access to additional revenue because they are no longer collecting tipping fees and the cost for GCCS and regulatory compliance were not factored into their closure plans, they may have poor or incomplete records for estimating landfill gas emissions, and they are less likely to be permitted.*[32]

EPA must demonstrate that any proposed change to the applicability threshold for applicability of the Landfill Rules is consistent with the many operational realities of landfill operations. Relatedly, NWRA and SWANA cannot comment meaningfully on the potential methane-based emission threshold if EPA does not suggest a numeric value. In any event, a methane-based emission threshold would be inconsistent with established rule applicability analyses using an NMOC-based emission threshold.[33] As expressed in further detail in Section B.5, it would be inappropriate to shift the focus of the Landfill Rules to methane in lieu of landfill gas emissions because doing so would cause administrative burden and disruption, and would not advance real reductions in emissions relative to the use of NMOC as an indicator for landfill gas. In addition, any methane-based emission threshold would require the formulation and implementation of a reliable and accurate methane emissions quantification methodology, like those currently employed for NMOC.[34] Indeed, quantifying methane emissions from MSW landfills does not occur on a measured basis, and is subject to variability over the landfill's life, depending on many site-specific factors that must be appropriately reflected in any such calculation.

EPA should continue to use a 2.5 million Mg capacity threshold requirement instead of a 450,000 ton WIP requirement. In support of the WIP concept, EPA asserts that methane emissions are closely related to landfill size (waste-in-place), whereas NMOC emission estimates can vary depending on the types of waste accepted by a given landfill and other site factors. In conjunction with this assertion, EPA states that a lowered size threshold and accompanying methane-based emission threshold would lead to increased capture of uncontrolled methane emissions, including specifically from accelerated food waste decay.[35] Using an assumed representative NMOC value of 200 ppm, EPA estimates that the current NMOC emission rate threshold of 34 MG/yr in the Landfill Rules would correlate with a waste-in-place of approximately 4 million short tons as the point at which the landfill would exceed the NMOC threshold and be subject to a requirement to install and operate a GCCS.[36]

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[32] *Emission Guidelines and Compliance Times for Municipal Solid Waste Landfills*, 80 Fed. Reg. 52100, 52119 (Aug. 27, 2015).

[33] 61 Fed. Reg. 9905, 9907 (Mar. 12, 1997); 81 Fed. Reg. 59332, 59334 (Aug. 29, 2016).

[34] 40 C.F.R. § 60.764.

[35] White Paper No. 3, at 3.

[36] White Paper No.3, at 5.

EPA lacks the technical and scientific basis required to justify transitioning to a 450,000 ton WIP threshold. EPA fails to provide a sufficient basis to support its use of 200 ppmv as the assumed representative NMOC concentration value in suggesting a WIP threshold. [37] EPA simply states, without specificity, that it chose 200 ppmv "[b]ased on experience with federal compliance inspections and direct observations at multiple landfills" where NMOC concentrations ranged from 100 ppmv to 300 ppmv. When measuring NMOC concentrations across their MSW landfill portfolios using Tier 2, NWRA and SWANA members routinely detect and calculate NMOC concentrations of 400 ppmv and often higher.[38] In another of EPA's publications, the AP-42 Emission Factors applicable to MSW landfills, EPA states that the default NMOC concentration that should be used at landfills that contain only MSW waste is 550 ppmv—which is well above the concentration used to support EPA's contentions in this White Paper. [39] Compounding the inaccurate representation of estimated emissions presented in the paper is the use of the default k = 0.05 yr-1 and L_0 = 170 m3/Mg. These values are not appropriate for emission inventory analysis and grossly overestimate methane generation, and as such, the figures used to show potential reductions in methane emissions are over estimated. EPA should rely on the experiences and site conditions faced by landfill operators on a regular basis to reevaluate its conclusion that the NMOC emission rate threshold of 34 MG/yr in the Landfill Rules correlates with a waste-in-place of 4 million short tons as the point at which the landfill would exceed the NMOC threshold, because as the White Paper acknowledges, any change in size thresholds will have significant nationwide impacts that could result in hundreds of landfills requiring additional permitting, construction, testing, and analysis much earlier than under the current Landfill Rules.

In addition to utilizing sound scientific data that reflects realistic site conditions at MSW landfills, it is incumbent upon EPA to thoroughly examine the potential costs against the potential methane emissions reductions of any such change. EPA appears to assume that smaller gas collection and control systems are less efficient than larger GCCS, as EPA estimates GCCS collection efficiency to be 50% 4-8 years after exceeding the size threshold (e.g., 2.5 million Mg and m^3), compared to a 75% collection efficiency 9-13 years after exceeding the threshold.[40] If the requirement to install GCCS is triggered sooner using a WIP threshold and because EPA has not indicated any intent to change the criteria for determining when GCCS may be capped or removed, landfills will be required to operate GCCS many years beyond what is currently required—imposing a host of additional annual operation and maintenance costs not contemplated by EPA. Moreover, landfills with smaller GCCS will be less able to comply with the currently-applicable wellhead requirements.[41]

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[37] While NMOC concentration may not always be the best indicator of landfill gas production, including at landfills located in arid regions of the country, it is a parameter that can be tested using the presently available test methods.

[38] Some sites have observed NMOC concentrations up to 1,300 ppmv. Accordingly, a 200 ppmv values is not representative of the industry at large.

[39] AP-42, Vol. I, Ch. 2.4: Municipal Solid Waste Landfills, at 2.4-4.

[40] White Paper No. 3, at 6.

[41] Indeed, EPA recognized this problem in 2016 when it removed oxygen from the wellhead parameters as a result of lowering the NMOC threshold from 50 MG/yr to 34 MG/yr. This issue could also be rectified by allowing other

4. *Improvements in Intermediate and Final Landfill Covers to Mitigate Emissions (October 2024)*

In this White Paper, EPA explores several options for improving the effectiveness of landfill cover, such as integrating a methane oxidation layer (MOL) in intermediate covers, incorporating gas distribution layers (GDL) to improve collection at extraction wells, and mandating final or enhanced cover once a landfill cell reaches its final grade. NWRA and SWANA disagree that mandates on intermediate and final covers are appropriate under the CAA; instead, cover requirements should remain governed under state solid waste regulatory programs and would constitute federal overreach if regulated in the context of reducing emissions. NWRA and SWANA agree with EPA that final cover is addressed under RCRA and within state solid waste regulations:

> *EPA continues to maintain that guidance on daily and final cover is addressed under RCRA subtitle D and therefore is not considered BSER under the CAA. The EPA also maintains that the primary responsibility for implementing specific aspects of Subtitle D lies with states and local governments.*[42]

With respect to intermediate covers, NWRA and SWANA agree with EPA that they are considered BMPs:

> *While we also agree that intermediate cover practices, which can improve methane oxidation and enhance collection efficiency, are not covered under Subtitle D, we are aware of several states (e.g., Texas, California) that require the use of intermediate cover. The EPA maintains the position that early installation of cover and use of covers that enhance methane oxidation (such as biocovers) are considered BMPs and will encourage the practice of these types of BMPs through its voluntary programs as well as the Tier 4 mechanism, which will encourage a more widespread use of BMPs and alternative technologies.*[43]

EPA correctly states that many states implement intermediate cover requirements, but these states do so under relevant solid waste management programs, rather than air pollution control programs.[44]

In terms of cover materials, the most common material used as a MOL is sand, which enables greater methane oxidation than other materials (e.g., clay) but must be viewed in the context of the GCCS as a whole. Specifically, NWRA and SWANA members have observed that the use of sand in a MOL increases the difficulty of GCCS management by making it more difficult to seal and balance the system and thereby potentially allowing more fugitive landfill gas to escape into the atmosphere. Given the nature and texture of sand, leak repair is nearly impossible. Further, sand MOLs increase gradient liquids, leading to higher gas generation, increased air infiltration, and heightened risk of subsurface oxidation and fires. Ultimately,

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flexible alternatives such as (1) intermittent operation of GCCS, (2) installation of passive systems to small passive torch flares, or (3) the connection of wells that flow to a solar powered blower/flare.

[42] 2016 RTC, at 304–05, Excerpt No. 17, EPA-HQ-OAR-2003-0215-0095.1.

[43] *Id.*

[44] *See, e.g.*, 6 Colo. Code Regs. § 1007-2; Cal. Code Regs. tit. 27, § 20700(a); Fla. Admin. Code Ann. R. 62-701.500.

methane oxidation does not reduce emissions and any mandated requirements governing intermediate cover using MOLs inhibits the flexibility needed for operators to maximize GCCS efficiency on a site-specific basis. Other types of biocovers similarly facilitate increased moisture, thereby increasing leachate generation and the risk of flooding wells. Thus, while biocovers generally may be resourceful in increasing methane oxidation, there are fundamental issues that they pose to GCCS as a whole that cannot be overlooked in their consideration for implementation into the Landfill Rules and, as such, are appropriately regulated under RCRA.

Regardless, implementing MOL and GDL as a global requirement, as EPA suggests, would involve significant costs, resources, and burden and assume the availability of necessary materials irrespective of geographic location. Typically, soils that are excavated as part of the landfill construction process are held on site for future use as cover material. To the extent that EPA requires different cover materials, operators will need to outsource materials and dispose of the excavated soils off-site—all for additional costs unaccounted for by EPA. Despite EPA's assumption that the MOL and GDL cover materials would be readily available irrespective of geographic location, EPA does not provide initial capital or operational costs associated with various cover options. EPA must conduct a comprehensive cost-benefit analysis of any potential intermediate cover regulatory provisions, including additional costs and emissions associated with excavating and hauling the material to geographically limited areas compared to any methane oxidation benefits. In this respect, to the extent that EPA intends to prescribe intermediate cover regulations, EPA should evaluate appropriate performance specifications rather than specify the materials, means, or methods that must be used. Performance specifications would allow landfills in different geographic regions to determine whether intermediate or final covers are appropriate to achieve the required specifications using the most cost-effective resources available to them.

5. *MSW Landfill Gas Collection and Control System (GCCS) Installation Lag Time and Nonmethane Organic Compound (NMOC) Destruction Efficiency (October 2024)*

This White Paper evaluates the reduction in emissions that could result from (1) decreasing the time required to install GCCS ("Lag Time") and (2) increasing the destruction efficiency required by a GCCS destruction device.

<u>Lag Time</u>

The current Landfill Rules establish two different GCCS installation and operation timelines: the first governs initial GCCS installation; and the second governs GCCS expansions:[45]

1. Install and start GCCS within 30 months of the first exceedance of the 34 Mg/yr NMOC emission rate ("Initial Lag Time").
2. GCCS must collect gas from each area, cell, or group of cells in the landfill in which the initial solid waste has been in place for 5 years. ("Expansion Lag Time").

[45] 40 C.F.R. § 60.762(b)(2)(ii).

EPA makes the claim that reducing Initial Lag Time would result in greater emissions captured. In particular, EPA states,"[e]arlier GCCS installation could collect and control significant emissions from this accelerated food waste decay pathway, which was estimated to account for approximately 58 percent of total fugitive methane emissions from MSW landfills in 2020."[46] This assertion is derived from the report titled "Quantifying Methane Emissions from Landfilled Food Waste" which states:

> *Because MSW landfills typically receive co-mingled wastes, landfills often do not have the ability to track the tonnage of incoming food waste specifically, and the annual estimates of food waste disposed at landfills vary depending on the method used (Kibler et al., 2018; Thyberg et al., 2015).*[47]

This broad assertion fails to account for several realities faced by MSW landfills in practice. While NWRA and SWANA agree that food waste decomposes more readily than other waste streams, methane generation rates of blended and/or composite waste streams are not known to a high degree of certainty. The k and L_0 values used in subpart XXX to generate an NMOC emission rate (0.05 and 170, respectively) lead to an overestimation of NMOC generation to account for this uncertainty. GHG emissions from MSW landfills are calculated using a modeled approach under Equations HH6, HH-7, and HH-8 because direct, repeatable, and reliable measurement methodology to determine exact emission rates does not exist.[48] As such, claims of reducing fugitive methane emissions by a certain percentage are not founded on data directly related to actual methane reductions. EPA's approach is muddled by additional uncertainty because in evaluating the emissions reductions associated with reducing the current Initial Lag Time of 30 months, EPA used a model 36-month lag time "because LandGEM can only model in whole year increments."[49]

Nevertheless, EPA recognizes that the Initial Lag Time serves to provide landfill owners and operators with "time to develop, permit, and construct a GCCS," and that doing so requires working with multiple external entities including consultants, contractors, and state and local regulatory agencies."[50] Though EPA does not mention it, GCCS installation is also seasonally-limited in certain regions across the country. Accordingly, the time between a landfill's initial exceedance of the NMOC emission limit and the beginning of GCCS operation is largely dependent on factors and third parties that are outside the control of owners and operators—which EPA acknowledges but alleges can be overcome by beginning the GCCS process "before threshold exceedances have occurred."[51] The suggestion to begin the GCCS process prior to a threshold exceedance is not practical or feasible, because it would require operators to predict the site-specific conditions impacting emissions without providing a framework to do so. Further,

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[46] White Paper No. 5, at 2.

[47] Krause et al, *Quantifying Methane Emissions from Landfilled Food Waste*, U.S. EPA ORD (Oct. 2023).

[48] NWRA has outlined this point extensively in Exhibit 3, Petition for Reconsideration of Subpart HH of the GHGRP.

[49] *Id.* at 9.

[50] *Id.* at 2.

[51] *Id.* at 15.

EPA states that agencies must approve or reject design plans, but often fail to do so, or do so in an untimely manner. EPA also realizes that bidding and procurement "can take several months and potentially longer" and construction may nonetheless be subject to delays due to "material shortages, inclement weather, or other site-specific challenges." In this respect, EPA quite clearly understands the hurdles associated with reducing Lag Time, irrespective of any emissions reductions that may be theoretically possible.[52]

In addition, EPA must be mindful of the significant burden that will fall on small and municipal landfills as a result of reduced lag time and must ensure that any changes do not affect closed or existing landfills that do not undergo an expansion or otherwise trigger Landfill Rules requirements. Smaller landfills that have never installed and operated GCCS must hire consultants to guide them in the process, which includes planning for and securing capital years in advance. Moreover, EPA must consider the costs that will be incurred as a result of reduced lag time. Per the White Paper, EPA estimates, using the data from the November 2023 LMOP database, that earlier capture or destruction will result in at least 3.5% emissions reduction—using the current lag times, approximately 31.1 million Mg methane will be captured and destroyed by 2060, as opposed to 32.2 million Mg methane captured and destroyed where initial lag time is reduced. In making these estimates, EPA fails to account for the fact that earlier installation of GCCS may require the use of supplemental fuel when more recently placed waste produces insufficient amounts of landfill gas, leading to increased emissions. EPA must also account for estimated compliance, material, and labor costs associated with expedited installation and expansion timelines so as to justify the estimated 3.5% reduction in methane emissions by 2060. EPA acknowledged that the cost did not justify the benefit the last time it considered such a change in lag time:

> *The cost-benefit analyses suggested that reducing lag time compared to the baseline (no reduction to current lag times) resulted in limited NMOC reductions relative to the costs that would be required for earlier installation and operation. Cost modeling estimated that the dollar-per-Mg cost to reduce initial and/or expansion lag times in conjunction with reducing the NMOC emission rate threshold (from 50 Mg/yr to 34 Mg/yr) was higher than the option to reduce this threshold without reducing the lag time: $6,900 to $11,300/Mg NMOC vs. $6,000/Mg NMOC.*[53]

To the extent that EPA intends to reduce Initial and Expansion Lag Times, EPA cannot forego conducting a cost-benefit and must do so in consideration of potential NMOC reduction.

<u>Destruction Efficiency</u>

EPA reviewed the destruction efficiency criteria for the following:

- Change from NMOC-based criteria to methane-based criteria; and
- Minimum required destruction efficiency for the GCCS.

[52] However, NWRA and SWANA would recommend that the EPA create a separate subcategory of system expansion timelines for arid landfills, which tend to produce less landfill gas and less NMOC despite the age of waste placement being the same as that in landfills in wetter climates.

[53] *See* White Paper No. 5, at 16.

Similar to implementing a methane-based emission threshold as discussed in NWRA's response to White Paper No. 3, *supra*, we reiterate here that regulating methane instead of NMOC would contradict EPA's historic approach to regulating destruction efficiency criteria at MSW landfills. Further, regulating methane is inconsistent with the Trump Administration's recent policy pronouncements around ensuring that the regulation of climate pollutants does not cause undue costs and burdens on the economy.[54] Here, there is no basis whatsoever to change the destruction criteria under the Landfill NSPS from NMOC to methane. BSER is a well-designed and well-operated landfill gas collection system and a control system for collected LFG that achieves 98% reduction of NMOC.[55] Switching from NMOC to methane would create legal uncertainty as methane is not identified as a separate pollutant in Title V Operating Permits, and it would create confusion and potentially add burden with respect to EPA's regulation of greenhouse gases (GHGs) under the Prevention of Signification Deterioration (PSD) program.[56]

The PSD program requires major stationary sources that emit, or have the potential to emit, 250 tons per year (tpy) or more of any "regulated [New Source Review] pollutant" [57] to receive a permit and comply with emissions limitations that reflect the "best available control technology," or BACT. Through a series of decisions, the U.S. Supreme Court held that EPA may indeed regulate GHG emissions under the NSPS and EG programs,[58] but by doing so, could not impermissibly expand the scope of the NSR, PSD, and Title V programs.[59] Instead, EPA may require PSD permits only for so-called anyway sources, those that are otherwise required to obtain a PSD permit based on one or more regulated NSR pollutants other that GHGs and also will emit or have the potential to emit 75,000 tons per year or more of CO_2e.[60] Regulated NSR pollutants include, *inter alia*, any pollutant that is subject to any standard promulgated under section 111 of the Act.[61] In the case of the Landfill Rules, the regulated NSR pollutant is already

[54] *See, e.g.*, Executive Order No. 14154, "Unleashing American Energy" (Jan. 20, 2025), https://www.whitehouse.gov/presidential-actions/2025/01/unleashing-american-energy/. President Trump stated that "estimates of the social cost of greenhouse gases" based in whole or in part on the Interagency Working Group's ("IWG") work or guidance are "no longer representative of governmental policy[.]" § 6(b)(iv). Accordingly, all cost-benefit analyses conducted for the purposes of promulgating updates to the Landfill Rules must not focus on the social cost of methane, but rather should focus on NMOC reductions, consistent with the existing structure of the Landfill Rules.

[55] *Standard of Performance for Municipal Solid Waste Landfills*, 81 Fed. Reg. 59332, 59341 (Aug. 29, 2016).

[56] In 2014, the United States Supreme Court held that the Clean Air Act cannot be interpreted to require a source to obtain a PSD or Title V permit on the sole basis of potential GHG emissions. *Utility Air Regulatory Group v. EPA*, 573 U.S. 302 (2014).

[57] 40 C.F.R. § 52.21(b)(1)(i)(B).

[58] *Massachusetts v. EPA*, 549 U.S. 497 (2007).

[59] *Utility Air Regulatory Grp. v. EPA*, 573 U.S. 302, 331–33 (2014).

[60] 40 C.F.R. § 52.21(b)(49)(iv)(A).

[61] *Id.* § 52.21(b)(50)(ii).

identified as MSW landfill emissions (measured as non-methane organic compounds ("NMOC")), with a significance threshold of 45 megagrams per year.[62]

There is no basis to change this well-settled structure. By revising the Landfill Rules to require the destruction of methane (a GHG) rather than NMOC, EPA may create confusion with respect to the status of methane as a regulated NSR pollutant under 40 C.F.R. § 52.21(b)(50)(ii).[63] Further, the only possible reason to focus on methane instead of landfill gas emissions measured as NMOC would be to support an outsized quantification of emission reduction benefits calculated using the now-disfavored social cost of methane. Indeed, EPA correctly articulated the following reason for regulating NMOC, as opposed to other constituents of landfill gas, such as methane:

> *EPA views [NMOC] emissions as a complex aggregate of pollutants which together pose a threat to public health and welfare based on the combined adverse effects of the various components…Although different effects may result from different individual constituents of the landfill gas, the constituents are emitted together and the same control technologies will control all of the constituents of MSW landfill emissions.*[64]

In the same proposal, EPA also stated that regulating NMOC allowed EPA to focus on cancer and non-cancer health effects of landfill emissions but also provided "the ancillary benefit of reducing methane" as well as "reduc[ing] the burden and complexity of measuring and monitoring the various constituents of landfill gas[.]"[65] Thus, EPA specifically considered methane as a climate pollutant and found that "[a]lthough different effects may result from different individual constituents of the landfill gas, the constituents are emitted together and the same control technologies will control all of the constituents of MSW landfill emissions."[66] This conclusion remains accurate, and EPA has not suggested otherwise. Accordingly, there is no need to revise the Landfill Rules to focus on the destruction of methane—doing so would be used only as a means to justify expenditures using the social cost of methane, where no additional emission reductions would occur as compared to the current structure of the Landfill Rules.[67] In addition, any shift from regulating NMOC to methane would be inconsistent with the

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[62] *Id.* § 52.21(b)(23)(i).

[63] EPA tenuously addressed the treatment of methane as a regulated NSR pollutant in the NSPS rules applicable to oil and gas facilities. *See Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review*, 89 Fed. Reg. 16820, 17016 (Mar. 8, 2024) ("EPA is adding provisions within the subpart OOOOb NSPS and subpart OOOOc EG to help clarify that the promulgation of GHG standards under section 111 will not result in additional sources becoming subject to PSD based solely on GHG emissions[.]" 40 C.F.R. §§ 60.5360b(b)(1)–(2), 60.5361c(b)(1)–(2). This disclaimer does not adequately resolve the conflict between regulating methane and the holding from *Utility Air Group*.

[64] *Standards of Performance for New Stationary Sources and Guidelines for Control of Existing Sources: Municipal Solid Waste Landfills: Proposal*, 56 Fed. Reg. 24468 (May 30, 1991).

[65] *Id.* at 24470.

[66] *Id.* at 24475.

[67] *See supra*, n. 54.

Landfill NESHAP, which also uses NMOC as the pollutant by which destruction efficiency is measured.[68]

EPA makes the following statement without substantiation in this White Paper: "In addition, defining the destruction efficiency in terms of methane instead of NMOC could reduce methane emissions post-collection."[69] EPA has no basis to assert that LFG combustion devices would behave differently than they already do—while flares may achieve 99% destruction of methane in practice, both the current regulations and flare specifications are correctly geared toward the control of NMOC. NWRA and SWANA dispute this unsupported assertion—NWRA and SWANA members are aware of no basis upon which to claim that a mere change in the metric used for estimating destruction efficiency would result in any greater efficiency levels from existing technologies.

Additionally, NWRA and SWANA and its members strongly oppose any prohibition of open flares. EPA has determined that open flares achieve 98% destruction of NMOC.[70] EPA assumes that enclosed flares achieve 99% destruction of methane; and that mandating the use of enclosed flares only for new or modified landfills will result in emission reductions. However, EPA has alleged elsewhere that currently-operational flares *already* achieve 99% methane destruction, thus obviating a need to mandate enclosed flares on the basis of greater destruction efficiency. Indeed, EPA's Landfill Methane Outreach Program (LMOP) broadly states that methane destruction in flares "is typically greater than 99%" and that "open flares are thought to have combustion efficiencies similar to those of enclosed flares."[71]

Open flares are critical to controlling landfill gas at the early and end stages of the LFG generation curve because they can operate at lower volumes and tolerate more variability in landfill gas heat input than enclosed flares. Open flares serve a vital role in the landfill industry and are favored because they:

- Reliably achieve 98% destruction of NMOC;
- Are straightforward to operate and maintain;
- Can operate properly even when LFG flow and quality are outside the acceptable operation criteria for other types of destruction devices, which happens at various times over the life of the landfill;
- Provide flexibility to manage poor-quality gas with diminished methane content under various circumstances, including where state or local programs have required the diversion of organic waste;

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[68] *National Emission Standards for Hazardous Air Pollutants: Municipal Solid Waste Landfills Residual Risk and Technology Review*, 85 Fed. Reg. 17244, 17246 (March 26, 2020).

[69] White Paper No. 5, at 3.

[70] 40 C.F.R. § 60.762(b)(2)(iii)(B).

[71] LMOP, *Continue to Operate Gas Collection System and Flare*, (July 1, 2024), https://www.epa.gov/lmop/continue-operate-gas-collection-system-and-flare (referencing U.S. EPA. Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from Municipal Solid Waste Landfills, Table 1 (June 2011), https://www.epa.gov/sites/default/files/2015-12/documents/landfills.pdf. Table 1).

- Are an important component of any LFG beneficial reuse project, as they provide backup control of LFG during periods when the primary reuse units (engines/turbines/upgrading facilities) are offline;
- Have a much broader operational turndown ratio (Open – 20:1, Enclosed – 5:1). The turndown ratio describes the operational flexibility of a device by indicating the range between its maximum and minimum capacity. For example, an open flare designed for 2,000 scfm can be operated down to 100 scfm before supplemental fuel is needed, whereas an enclosed flare would need supplemental fuel at around 400 scfm. Though cost data related to augmentation of heat input using propane or natural gas varies depending on the geographic location, one our members utilizes approximately 3,000 gallons of propane per year to keep a single open flare lit at its minimum capacity; and
- Promote integration of beneficial landfill gas utilization projects. For example, a site collecting 2,100 scfm can send 2,000 scfm to operate four landfill gas energy engines, and send the remaining 100 scfm to an open flare without the need for supplemental fuels. If, however, this site replaced the open flare with an enclosed flare, the site would need to shut down one engine or use supplemental fuel to provide sufficient gas to operate the enclosed flare—neither of which provides any tangible environmental benefit.

In suggesting the phase-out of open flares in this White Paper, EPA fails to account for the burdensome costs that would be imposed without an overall reduction in emissions. Further, if the EPA banned open flares, the supply of enclosed flares would not be able to meet demand. The current process – including design, construction, shipment, and installation – takes 45-52 weeks. EPA must evaluate the delays and costs of this potential change. Currently, the cost to design, permit, and construct one open flare is roughly one third of the cost to design, permit, and construct one enclosed flare, while enclosed flares have higher operating and maintenance costs.[72] .

Industry's experience with open/non-enclosed flares confirms that these control devices can achieve the performance standard that EPA has established, allow for the operational flexibility required to meet site-specific needs, and promote effective gas utilization projects..

Tier 4

NWRA and SWANA suggest that EPA clarify when landfills can utilize Tier 4 monitoring. Clarity is necessary because whether a landfill may use Tier 4 influences the requisite timelines associated with installing and operating a GCCS. The following provisions create confusion:

- 40 CFR §§ 60.764(a)(6), 60.35f(e)(2) permitting Tier 4 where NMOC emissions are shown to be greater than or equal to 34 Mg/yr but less than 50 Mg/yr using Tier 1 ***or*** Tier 2.
- 40 CFR §§ 60.762(b)(2), 60.33f(e)(2) permitting Tier 4 where NMOC emissions are shown to be greater than or equal to 34 Mg/yr but less than 50 Mg/yr using Tier 1, Tier 2, ***or*** Tier 3.

[72] Again, the comparison of costs and any purported benefits should not be measured using the disfavored social cost of methane, *see supra* n. 54, especially because here, there would be no additional emissions reductions as a result of switching from an NMOC to methane-based destruction efficiency standard.

- 40 CFR §§ 60.767(c)(4)(iii), 60.38f(d)(4)(iii) Tier 4 emissions report must include the most recent Tier 1 ***and*** Tier 2 results.

If there is any measured surface concentration of methane of 500 ppm or greater from a Tier 4 test, then the owner or operator must submit a GCCS design plan within 1 year of the first such surface concentration measured according to § 60.767(c) and it must install and operate a GCCS according to § 60.762(b)(2)(ii) and (iii) within 30 months of the most recent NMOC emission rate report in which the NMOC emission rate equals or exceeds 34 megagrams per year based on Tier 2. 40 CFR §§ 60.764(a)(6)(v), 60.35f(a)(6)(v). By linking GCCS installation and operation for sources using Tier 4 to the Tier 2 NMOC emission rate report rather than the triggering surface methane exceedance under Tier 4, EPA has effectively reduced the one year period of time a Tier 4 source has to install and operate a GCCS.[73] There are additional issues with Tier 4 that make it an unfavorable option for determining GCCS requirements. Namely, as previously articulated by industry members, including NWRA, Tier 4 imposes unduly restrictive windspeed requirements that are not scientifically sound.[74] Tier 4 also fails to provide corrective action in order to fix exceedances that are detected above 500 ppm, which the Small Business Advocacy Review Panel stated limited the usefulness of Tier 4.[75] Accordingly, EPA should revise Tier 4 so that it may function as a practical tool for threshold applicability in the Landfill Rules.

6. Aerial Monitoring for Examining Landfill Methane Emissions (October 2024)

This White Paper focuses on identifying and quantifying methane emissions using aircraft and satellite monitoring technologies, which EPA describes as having potential regulatory applications in rule applicability, routine monitoring requirements, and emissions detection and quantification. NWRA and SWANA believe that aerial technology is not ready for regulatory application, however. We ask EPA to carefully consider the following overarching principles, which were raised in great detail in NWRA's response to EPA's RFI:[76]

- Emerging measurement methods encompass a variety of technologies that differ in approach and have shown a wide range of accuracy in detection and quantification when compared to known release rates.
- Given the nature of landfill gas emissions, emerging measurement technologies are currently incapable of detecting emissions at the same level of precision as in the oil and gas sector.

[73] NWRA and SWANA made and incorporates herein by reference, other comments on Tier 4. *See* Exhibit 1, NWRA and SWANA Petition for Rulemaking, Reconsideration, and Stay of the 2016 Landfill Rules, 28–43 (2016).

[74] *See* 40 C.F.R. §§ 60.764(a)(6) and 60.767(c)(4)(iii). *See also* Petition for Rulemaking, Reconsideration, and Administrative Stay of Subpart XXX, Docket I.D. EPA-HQ-OAR-2003-0215; EPA-HQ-OAR-2014-0451, at 33–37.

[75] *See* Final Report of SBARP on EPA's Planned Proposed Rules Standards of Performance for Municipal Solid Waste Landfills and Review of Emissions Guidelines for Municipal Solid Waste Landfills, at 7–8 (July 21, 2015), https://www.epa.gov/system/files/documents/2021-08/report-sbarpanel-landfills.pdf.

[76] *See* Exhibit 2, NWRA RFI Response.

- Point-in-time observations cannot be used to estimate annual emissions due to high levels of variability that render such estimates unreliable.
- At this time, emerging measurement technologies are not transparent, open-source, or standardized.
- At this time, emerging measurement technologies are only effective as a tool to locate fugitive emissions and support landfill gas collection and control practices. Site-specific data using established methodologies are critical to accurately quantifying landfill gas emissions and cannot be replaced by emerging measurement technologies.
- MSW landfill operations are unique and pose challenges not experienced in the oil and gas context in measuring greenhouse gas (GHG) emissions. Thus, EPA's assessments and regulatory determinations for oil and gas facilities cannot be imposed upon municipal solid waste landfills without significant additional evaluations and methods development.

NWRA and SWANA do not support the mandated use of these technologies via regulation; however, NWRA and SWANA do support the continued research and development of these technologies and their potential application to landfills. The Environmental Research and Education Foundation ("EREF") evaluated several aerial technologies as part of a large-scale controlled release study[77] between November 6, 2023, and November 14, 2023. This study included 16 vendor combinations and methodologies assessed for their performance in detecting and quantifying controlled releases of methane during 71 experiments, and was a critical step in determining the readiness of emerging technologies for methane detection and quantification at landfills. As a general matter, while a broad range of technologies are in development, they lack consistency and accuracy to varying extents. EREF made the following conclusions regarding aerial technologies:

- Aircraft (APSEA)
  - Requires windspeed ranging from 2-6 m/s, good solar insolation, limited cloud cover.
  - Typically reported only 64% of the actual emission rate.
  - Underestimated measurements consistently and vendor reported that estimates were not classified as high quality due to the fact that meteorological conditions did not allow for emission plumes to rise and disperse.
  - Minimum detection limit: 3-5 kg/hr
- Helicopter (LiDAR)
  - Both LiDAR and mass balance methods were accurate and had a tendency to overestimate emission rates.
  - Quantification estimates increased when the vendor considered onsite weather data, causing overestimation by 45% with an uncertainty of ± 45%.
  - Requires good visual flight rules conditions for flying aircraft. Ideal wind speed ranges from 3- 6 m/s.
  - Minimum detection limit: 0.5 kg/hr
- Satellite (SISEA)
  - Emissions were not detected for quantification or localization purposes.

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[77] EREF, *A Controlled Release Experiment for Investigating Methane Measurement Performance at Landfills: Final Report*, (July 9, 2024), https://erefdn.org/product/a-controlled-release-experiment-for-investigating-methane-measurement-performance-at-landfills/.

- Minimum detection limit expected to be at least 300 kg/hr.
- Cloud cover over the site and/or wind speed exceeding 10 m/s prevents emission measurement.
- Minimum detection limit: 100 kg/hr

As evidenced by EREF's findings, the costs of utilizing these technologies are high. To the extent that EPA intends to consider mandating the use of these technologies under the Landfill Rules, their costs must be justified by the accuracy, reliability, and certainty of the methodologies. As described below, these technologies do not currently detect, measure, or quantify methane emissions from MSW landfills accurately, reliably, or with reconcilable certainty. These issues are a result of both the limitations of the technologies and the very nature of landfill gas emissions.

Regulations applicable to the oil and gas sector[78] ("Oil and Gas Methane Rule") incorporate the use of advanced technologies to a limited degree. However, several important distinctions exist between emissions from landfills and the oil and gas sector. Most importantly, LFG behaves differently than natural gas, for several reasons. First, LFG is composed of 50% methane and 50% carbon dioxide, making it heavier than air. In contrast, natural gas is nearly 100% methane, and is significantly lighter than air. Second, some LFG releases are intrinsic,[79] and occur sporadically and ephemerally, but not unexpectedly, and are emitted at atmospheric pressure due to construction activities and the nature of the moving working face. Natural gas releases at oil and gas facilities, on the other hand, are not intrinsic—once the gas is captured in a piping system, it only escapes if the piping system fails to function as designed. Therefore, unlike landfill gas emissions, oil and gas emissions can be reduced and/or avoided, and are emitted at positive pressure. These factors, coupled with the complex topographic, micro-climatic, atmospheric, and barometric conditions across areas of landfill surfaces, cause LFG to behave in a non-Gaussian (i.e., skewed an uneven) manner. Indeed, LFG often pools or disperses in response to ground-level vegetation and physical interferences across the landfill surface; whereas natural gas plumes from oil and gas facilities tend to follow predictable Gaussian distribution—making them more readily detectable and more easily quantifiable. In addition, LFG emissions occur due to the decomposition of organic waste that is already a part of the carbon cycle; whereas oil and gas emissions are primarily the result of extracting, processing, and transporting fossilized carbon from underground shale areas and introducing that carbon into the carbon cycle.

Emission detection techniques have historically differed across both industries. From a work practice standpoint, under the Landfill Rules, fugitive emissions from covered areas are detected and mitigated by conducting SEM to detect methane concentrations at landfill surfaces.

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[78] *Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review*, 89 Fed. Reg. 16,820 (Mar. 8, 2024) ("Oil and Gas Methane Rule").

[79] "Intrinsic" has been used to describe emissions that are emitted from the landfill working face, as a result of maintenance activities, and/or by way of diffuse emissions through landfill cover. Members of EPA's Office of Research and Development ("ORD") have referred to these emissions as "intrinsic" or "expected" in that they can be partially controlled but never eliminated. *See e.g.*, *EPA webinar materials, Airborne Survey-Methane from U.S. Landfills*, at slide 13.

At oil and gas facilities, emissions are measured utilizing various techniques including direct measurement with sensors installed at key points, such as valves and compressor stations, to monitor and detect leaks continuously. Oil and gas facilities use portable gas analyzers to measure specific components around equipment such as pumps, valves and flanges. Accordingly, oil and gas facilities can measure emissions directly.

These differences are particularly important for several reasons. First, technology vendors must be able to account for the unique behavioral characteristics of landfill gas and fluctuations inherent to landfill operations that influence emissions, so as to create standardized methodologies for all intended uses. Ignoring these complexities will lead to inaccurate understandings of landfill emissions, and diversion of time, effort, resources, and capital in regulating an essential industrial sector in an inefficient manner. Second, these differences are important to the extent that EPA intends to consider transferring the regulatory obligations contained in the Oil and Gas Methane Rule to the MSW Landfill Rules.

One example is the potential implementation of a "Super Emitter" program, comparable to that finalized in the Oil and Gas Methane Rule. The Super Emitter Program is based on third-party detection and reporting of leaks and releases of 100 kg/hr or more of methane from affected facilities (individual well sites, centralized production facilities, compressor stations, and natural gas processing plants). [80] Currently, only one entity – Carbon Mapper – has applied for and been approved as a third-party notifier. Carbon Mapper uses aircraft-mounted hyperspectral spectrometer technology to purportedly image and quantify methane plumes during planned surveys of target regions. As articulated in more detail below, this type of detection technology and accompanying quantification methodology is not appropriate for use in the Landfill Rules at this time. Moreover, NWRA and SWANA understand that significant challenges remain in terms of meeting EPA's objectives for the oil and gas Super Emitter program.

EPA has also acknowledged in this White Paper that aerial and satellite technologies are limited in their detection capacity, particularly with respect to "diffuse" area sources, or those "expected of typical landfill operation."[81] EPA indicates that these limitations may be inherent in the technologies themselves; but aerial and satellite technologies are limited in additional respects, namely, cloud cover and surface reflectivity anomalies as well as wind speed and direction. For example, satellite orbital hours vary by season and geographic location—the orbital schedule for nine satellites over Colorado in November 2024 were all within a 5-hour window. In this respect, orbital satellites capture an unrepresentative fraction of the site-specific conditions at observed landfills. Using such limited information to create annual assumptions is

[80] The concept of the third-party notification system has formed one bases of the challenges. In an application for a stay of the Oil and Gas Methane Rule, petitioners argued that "EPA plainly lacks authority under the CAA to delegate its monitoring duties to private third parties." *See Continental Resources, Inc., v. EPA,* Application (24A215) for a stay, submitted to The Chief Justice (Aug. 26, 2024), at 15. The Trump administration recently announced that it is reconsidering the Oil and Gas Methane Rule altogether. *See Trump EPA Announces OOOO b/c Reconsideration of Biden-Harris Rules Strangling American Energy Producers*, https://www.epa.gov/newsreleases/trump-epa-announces-oooo-bc-reconsideration-biden-harris-rules-strangling-american (Mar. 12, 2025).

[81] White Paper No. 6, at 9.

unreasonable, statistically unreliable, and fails to consider the practical realities and changing site-specific conditions at landfills.

Direct sampling (a/k/a "in-situ," *i.e.*, aircrafts) are similarly limited by external factors. Aircraft flights must be "carefully planned and operated" in order to "capture plumes accurately," making them unsuitable for unpredictable landfill emissions and putting them directly at odds with the very nature of landfills, whose working face is constantly moving and whose cells are constantly under construction. Though in-situ sampling may be capable of capturing both point sources and diffuse area sources, flight and sampling conditions must be "ideal" – that is, wind speed and direction are moderate and steady, and turbulence and precipitation are limited – in order to approach the level of accuracy already achievable by existing techniques.

Moreover, while a few of the existing advanced measurement technologies are able to attribute landfill emissions, satellite technologies are incapable of attributing detected plumes to specific equipment types, facilities, or processes in an automated manner. Carbon Mapper describes its attribution process as one considering two criteria: "high concentration - typically a spatially tightly constrained area of maximal constrained area of maximal concentration, indicative of a large gas release," and "plausible RGB/GIS infrastructure." Carbon Mapper then attributes plumes to "sectors," rather than specific areas within the site. Recent publications even state that misattribution to co-located oil and gas facilities may occur.[82]

NWRA has provided extensive feedback on the following studies cited by EPA in this White Paper, illustrating further why the technologies evaluated therein are not primed for implementation into the Landfill Rules:

- *Balasus, N. et al.* (2024) – *See* **Exhibit 2**, NWRA RFI Response, at 24–25.
- *Cusworth, D.H. et al.*(2024) – *See* **Exhibit 2**, NWRA RFI Response, at 25; and **Exhibit 3**, NWRA Petition for Reconsideration of Subpart HH of the GHGRP, at 35.
- *Duren, R. et al.* (2019) – *See* **Exhibit 3**, NWRA Petition for Reconsideration of Subpart HH of the GHGRP, at 30; NWRA Comment on GHGRP 2023 Supplemental Proposal, at 4–8, EPA-HQ-OAR-2019-0424-0319 (attached hereto as **Exhibit 4**).
- *Nesser H. et al.* (2024) – *See* **Exhibit 2**, NWRA RFI Response, at 23–24, 30; and **Exhibit 3,** NWRA Petition for Reconsideration of Subpart HH of the GHGRP, at 17, 25–28.

This White Paper also raised the potential to utilize advanced aerial technologies for the purposes of Landfill Rule applicability:

> *Potential rule changes could be either in addition to or a replacement of the existing NSPS/EG applicability standards for the installation of a landfill gas collection and control system. One scenario could be if a landfill site exceeds the design capacity threshold but has a modeled NMOC emission threshold of under 34 Mg/yr NMOC, it would not be required to install a GCCS; however, if this site had an observed monitored methane emission rate exceeding a predetermined threshold, either once, or over an accepted frequency, then it would be subject to*

[82] Nesser et al., *High-resolution US methane emissions inferred from an inversion of 2019 TROPOMI satellite data: contributions from individual states, urban areas, and landfills*, ATMOSPHERIC CHEMISTRY & PHYSICS 5079 (2024).

NSPS/EG requirements for LFG collection and monitoring. Alternatively, revised rules could subject sites to the NSPS/EG based on this monitored methane emission rate exceedance alone.[83]

As stated several times throughout this response, the advanced technologies are not primed for inclusion into the Landfill Rules at all, let alone to act as substitutes for applicability criteria. First, the accuracy and repeatability of such detections are questionable. Second, using aerial images to quantify methane emissions from MSW landfills would require extrapolation of point-in-time measurements into emission rates, which would not be reliable due to the high level of variability in emissions from landfills. .[84]

Likewise, aircraft or satellite methods are not reliable enough to serve as routine monitoring methodologies at this time, because most minimum detection limits are not low enough to detect the same exceedances that Method 21 and/or ALT-150 can detect. Further, the ability to pinpoint such detections is uncertain. If these technologies are able to supplement or replace current SEM methods, landfills should be able to choose among all approved methods, without being limited to one.[85] In the event that EPA integrates this technology into the Rules, there should be some flexibility with respect to reducing ground-based quarterly SEM requirements. Moreover, should the use of various technologies be considered, EPA must establish standard methods with stakeholder input that are technically feasible, scalable and cost effective and produce accurate repeatable and reliable results. EPA should be able to answer the following questions:

- How to address emissions variation throughout the day/night as most measurements are taken during clear daytime conditions?
- How to weight episodic (construction, maintenance) events?
- How to reconcile differences in measurements of emissions using same technologies (e.g., satellite vendors) and then different technologies (drones v portable analyzers)?
- How to modernize equivalency demonstration for alternative monitoring / measurement technologies?

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[83] White Paper No. 6, at 12.

[84] *See* Exhibit 2, NWRA RFI Response, at 17–23.

[85] In the letter approving OTM-51 as an Alternative Test Method, EPA stipulates that "[o]nce a facility chooses to use OTM-51 under one or more of the Subparts cited above, the facility must continue to use the alternative method in meeting the provision(s) until the owner/operator receives approval from this office for use of a new alternative method or the responsible agency for use of any other options in the applicable Federal subpart." *See* EPA, *Letter Approving OTM-51 as an Alternative Test Method*, at 9 (Dec. 15, 2022), https://www.epa.gov/system/files/documents/2022-12/Barron%20Sniffer%20Alt%20with%20OTM%2051%20attached_signed.pdf.

7. Increasing Landfill Gas Collection Rates (October 2024)

This EPA White Paper focuses on using durable materials, implementing decommissioning procedures, encouraging dual extraction (gas and liquids), dewatering wastewater sludge, and well technology. Each of these are discussed below.

<u>Durable Materials</u>

This White Paper suggest that landfills utilize high-density polyethylene (HDPE) pipes instead of PVC pipes in GCCS. The current regulations and individual site's GCCS Design Plans already address materials to be used in GCCS construction:

> *The landfill gas extraction components must be constructed of polyvinyl chloride (PVC), high density polyethylene (HDPE) pipe, fiberglass, stainless steel, or other nonporous corrosion resistant material.*[86]

Flexibility in the types of materials to be used for GCCS construction should be maintained at the professional engineer's discretion based on site-specific landfill conditions and not mandated by regulation. Standard HDPE and PVC pipe have generally the same functional temperature rating. While HDPE might have a higher short term temperature tolerance, in standard long-term applications the recommended operating temperatures are generally the same for both materials. However, CPVC and other piping materials do have a higher operating temperature tolerance compared to both PVC and HDPE, but these higher temperature rated materials are only needed on a case-by-case basis. In the absence of elevated temperatures, HDPE and PVC well casings have had a long history proper performance under the stresses and strains of landfill operations and waste settling.

Mandating the use of certain materials in GCCS components would place the EPA in the role of design engineers, who have the requisite academic and professional accolades and training to carefully evaluate and determine the materials that would be best suited based on a site-by-site basis. Removing or mandating a specific material from consideration would significantly limit the engineer and the operator's options for a well-designed and operated GCCS.

NWRA and SWANA reiterate that EPA should not impose GCCS management practices that inhibit or eliminate the flexibility needed for engineers and operators to maximize the efficiency of GCCS on a site-specific basis.

<u>GCCS Decommissioning</u>

NWRA and SWANA support the development of a robust decommissioning procedure, which is especially important for (1) managing declining landfill gas flows and quality at the back end of the landfill gas generation curve, and (2) removal of interim GCCS that may be installed to capture emissions at or around the working face.[87]

The Landfill Rules currently allow for removal of GCCS from entire closed landfills, and not non-producing areas. It is essential that EPA provide flexibility with respect to *areas* of

[86] 40 C.F.R. §§ 60.769; 63.1962(b)(1).
[87] *See* NWRA and SWANA Response to White Paper No. 7, *infra*, regarding interim GCCS at the working face.

MSW landfills that have declining flows.[88] Without the ability to decommission GCCS in non- or low-producing areas, landfills are unable to comply with wellhead parameters, risk pulling ambient air into the GCCS, and must use fossil fuels to maintain flare operation - none of which provide any emission reduction or other environmental benefit.

To better provide flexibility in areas with declining flows, EPA should revise the definition of "closed areas" to be less restrictive. The Landfill Rules currently exclude closed areas from GCCS coverage when they contribute less than 1% of a landfill's total NMOC emissions.[89] The definition of "closed area" is prohibitively narrow, and only includes separately lined areas where waste is no longer being placed. As stated previously, EPA's concern regarding gas migration from unclosed areas with GCCS to closed areas without GCCS in the absence of separate lining is unfounded because landfill gas travels from areas of high to low pressure.

EPA should also promulgate a definition of the term "decommission" to allow for the shut-off of collection components to prevent air intrusion either on a short-term or long-term basis. Decommissioning should be allowed where flow and quality of landfill gas declines, causing or having the potential to cause air infiltration leading to oxygen concentration above 5% with minimal vacuum. EPA should also define the term "abandonment" to mean capping/removing components of the GCCS that are unable to sustain methane concentrations above 30% and oxygen below 5% while under vacuum. Decommissioning and abandonment should not require EPA/state agency approval. Given the dynamic and fluctuating nature of landfills, the decision to decommission and/or abandon wells should be left to landfill personnel after consultation with a professional engineer. The evaluation of decommissioned wells and wells that need to be abandoned, as well as new or replacement collectors, are best and most efficiently made on a site-specific basis and following engineering analysis and judgment. There are many factors and data points that need to be analyzed as part of ongoing GCCS operations and maintenance, and given the individual uniqueness of the landfill and the landfill gas collectors, site personnel in consultation with professional engineers are the best equipped to make these decisions and report them to regulatory agencies.

In addition, landfill operators should be allowed to utilize SEM to determine whether decommissioning would be appropriate. EPA proposed to allow this in its 2015 Supplemental Proposal to update the Landfill Rules, but ultimately declined to do so.[90]

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[88] NWRA, SWANA and WM have raised this issue to EPA on several occasions, including in Comments to EPA's proposals in 2014 (EPA-HQ-OAR-2003-0215-0100), 2015 (EPA-HQ-OAR-2003-0215-0198), and in a Petition for Reconsideration of the 2016 promulgation of subparts XXX and Cf.

[89] 40 C.F.R. §§ 60.769(a)(3)(ii)(B), 60.761 (defining "closed areas").

[90] *Emission Guidelines, Compliance Times, and Standards of Performance for Municipal Solid Waste Landfills; Proposed Rule*, 80 Fed. Reg. 52100, 52150 (Aug. 27, 2016).

NWRA and other industry members have made this suggestion since 2003. *See* Docket ID Numbers EPA-HQ-OAR-2014-0451-0037, EPA-HQ-OAR-2003-0215-100, EPA-HQ-OAR-2003-0215-017, EPA-HQ-OAR-2003-0215-0055, EPA-HQ-OAR-2003-0215-0057 and EPA-HQ-OAR-2003-0215-0058, EPA-HQ-OAR-2014-0451-0176; *see also* SWANA, Letter to JoLynn Collins, EPA Waste and Chemical Process Group (Docket ID EPA-HQ-OAR-2003-0215-003).

Accordingly, EPA should create a standardized decommissioning procedure for landfill personnel to follow.

1. Complete/document inspection for well integrity to confirm well components are functioning properly.
2. Conduct monthly monitoring of the well as required under 40 C.F.R. § 60.765. If gas quality readings indicate a collector is low-producing (methane quality less than 30% and oxygen above 5%) the well may be decommissioned by closing the collection valve.
3. Monthly monitoring will be conducted for decommissioned wells, but positive pressure will not be considered an exceedance of the operating limits.
4. If the monthly monitoring indicates gas quality has improved so that methane is above 30% while under sustained negative pressure and oxygen is less than 5%, then the vacuum valve will remain open.
5. Record which collectors are decommissioned, the date the collector was decommissioned, and the number of days each collector was decommissioned due to low gas production rates that prevent continuous extraction. Include records in the NSPS/EG compliance report.
6. Conduct routine quarterly SEM. If exceedances of the 500 ppmv threshold are detected at decommissioned wells, operators must evaluate the need to restart the wells.
7. Record decommissioned collectors, including date and number of days of decommission to include in compliance reports.

Following this procedure will increase gas control efficiency by preventing air infiltration when collectors have low gas quality and allowing operators to quickly resume gas collection if/when gas quality and production returns.[91]

Liquids Management

EPA suggests that there is a direct correlation between landfill gas collection efficiency and leachate levels. To that end, EPA states that removing leachate from gas collection wells will enhance the efficiency of GCCS because leachate causes blockages and reduces vacuum pressure, causing lower volumes of gas capture, and notes that several things, including the use of fine soils for daily and intermediate covers, contribute to the formation of leachate mounds within landfills.[92] To reduce leachate, EPA makes several suggestions regarding liquids management, including removing leachate using dual-phase extraction wells with liquid pumps, to extract both gas and liquids simultaneously. Requiring dual-phase wells is unnecessary because the combination of monitoring wellheads for pressure and conducting SEM provides significant and adequate insight as to whether wells are functioning properly and/or impacted by

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[91] Though not the subject of this White Paper, NWRA and SWANA also suggest that EPA implement an abandonment procedure for capping and/or removing GCCS components that have been decommissioned for at least 12 consecutive months without SEM exceedances.

[92] Interestingly, EPA contemplates the increased use of MOLs in intermediate cover in White Paper No. 4. As noted by NWRA, *supra*, the most common component of MOLs is sand.

excessive liquids.[93] Landfill operators may therefore use pressure and SEM indicators to remove excessive liquids so as to increase LFG recovery,

Because current monitoring techniques adequately identify excessive liquids, the costs of implementing dual-phases pumping systems would be burdensome with no guarantee of additional LFG recovery. In fact , a typical pneumatic or electric pump installation will double the capital cost of a well and add significant operational and maintenance costs. In addition, each pump will need routine operation and maintenance—at larger sites, this could require the added costs associated with a 2-3-person pump crew. As such, installing a dual extraction well is a significant investment and should be installed only after careful evaluation of the data on a well-by-well basis so as not to be based on an arbitrary, one-size-fits-all approach.

EPA also identifies the drying of wastewater sludge prior to placement in landfills as a means of avoiding low-permeable wet patches that contribute to high leachate levels in collection wells.[94] However, requiring wastewater sludges to be dried before landfill placement will impose a financial burden on wastewater treatment plants, which are not the subject of these regulations. In addition, the RCRA regulation already regulates the placement of high liquid content waste, and additional regulation in the CAA is unwarranted.

Wellhead Technology

EPA posits that the fluctuation of wellhead pressure, temperature, and oxygen directly impact methane emissions at landfills, and suggests that gas recovery efficiency can be improved by "[i]ntegrating barometric pressure and wind speed considerations into comprehensive collection system tuning[.]"[95] As a result, EPA states that automated wellhead tuning may pose as a solution in that it can "dynamically adjust[] system parameters like vacuum pressure and flow rates in response to real-time data" by utilizing continuously monitored atmospheric conditions. EPA also suggests that automated wellheads are a promising solution to "traditional monthly GCCS tuning," which "often struggles to adjust to [] more rapid temporal changes" and in turn leads to "inconsistencies in gas capture and potential environmental impacts."[96]

The Landfill Rules currently require landfill operators to monitor wellhead temperature and pressure on a monthly basis.[97] If monthly monitoring indicates positive wellhead pressure, landfill operators must achieve negative pressure within 15 calendar days.[98] Similarly, if monthly monitoring indicates that the landfill gas at a particular wellhead exceeds the 55 degrees Celsius (131 degrees Fahrenheit) standard, operators must initiate corrective action and correct the

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[93] *See* Comment submitted by Kerry Kelly, Senior Director, Federal Affairs and Amy Van Kolken Banister, Senior Director, Corporate Air Programs, Waste Management (WM), at 48–49 (Sept. 15, 2014), EPA-HQ-OAR-2003-0215-0100.

[94] White Paper No. 7, at 12.

[95] *Id.* at 10.

[96] *Id.*

[97] 40 C.F.R. § 60.766.

[98] *Id.* § 60.765(a)(3).

exceedance within five calendar days.[99] If negative pressure cannot be achieved within 15 calendar days or temperature exceedance cannot be corrected within five calendar days, operators must conduct a root cause analysis and correct either type of exceedance within 60 days of detection. If corrective action cannot be fully implemented within 60 days of detection, operators must conduct corrective action analysis and develop an implementation plan to correct the pressure or temperature within 120 days of detection.[100] The monitoring and subsequent corrective process is not conducive to continuous monitoring that would be utilized with automated wellheads. As currently structured, the Landfill Rules provide operators with a somewhat predictable schedule that allows operators to delegate time, resources, and capital effectively and efficiently. Automated continuous wellhead monitoring would facilitate the opposite result—subjecting operators to corrective action requirements at less predictable, and likely infeasible, times. Accordingly, to the extent EPA requires the use of automated wellheads, EPA must maintain structure with respect to the timeliness of implementing corrective action. To do so, EPA may require continuously-collected wellhead data to be collected and averaged on a monthly basis, and then allow operators to use the monthly average value to determine whether corrective action is necessary.

Although manufacturers of automated wellheads claim that their product will reduce methane emissions at an affordable cost,[101] this has not been the consistent experience of NWRA and SWANA members and has not been proven in a large-scale study or a peer-reviewed technical analysis. Moreover, NWRA and SWANA and its members have examined automated wellhead tuning systems and have the following observations:

- There is a tendency to counter-influence other surrounding wells if too many are automated. Given the close proximity of several automated wellheads, the interaction amongst one another due to the algorithms used in automation can result in significant fluctuations.
- Automated wellheads require significant time to determine the appropriate algorithms to reduce the potential for noncompliance.
- Some automated wells have been effective in high-producing wells, but less so in wells with medium to low flow rates.
- Relying on automated wellheads and continuous monitoring has not always been reliable, as it will not always automatically shut off wells at low flow or methane content.
- Automated wellheads are orders of magnitude more expensive than traditional wellheads, which would overburden small or municipally owned landfills.
- Automated wellheads cannot comply with the Landfill Rules as currently written, because the Landfill Rules require wellhead calibration of 10-12% oxygen. The revised Landfill Rules should allow for atmospheric air calibration, thereby allowing for simpler calibration of automated wellheads, where used.

One argument for using automated wellheads is that they can be adjusted in real-time as barometric pressure changes, which can affect gas collection. However, this impact is most

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[99] *Id.* § 60.765(a)(5).

[100] *Id.* §§ 60.765(a)(3), 60.765(a)(5).

[101] *See, e.g.* comments submitted to this docket at EPA-HQ-OAR-2024-0453-0051.

significant at arid landfills which have significantly lower methane generation and therefore would not justify the expense associated with automated wells.

Using automated wellheads is not a viable economic solution to wellfield tuning. The White Paper does not address the potential compliance aspect of automated wellhead data or the wellhead instrument calibration requirements. Instead of a requirement to deploy automated wellheads, EPA should establish guidance that encourages (or at least, does not discourage) the solid waste industry to pilot this technology on a voluntary basis.

8. Improvements to Working Face and Daily Cover to Reduce LFG Emissions (October 2024)

This EPA White Paper focuses on working face emissions and daily covers. A landfill's ability to utilize cover materials is dependent on the geographic location of the landfill—which influences the availability cost-effective materials. Accordingly, EPA should not prescribe such materials, which are the province of local waste program rules and are outside of the agency's authority to regulate under the Clean Air Act. In addition, the working face area is highly variable, underscoring the unique nature of landfill operations. To that end, NWRA conducted a Daily Cover/Working Face Study at 148 landfills. The results are summarized below.

- The average MSW landfill accepts 2,900 TPD, with a range of 400 TPD to greater than 14,000 TPD.
- The average working face is one acre, with a range of 0.25 acres to three acres.
- The average number of trucks simultaneously using the working face is seven, with a range of two to 30.
- One-third of surveyed MSW landfills have more than one working face due to site-specific operational needs such as:
    a. the placement of shallow waste lifts to finish out and/or bring an area to grade for proper drainage;
    b. new cells for soft trash, or wet weather pads;
    c. separation of different disposal vehicle types; or separate locations for different wastes, such as: friable asbestos, industrial wastes, contaminated soils, C&D wastes; dredge materials, and sludge/biosolids;
    d. solidification operations; or
    e. dig-out operations.

<u>Daily Cover</u>

NWRA and SWANA agree with EPA's previous conclusions that daily cover practices are subject to regulation under RCRA subtitle D rather than the Clean Air Act. EPA stated:

> *However, the EPA continues to maintain that guidance on daily and final cover is addressed under RCRA Subtitle D and therefore is not considered BSER under the CAA. The EPA also maintains that the primary responsibility for regulating and implementing specific aspects of Subtitle D lies with states and local governments*."[102]

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[102] 2016 RTC, at 304–05, EPA-HQ-OAR-2003-0215-0095.1, Excerpt 17.

Indeed, the RCRA subtitle D regulations address daily cover, requiring "six inches of earthen material at the end of each operating day, or more frequent intervals if necessary, to control disease vectors, fires, odors, blowing litter, and scavenging."[103] State agencies administering the RCRA regulations may approve use of alternative daily cover ("ADC") where an owner or operator "demonstrates that the alternative material and thickness control disease, vectors, fires, odors, blowing litter, and scavenging without presenting a threat to human health and the environment."[104]

Accordingly, the RCRA regulations—and relevant state solid waste requirements—govern daily (and final) cover and leave little room for authority under the CAA, as EPA has stated. Adding requirements under the CAA would cause undue regulatory burden, uncertainty, and confusion. To the extent that EPA identifies a basis to regulate daily cover under the CAA, flexibility is warranted. Daily cover practices should be performance- rather than method-based, to provide geographically limited landfills with flexibility to utilize cover materials that are readily available and cost-effective, including but not limited to hydro mulch, geosynthetic covers, tarps, form and slurry, and/or mechanical spreading. Indeed, several NWRA and SWANA member landfills are testing the feasibility and performance of ADC types. In a Working Face/Daily Cover survey of 148 MSW landfills conducted by NWRA in 2024, two-thirds of MSW landfills use tarps, while the remaining one-third use either six inches of clean fill or spray-on materials. NWRA and SWANA and its members will continue to evaluate and implement daily cover practices, in accordance with obligations set forth under RCRA.

Working Face

EPA makes several observations and suggestions in this White Paper regarding working face regulations. EPA alleges that numerous studies have shown that working faces are a "hotspot" source of methane emissions, particularly in humid, subtropical climates. EPA's potential suggestions include: (1) implementing working face management strategies and size limitations, (2) requiring the installation of interim GCCS beneath active waste layers, and (3) imposing routine working face emissions monitoring.

A working face size limitation would be impractical because the working face is a complex, dynamic operational environment the size of which depends on a host of factors. Most importantly, the working face must be large enough to allow for waste disposal in a safe and effective manner, and the working face size is determined according to the average tons of waste accepted per day. As mentioned previously, MSW landfills perform an essential public service, and for that reason, have limited practical control over the tons per day ("tpd") of waste accepted. EPA should also carefully consider the practical implications of reducing the size of working faces—for example, a reduction in size would increase the disposal truck queue during peak disposal times, creating an increase in idling emissions or potential local impacts.

EPA indicates that it may propose to require implementation of interim operational plans for adjacent gas collection wells near the working face and/or installation of horizontal gas collection trenches beneath the active working face. EPA must consider the following if it intends to require interim GCCS within or near active areas:

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[103] 40 C.F.R. § 258.21(a).

[104] *Id.* § 258.21(b).

- Age of waste – placement of horizontal collectors in areas with newer waste will collect low-quality LFG (low methane, high oxygen), making it unsuitable for beneficial use projects.
- Design plan – interim measures will inherently be at odds with a site's submitted design plan. EPA must provide clarity and flexibility with respect to transitioning to full GCCS, by allowing well abandonment and/or decommissioning without seeking prior agency approval.
- Existing interim requirements under state programs – to the extent that EPA considers interim collection requirements, it should model interim GCCS requirements on already-existing programs that are successfully implemented by affected facilities.
- Changing dynamic of the working face - because the working face must be responsive to ever-changing operational needs, EPA should not require the submission of a working face operational plan. The location of the working face may change as often as daily, especially if weather conditions (snow, rain, etc.) would create circumstances inhibiting trucks' ability to reach the working face. Moreover, other situations may necessitate large increases in incoming waste (wildfires, hurricanes, etc), that might render any proposed/existing working face operational plans obsolete.

With respect to monitoring working face emissions, EPA suggests using fixed methane concentration sensors downwind of the working face area to continuously monitor emissions. NWRA's members are engaged in evaluation of fixed sensors, but we reiterate our position that advanced measurement technologies, including fixed sensors, are not primed for implementation into the rule.[105] Further, the practical implications of monitoring emissions at the working face include establishing evaluative criteria for determining relevant action levels and associated responses. Perhaps most importantly, EPA should consider the costs and capabilities associated with the use of fixed sensors, especially because working face is a dynamic space that is constantly moving. As the working face moves, sensors would need to be repositioned with it and recalibrated in consideration of elevation, atmospheric, and climactic conditions. EPA also suggested conducting SEM at the working face using advanced technologies such as UAS/drone technologies. Due to the nature of the working face, owners and operators simply would not have enough time to conduct corrective action for any SEM exceedance detected because new waste would be placed shortly thereafter. Accordingly, the benefits of conducting working face SEM would be virtually nonexistent.[106]

9. Fenceline Monitoring (December 2024)

This White Paper examines the use of fenceline monitoring as a technique to detect methane and H_2S emissions from MSW landfills. The practice is typically implemented at oil and gas facilities using Methane 325 A/B, which EPA alleges has allowed for early notification of emissions events and early mitigation procedures. The White Paper acknowledges that these technologies have only been used and evaluated at MSW landfills a handful of times. EPA intends to continue gathering information on the effectiveness of perimeter monitoring programs

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[105] *See* NWRA RFI Response, at 17–18 (discussing fixed sensors). Notwithstanding, NWRA and SWANA support the use of fixed sensors, at this time, for research and development purposes on a voluntary basis.

[106] *See* NWRA comments on White Paper No. 10 for additional information on the costs associated with UAS/drone technologies.

so as to focus on: (1) early identification and mitigation of emissions events; (2) equipment monitoring; (3) reducing impacts on residents living nearby MSW landfills; (4) enhancing SEM procedures; and (4) developing a method to implement this technology into the Landfill Rules.

EREF evaluated fixed sensors from three vendors as part of its first controlled release study, and found that collectively, the sensors had an average uncertainty ± 39% in the best case scenario.[107] One sensor, EM27 (RPSEA), requires clear weather conditions, has no specified minimum detection limit, and was expensive. Two metal oxide (RPSEA) vendors were evaluated and varied in cost. Vendor J had a minimum detection limits of 100 ppm at 100 meters, while Vendor K had a minimum detection limit of 1 kg/hr.

Accordingly, fenceline monitoring is not appropriate for implementation into the Landfill Rules at this time. EPA has not shown that the technology is adequately demonstrated for localizing or quantifying emissions. The examples provided by EPA in this White Paper relate primarily to odor issues associated with H_2S, which is not currently a regulated pollutant under the Landfill Rules.[108] Moreover, perimeter monitoring will not adequately capture emissions across the surface of entire MSW landfills and will not account for the unique behavior of LFG. Indeed, EPA indicates in this White Paper that methane concentration thresholds are only triggered at night, which illustrates a change in atmospheric conditions, rather than a change in operational conditions that needs to be corrected. As demonstrated at EPA's Fall Technology Workshop, technology vendors that are developing continuous emissions monitoring devices specifically place sensors across the entire LF surface, rather than on the perimeter because the accuracy of such sensors declines as distance from emissions sources increases. Placement of sensors across the entire landfill surface should continue to be used only on a voluntary basis for research purposes to gather information on the working face and other operational insights. Moreover, as detailed in NWRA's response to EPA's Request for Information, these technologies are not yet standardized or open-sourced, and require software improvement before implementation into the rule would be appropriate.

To the extent that EPA intends to use fixed sensors to inform or replace current SEM practices, EPA must be cognizant of the fact that fixed sensors generally use volume-based data to estimate flow rates, and there is no accepted methodology to consistently convert data collected to ppm.

10. Unmanned Aircraft Systems (UAS) Technologies for Landfill Methane Monitoring (December 2024)

NWRA and SWANA and its members support the future incorporation of UAS devices for SEM purposes as long as an open-source, transparent, standardized methodology has been fully developed following public participation. Industry agrees that data gathering is necessary and requires investment of resources and cooperation among industry, non-governmental organizations, technology vendors, EPA, and relevant agencies. EREF conducted a

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[107] EREF, *A Controlled Release Experiment*, *supra*, n. 76.

[108] Fenceline monitoring is typically implemented as a means to detect emissions and prevent harm to the community. Climate emissions such as methane, which pose no acute health risks, are not generally the focus of fenceline monitoring programs. *See, e.g.*, EPA, *Tracking Emissions Using New Fenceline Monitoring Technology* (June 18, 2018), https://www.epa.gov/sciencematters/tracking-emissions-using-new-fenceline-monitoring-technology.

comprehensive controlled release study and made the following conclusions with respect to UAS technologies:

- Three drones tested for detection purposes –
  - 1 UPSEA vendor using TDLAS
    - Methodology did not register any true positive emission estimates during the localization phase of the study.
  - 2 UCSEA vendors using TDLAS/Laser Falcon (column-type)
    - Vendor L –
      - Reported high number of false positive estimates with limited visibility when measuring active emission points on slopes.
      - Minimum detection limit at 90 % probability of detection was determined to be 95.34 kg/hr.
      - Limitations: Precipitation, snow on ground, wind speed exceeding 6 m/s and visibility below 5 km prevent measurements from taking place.
    - Vendor M –
      - Performed slightly better than compared to other methods using TDLAS sensors.
      - Had high number of false positives and a minimum detection limit at 90% probability of detection of 101.88 kg/hr.
      - Limitations: Precipitation and windspeed exceeding 7 m/s prevent measurements from taking place.
      - Minimum detection limit: 1 ppm

NWRA and SWANA and its members generally support OTM-51/ALT-150 and encourage EPA in the development of future ALT methods. At the same time, NWRA and SWANA believe EPA should allow landfills to utilize any of the approved SEM methodologies interchangeably.

Other UAS devices are not ready for implementation into the rule and should undergo OTM/ALT procedures with stakeholder input. EPA currently employs a multi-step process for standardizing regulatory test methods. Test methods must first be designated as an Other Test Method ("OTM"), and then an Alternative Test Method ("ALT"), before EPA can approve it as a Reference Method for compliance purposes within the NSPS/EG or NESHAP programs. To go from an OTM to an ALT, EPA must be assured that the test method alternative provides "a determination of compliance status at the same or greater stringency as the test method specified in the applicable regulation," which should be shown by including the results of a Method 301 validation (Validation of Pollutant Measurement Methods from Various Waste Media) and justification for not using the regulation's specified method, which compares the test method against a validated reference test method to determine the method's bias and collecting multiple or co-located simultaneous samples to determine the method's precision.

Devices utilizing same technologies (*i.e.*, downward facing lasers, LiDAR) must have standardized methodologies for detecting LFG and accounting for site-specific conditions. Methodologies must standardize conversion of ppm-m to ppmv, because ppmv is the current standard for determining whether a SEM exceedance exists. Path integrated (ppm-m) is influenced more by environmental factors (wind, pressure, topographic conditions) that must be reconciled in a standardized manner. Further development is necessary to reduce uncertainties and gain better understanding of how environmental, topographic, and meteorological conditions impact accuracy.

Only one method exclusive to one vendor is currently approved as an Alternative Test Method to Method 21 so as to satisfy the SEM requirements under the NSPS/EG is ALT-150/OTM-51.[109] Because ALT-150 was approved in accordance with EPA's procedures, its implementation is the only option that exists among the new advanced measurement technologies. EPA should work with technology vendors and other stakeholders to establish standard methods for classes of UAS technologies prior to and after promulgation of any updates Landfill Rules, so as to allow for pathway to continuously advance appropriate technologies without rushing to require their use before they are sufficiently proven. In establishing this process, EPA should prioritize its goal to "peer review [] all scientific and technical information that is intended to inform or support Agency decisions.[]"

NWRA and SWANA support the further research and development of UAS devices because NWRA and SWANA agree that they can provide solutions to issues posed by walking SEM pursuant to Method 21, including: (1) eliminating the need to avoid dangerous walking conditions; (2) covering larger distances in shorter periods of time; and (3) allowing for faster mitigation and response where exceedances are detected.

EPA has indicated that potential regulatory changes could include increasing SEM monitoring points.[110] The Landfill Rules currently require SEM measurements be taken at 30-meter intervals.[111] Environment and Climate Change Canada ("ECCC") recently proposed 7.5-meter intervals, while California and Oregon require 7.5-meter intervals.

In response to ECCC's proposal, NWRA commented:

> *The 7.5-metre line separation requirement . . . is overly stringent and should be revised to reflect the Quebec and EPA NSPS requirement of 30 metres. Under the 7.5-metre interval provision, ECCC would quadruple the labour-hours required to perform field monitoring relative to the aforementioned standards. Over a 100 hectare landfill it currently takes WM approximately 3 days to complete a walking sweep under a 30-metre line separation requirement that is applied in Quebec. Under a 7.5 meter spacing requirement, WM's staff would be required to walk a total distance of 140 to 150 kms. This raises safety and labour shortage concerns and is an interval that would not equate to a commensurate level of exceedance detections.*

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[109] *See* EPA OAQPS, *Approval to Use Unmanned Aerial System Application as an Alternative to Method 21 for Surface Emission Monitoring of Landfills*, (Dec. 15, 2022) https://www.epa.gov/system/files/documents/2022-12/Barron%20Sniffer%20Alt%20with%20OTM%2051%20attached_signed.pdf.

[110] *See* White Paper No. 2, *Review and Comparison of Existing State Rules and Proposed Canadian Rule to MSW Landfill NSPS/EG* (Oct. 2024).

[111] 40 C.F.R. § 60.763(d).

Reduced interval spacing without the use of UAS technologies would provide no observable benefit in terms of emissions reductions. In comments submitted to EPA in 2015, Waste Management ("WM") described the shortcomings associated with California Air Resources Board (CARB)'s Landfill Methane Rule (LMR) 7.5-meter interval spacing. Specifically, WM stated that each monitoring event cost $35,000 with no objectively observable improvements in system performance.[112]

Reducing the space between SEM intervals would be appropriate only where landfill owners and operators had the technological means to cover the ground required for compliance purposes. Use of UAS technologies could rectify this issue, but only where such use would result in accurate, reliable, and cost-effective data collection using established standard methods and procedures. Accordingly, EPA should remain engaged with the research and development of UAS technologies and subject them to OTM/ALT procedures as well as a thorough cost-benefit analysis prior to implementing their use into the Landfill Rules.

[112] WM: Comments on EPA's Proposed Standards of Performance for MSW Landfills at 40 C.F.R. Part 60, subpart XXX, 79 Fed. Reg. 41796 (July 17, 2014), EPA-HQ-OAR-2003-0215-0100 (Sept. 15, 2024), at 39–40.

Exhibit 1

Petitioners: National Waste & Recycling Association,
Solid Waste Association of North America,
Republic Services, Inc.,
Waste Management, Inc., and
Waste Management Disposal Services of Pennsylvania, Inc.

PETITION FOR RULEMAKING, RECONSIDERATION, AND ADMINISTRATIVE STAY

DOCKET I.D. EPA-HQ-OAR-2003-0215; EPA-HQ-OAR-2014-0451

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I. Introduction

On August 29, 2016, the Environmental Protection Agency ("EPA" or "Agency") promulgated final rules entitled, *Standards of Performance for Municipal Solid Waste Landfills*, 81 Fed. Reg. 59332-59384 (Aug. 29, 2016) ("Subpart XXX"), and *Emission Guidelines and Compliance Times for Municipal Solid Waste Landfills*, 81 Fed. Reg. 59276-59330 (Aug. 29, 2016) ("Subpart Cf") (collectively referred to as the "Final Rules"). Prior to publication of the Final Rules, EPA issued the following notices of proposed rulemaking: *Standards of Performance for Municipal Solid Waste Landfills*, 79 Fed. Reg. 41795-41843 (July 17, 2014) and *Emission Guidelines and Compliance Times for Municipal Solid Waste Landfills; Advanced Notice of Proposed Rulemaking*, 79 Fed. Reg. 41771-41793 (July 17, 2014) (collectively referred to as "2014 Proposal"). A year later, EPA issued supplemental proposals, entitled *Standards of Performance for Municipal Solid Waste Landfills*, 80 Fed. Reg. 52162-52168 (Aug. 27, 2015) and *Emission Guidelines, Compliance Times, and Standards of Performance for Municipal Solid Waste Landfills; Proposed Rule*, 80 Fed. Reg. 52100-52162 (Aug. 27, 2016) (collectively referred to as "2015 Supplemental Proposal"). The Final Rules are intended to update existing rules regulating municipal solid waste ("MSW") landfills – the Standards of Performance for Municipal Solid Waste Landfills at 40 C.F.R. Part 60, Subpart WWW ("Subpart WWW") and the Emission Guidelines and Compliance Times for Municipal Solid Waste Landfills at 40 C.F.R. Part 60, Subpart Cc ("Subpart Cc").

Pursuant to Section 553(e) of the Administrative Procedure Act ("APA"), 5 U.S.C. § 553(e), the National Waste & Recycling Association, the Solid Waste Association of North America, Republic Services, Inc., Waste Management, Inc., and Waste Management Disposal Services of Pennsylvania, Inc. (collectively referred to as "Petitioners") request that EPA immediately undertake a rulemaking to revise the Final Rules, as further specified in Section III, below. Additionally, pursuant to Section 307(d)(7)(B) of the Clean Air Act, 42 U.S.C. § 7607(d)(7)(B) ("CAA" or "Act"), Petitioners request that EPA reconsider certain aspects of the Final Rules, as set forth in Section IV, below. Finally, Petitioners request that EPA immediately grant Petitioners' request for administrative stay of the Final Rules, as more fully detailed in Section V, below, in order to suspend the effectiveness of the Final Rules and to allow the Agency time to correct the significant substantive and procedural flaws identified in this Petition.

II. Petitioners' Background

The National Waste & Recycling Association ("NWRA") is a trade association that represents private-sector waste and recycling companies in the United States, and manufacturers and service providers who do business with those companies. NWRA's members operate in all 50 states and the District of Columbia. NWRA provides leadership, education, research, advocacy, and safety expertise to promote North American waste and recycling industries, serve as their voice, and create a climate where members prosper and provide safe, economically sustainable, and environmentally sound services.

The Solid Waste Association of North America ("SWANA") is a California nonprofit public benefit corporation. Its membership includes more than 8,500 public and private sector professionals committed to advancing from solid waste management to resource management through their shared emphasis on education, advocacy and research. For more than 50 years, SWANA has been the leading professional association in the solid waste management field.

Republic Services, Inc.[1] ("Republic") serves residential, municipal, commercial, and industrial customers nationwide and is dedicated to providing dependable solutions for recycling and waste challenges. Republic provides reliable service through 340 collection operations, 201 transfer stations, 193 active landfills, 67 recycling centers, eight treatment, recovery and disposal facilities, 12 salt water disposal wells, and 69 landfill gas and renewable energy projects across 41 states and Puerto Rico. Republic maintains approximately 125 closed MSW landfills. Republic is a holding company and all operations are conducted by its subsidiaries.

Waste Management, Inc. [2] ("WM") is North America's leading provider of integrated waste management and environmental solutions. Through its network of subsidiaries, including Waste Management Disposal Services of Pennsylvania, Inc., WM operates 244 active, solid waste landfills, and at 136 of them, operates beneficial landfill-gas-to energy ("LFGTE") projects. These projects produce renewable electricity, renewable fuel for stationary facilities, and renewable transportation fuel for vehicles, including about 1000 of WM's own refuse collection trucks. WM maintains approximately 200 closed MSW landfills.

Petitioners have engaged with EPA during the rulemaking period and submitted comments on both the 2014 Proposal and 2015 Supplemental Proposal. *See* NWRA & SWANA, Comments on 2014 Proposal, Docket ID EPA-HQ-OAR-2003-0215-0108 & EPA-HQ-OAR-2014-0451-0062 ("NWRA & SWANA 2014 Comments"); NWRA & SWANA, Comments on 2015 Supplemental Proposal, Docket ID EPA-HQ-OAR-2003-0215-0196 & EPA-HQ-OAR-2014-0451-0186 ("NWRA & SWANA 2015 Comments"); Republic Services, Comments on

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[1] Republic Services, Inc. is a holding company and all operations are conducted by its wholly-owned and majority-owned subsidiaries. This Petition is being filed by Republic Services, Inc. on behalf of these consolidated subsidiaries (collectively "Republic").

[2] Waste Management, Inc., a Delaware Corporation, is a holding company and all operations are conducted by its wholly-owned and majority-owned subsidiaries. This Petition is being filed by Waste Management, Inc. on behalf of these consolidated subsidiaries (collectively "Waste Management" or "WM").

Proposed Standards of Performance for Municipal Solid Waste Landfills, Docket ID EPA-HQ-OAR-2003-0215-0099 ("Republic 2014 NSPS Comments"); Republic Services, Comments on Supplemental Proposal – Standards of Performance for Municipal Solid Waste Landfills, Docket ID EPA-HQ-OAR-2003-0215-0202 ("Republic 2015 NSPS Comments"); Republic Services, Comments on the Advanced Notice of Proposed Ruling Making for Emission Guidelines and Compliance Times for Municipal Solid Waste Landfills, Docket ID EPA-HQ-OAR-2014-0451-0061 ("Republic 2014 EG Comments"); Republic Services, Comments on Proposed Rules; Emission Guidelines, Compliance Times, and Standards of Performance for Municipal Solid Waste Landfills, Docket ID EPA-HQ-OAR-2014-0451-0176 ("Republic 2015 EG Comments"); Waste Management, Inc., Comments on 2014 Proposal, Docket ID EPA-HQ-OAR-2003-0215-0100 & ("WM 2014 Comments"); Waste Management, Inc., Comments on 2015 Supplemental Proposal, Docket ID EPA-HQ-OAR-2003-0215-0198 & EPA-HQ-OAR-2014-0451-0192 ("WM 2015 Comments"). Additionally, WM, Republic, and other industry stakeholders have provided supplemental information relating to implementation of Subparts WWW and Cc, which can be found in the docket for Subpart XXX at the following Docket ID numbers: EPA-HQ-OAR-2003-0215-0003, EPA-HQ-OAR-2003-0215-0007, EPA-HQ-OAR-2003-0215-0053, EPA-HQ-OAR-2003-0215-0055, EPA-HQ-OAR-2003-0215-0057, EPA-HQ-OAR-2003-0215-0058.

III. Petition for Rulemaking

Petitioners ask EPA to initiate rulemaking to address certain aspects of EPA's Final Rules that were raised in comments at proposal. Under Section 553(e) of the APA, any party can ask any agency to issue, amend, or repeal a rule. 5 U.S.C. § 553(e). Although Section 307(d) of the CAA states that Section 553 of the APA shall not apply to the promulgation or revision of most nationally-applicable CAA rules, including NSPS or EG rules,[3] the federal courts continue to recognize the right of the public to petition EPA for rulemaking under the CAA. [4]

The Petitioners recognize that the federal courts' authority to review EPA decisions on whether to grant or deny petitions for rulemaking is "extremely limited and highly deferential." *See WildEarth Guardians v. EPA*, 751 F.3d 649 (D.C. Cir. 2014) (denying a challenge to EPA's decision to deny a petition for rulemaking under Section 111 on the basis of ongoing budget uncertainties and limited resources). Nevertheless, Petitioners believe that the Final Rules are fundamentally flawed, are inconsistent with the structure and purpose of Section 111 of the CAA, and therefore warrant revision. Accordingly, Petitioners submit this petition for rulemaking in the hope that EPA will recognize that numerous flaws remain unaddressed, despite timely comments raising those concerns, and initiate a rulemaking process to address them. Since Petitioners believe that the issues for which rulemaking is requested below can be more fully vetted through an official notice and comment rulemaking process, the issues are described here only in general terms. Petitioners look forward to providing greater detail and proposed solutions for the concerns identified below during the rulemaking process. Nevertheless, because Petitioners did comment on the issues identified in this Section III during the rulemaking process for the Final Rule, such issues are also ripe for judicial review. 42 U.S.C. § 307(d).

A. Overlapping Applicability of Old and New Subparts

In promulgating the Final Rules, the Agency has created an unintelligible web of standards that apply to MSW landfills in contravention of Section 111, consisting of: (1) old

[3] 42 U.S.C. § 307(d).

[4] *Massachusetts v. EPA*, 415 F.3d 50, 53 (D.C. Cir. 2005) (noting that Section 307 authorizes judicial review of EPA's decision to deny a petition for rulemaking), *rev'd and remanded on other grounds by* 549 U.S. 497, 527 (2007) (referring to the filing of a petition for rulemaking under the CAA as "procedural right" and confirming that the denial of such a petition may be addressed via judicial review under Section 307). *Accord Friends of the Earth v. EPA*, 934 F. Supp.2d 40, 54 (D.D.C. 2013) ("EPA is required to respond to a citizen petition for rulemaking.") (citing *Massachusetts v. EPA*).

Subparts WWW and Cc, which have not been expressly superseded; (2) 40 C.F.R. Part 63, Subpart AAAA ("the Landfill NESHAP" or "Subpart AAAA"), which continues to rely on Subparts WWW and Cc for its substantive compliance obligations; and (3) new Subparts XXX and Cf, which were intended to update the standards for landfills but were adopted as free-standing and separate subparts.

Despite many comments asking EPA to address the potential overlap among its old rules, the new rules, and the Landfill NESHAP (which requires compliance with Subparts WWW and Cc), EPA did not address that critical concern. For example, WM's comments expressly asked "how EPA's proposal to correct and clarify the regulatory language based on Subpart WWW would affect Subpart WWW itself, and importantly, compliance obligations for existing facilities." WM 2014 Comments at 3-4. Republic similarly commented that "EPA must also address the compliance obligations that may result for sites that must transition from Subpart WWW to Subpart XXX following a modification." Republic 2015 EG Comments at 33. Both companies also commented that the decision to adopt entirely separate subparts for the revised rules (Subparts XXX and Cf) ignores the fact that the Landfill NESHAP continues to require compliance with the old subparts (Subparts WWW and Cc). WM 2015 Comments at 70; Republic 2015 EG Comments at 33.

Despite these comments, EPA adopted applicability provisions in its new subparts that fail to take into account the applicability provisions of the old subparts and the Landfill NESHAP, which EPA did not revise. EPA acknowledges that the Agency could have accomplished the updates to Subparts WWW and Cc merely by updating those old subparts. *See* 81 Fed. Reg. at 59333, FN 3. Such a decision would have avoided the confusion that has resulted. Nevertheless, the Agency decided instead to forge a more complicated path by updating Subparts WWW and Cc via promulgation of two new and separate subparts. As a result, the applicability provisions for all five rules—the old and new NSPS and EG and the Landfill NESHAP—are now codified as follows:

- Subpart Cc: landfills constructed / modified "before May 30, 1991"[5]
- Subpart WWW: landfills constructed / modified "on or after May 30, 1991"[6]
- Subpart Cf: landfills constructed / modified "on or before July 17, 2014"[7]
- Subpart XXX: landfills constructed / modified "after July 17, 2014"[8]
- Subpart AAAA: requiring landfills that are major sources or area sources meeting certain design capacity thresholds to comply with WWW or Cc[9]

Because of the overlapping applicability provisions, a landfill will necessarily meet the applicability criteria of more than one subpart, as illustrated in the table provided below:

Landfills that were last constructed / modified …	Emission Guidelines		NSPS	
	Cc (old)	Cf (new)	WWW (old)	XXX (new)
… before May 30, 1991	×	×		
… on or between May 30, 1991 & July 17, 2014		×	×	
… after July 17, 2014			×	×

This overlapping applicability is unreasonable because on their face the rules would require landfills to simultaneously comply with different and overlapping provisions from either the new or old subparts, forcing Petitioners to engage in two different sets of activities to ensure compliance with the new and old rules. In doing so, EPA is forcing landfills to meet all provisions of the Final Rules without allowing landfills to benefit from the regulatory provisions that EPA intended to update and streamline, since the old rules will still apply. As just one

[5] 40 C.F.R. § 60.32c.

[6] 40 C.F.R. § 60.750.

[7] 40 C.F.R. § 60.31f.

[8] 40 C.F.R. § 60.760.

[9] 40 C.F.R. §§ 63.1935; 63.1955.

example, EPA eliminated the wellhead oxygen parameter as a basis for requiring corrective action in Subparts XXX and Cf, but Subparts WWW and Cc—one of which will still apply to all landfills—will continue to require all landfills to take corrective action for oxygen exceedances.

The overlapping applicability provisions contravene the CAA because they have the effect of simultaneously regulating some landfills as both "new" landfills subject to a NSPS and "existing" landfills subject to an EG. That result is prohibited by the CAA, which defines the two terms "new source" and "existing source" in mutually exclusive fashion and establishes separate programs for "new" and "existing" sources—Section 111(b) for new sources, and Section 111(d) for existing sources. Given that the definition of "existing source" is "any stationary source *other than* a new source," a single source cannot be regulated simultaneously as both a "new source" under a Section 111(b) NSPS and an "existing source" under a Section 111(d) EG. 42 U.S.C. § 7411(a)(6). But that is exactly the result of EPA's failure to properly address the overlapping applicability of its old and new NSPS and EG for some landfills, as illustrated above.

Likewise, EPA failed to address the fact that the Landfill NESHAP still requires compliance with the substantive obligations of Subparts WWW and Cc. Despite many comments identifying the inconsistency between the proposed rules and the Landfill NESHAP, EPA completely failed to address these comments in the Final Rules.

EPA's own statements confirm that the Agency did not intend for landfills to comply with both the old and new rules simultaneously. The most obvious indication of EPA's intent with the Final Rules is EPA's description of them as a "revision," "update," or "changes" to the old rules. *See e.g.*, 81 Fed. Reg. at 59276 ("Based on this review, the EPA has determined that it is appropriate to revise the Emission Guidelines . . ."). Even more explicitly, the preambles explain that EPA believes "the most appropriate way to proceed is to establish a new subpart that includes both the verbatim restatement of *certain provisions* in the existing Emission Guidelines and revisions to, or the addition of, *other provisions*." *Id*. at 59286. This statement confirms that EPA did not intend for all provisions of Subpart WWW and Cc to continue to apply as currently written, but EPA's Final Rules do not reflect that intent. EPA even justified its decision to revise Subparts WWW & Cc by quoting Supreme Court precedent holding that "[r]egulatory agencies do not establish rules of conduct to last forever," even though EPA has failed in this instance to adopt any language to terminate the effectiveness of such standards. *Id*. at 59277 (citing *Am. Trucking Ass'n v. Atchison, Topeka & Santa Fe Ry.*, 387 U.S. 397, 416 (1967)).

EPA's failure to enact appropriate applicability provisions in its Final Rules renders them unlike any other NSPS revision that EPA has ever adopted. All of the other NSPS revisions that EPA has adopted make clear that only one NSPS subpart should apply at a time (and EPA has never before revised an EG). For example, when EPA adopted a new standard for stationary combustion turbines in Subpart KKKK, EPA confirmed that sources subject to the new Subpart KKKK provisions would be "exempt" from the provisions of Subpart GG. 40 C.F.R. § 60.4305 ("Stationary combustion turbines regulated under this subpart [KKKK] are exempt from the requirements of subpart GG of this part."). Similarly, after EPA adopted a new standard in Subpart Da for fossil fuel-fired steam generators, EPA revised the old Subpart D to make clear that any facility subject to the new standard "is not subject" to the old standard. 40 C.F.R. § 60.40 ("Any facility subject to . . . subpart Da . . . of this part is not subject to this subpart."). Many other subparts contain language of similar effect to avoid the overlap of old and newly revised standards. *See, e.g.*, 40 C.F.R. Part 60, Subparts Ea, Eb, K, Ka, Kb, AA, AAa, J, Ja, VV, VVa, GGG, GGGa, AAAA, BBBB, CCCC, DDDD, EEEE, FFFF. The only instance of EPA adopting a new subpart without expressly addressing the applicability of an old subpart that Petitioners were able to identify is Subpart TTTT, in which EPA adopted standards for electric generating units, but in that case no overlap occurred because Subpart TTTT only regulates an entirely new pollutant—greenhouse gas emissions—that was not covered by the preexisting standards.

EPA's error in failing to address the overlapping applicability of the Final Rules, Subparts WWW and Cc, and the Landfill NESHAP requires an additional rulemaking action. Only through further revisions to its regulations can EPA make sufficiently clear that only the newly "revised" and "updated" versions of the regulations apply, as EPA originally intended. In the case of the Landfill NESHAP, EPA must acknowledge that compliance with the Final Rules satisfies the sections of Subpart AAAA that currently reference Subparts WWW and Cc. When EPA promulgated the Landfill NESHAP, the Agency concluded that substantive provisions of Subparts WWW and Cc were the appropriate basis for the rule's MACT standard. Having now updated Subparts WWW and Cc via promulgation of the Final Rules, the Agency must carry through such updates to the Landfill NESHAP.

Certainly, if a State adopts a Section 111(d) plan for implementing the EG that confirms compliance with the new EG satisfies the old EG, and EPA approves that plan, the State may be able to resolve this overlapping applicability concern for landfills subject only to the old and new EG (i.e., those constructed and last modified prior to May 30, 1991). However, Section 111(b) does not authorize States to revise the applicability provisions of the standards that EPA has adopted for new sources. Therefore, States will not have the authority to resolve the applicability concerns for any landfill subject to Subpart WWW, XXX, or both (i.e., those constructed and last modified on or after May 30, 1991).

When EPA initiates a rulemaking process to resolve the overlapping applicability of Subparts XXX, WWW, Cf, and Cc, and the Landfill NESHAP, EPA must also address the process by which a landfill transitions from the old rules to the new. Again, despite numerous comments requesting that EPA address the procedures and timing for transitioning to the compliance obligations of the Final Rules, EPA simply failed to respond. *See* WM 2014 Comments at 3-4; Republic 2015 EG Comments at 33. As a result, states and regulated entities are left without any direction on how to implement the new rules once they take effect. Landfills will need some time to make the changes that the Final Rules require, so a transition policy should allow a reasonable amount of time for achieving compliance.

Thus, Petitioners respectfully ask EPA to convene a notice-and-comment rulemaking action to address this overlapping applicability concern through rule revisions, accompanied by provisions that allow a reasonable time period for compliance with the new requirements.

B. Design Plan and Alternatives Approval Process

The Final Rules contain numerous and conflicting provisions addressing the need for submittal and approval of landfill gas collection and control system ("GCCS") design plans, the obligation to operate in accordance with an approved design plan, and the potential enforcement risk for facilities that have not yet received approval of their design plan. Petitioners request that the Agency initiate a rulemaking intended to provide greater clarity for compliance obligations related to the design plan approval process.

Under Subparts WWW and Cc, Petitioners have experienced a very low rate of agency review and approval of design plans, including alternatives to the design standards and operating parameters, leaving many facilities without any certainty as to whether the design plan requirements have been met or whether their alternatives are appropriate. At proposal, EPA solicited comments on streamlining the design plan approval process. Petitioners urged EPA to clarify and streamline these requirements, recommending that the Agency (1) establish a defined timeline for review and approval or denial of design plan submittals; and (2) establish a process for automatic approval should the Administrator or delegated authority fail to respond within the established deadline. As an alternative, Petitioners urged EPA to reexamine the need for an affirmative approval of design plans in general, noting that many EPA rules do not require approval of similar types of conceptual plans. See WM 2014 Comments at 30-35. In supplemental comments submitted to EPA, Petitioners provided numerous examples of EPA rules that do not require agency approval of analogous plans. A copy of Petitioners' Supplemental Comments[10] is attached hereto at Appendix "A". (Note that these comments were provided at EPA's request.) In the Final Rules, EPA did not address Petitioners' comments and instead worsened the compliance uncertainty associated with GCCS design plan review and approval. Thus, Petitioners request that the Agency initiate a rulemaking, respond to Petitioners' comments, and provide greater clarity around compliance obligations related to the design plan approval process.

1. The Final Rules Do Not Ensure Agency Review or Approval of Design Plans

In the Final Rules, EPA definitively stated that agency approval of GCCS design plans is required. See 40 C.F.R. § 60.762(b)(2)(i) and 40 C.F.R. § 60.767(c)(4). Yet, having established in the Final Rules that design plans must be submitted for approval, EPA's approval process fails to ensure that the Agency will ever review submitted design plans, let alone approve them.

[10] Petitioners note that EPA has failed to include the Supplemental Comments in Appendix A in the dockets for the Final Rules, despite requesting that Petitioners submit them. Petitioners have attached the Supplemental Comments to this Petition for the Agency's ease of review.

Specifically, section 60.767(c)(5) requires "[t]he landfill owner/operator to notify the Administrator that the design plan is completed and submit a copy of the plan's signature page. The Administrator has 90 days to decide whether the actual design plan should be submitted for review. If the Administrator chooses to review the plan, the approval process continues as described in (c)(6) of this section." The section thus leaves entirely to the discretion of EPA or delegated authority whether to review any submitted design plan. Section 60.767(c)(6) creates even more confusion as it consists of two contradictory sentences. The first requires that the Administrator, upon receipt of an initial or revised design plan, "*[m]ust* review information submitted . . . and either approve it, disapprove it, or request additional information." But the second sentence then imposes an unacceptable enforcement risk on the landfill owner/operator in the event that "the Administrator indicates that submission is not required, or does not respond within 90 days," by stating that "the landfill owner/operator *can* continue to implement the plan with the recognition that the owner/operator is proceeding at their own risk." The same paradoxical provisions are reflected in Subpart Cf in Section 60.38f(d)(5) and (6).

Notwithstanding use of the word "must" in these provisions, the overall process described in (c)(5) and (6) indicates that the Agency may choose whether or not to review the design plan. This is completely at odds with the Agency's unambiguous statements in the Final Rules requiring design plan approval. The EPA has thus created a system by which the landfill owner/operator is required to submit a design plan for agency approval, but neither EPA nor its state or local counterparts are held accountable for actually reviewing and approving or disapproving those plans. In fact, the process outlined in the Final Rules does not even require the regulatory agencies to acknowledge receipt of the plans.

2. The Final Rules Provide no Clarity on Whether Landfills Must Proceed with GCCS Installation in the Absence of Agency Approval

The Final Rules state that if the Administrator does not approve or disapprove the design plan, or request additional information within 90 days of receipt, then the owner or operator *"can"* continue with implementation of the design plan, recognizing that they would "be proceeding at their own risk." 40 C.F.R. § 60.767(c)(6); 40 C.F.R. § 60.38f(d)(5) and (6). The language is permissive, failing to inform the regulated entity what it should or must do when the regulator fails to review and approve their plan, or to provide a path forward for obtaining plan approval should the agency be non-responsive. 40 C.F.R. § 60.767(c)(5) & § 60.38f(d)(5).

This permissive language conflicts with other provisions of the Final Rules requiring actions to be taken in conformance with an approved plan. For example, the compliance provisions in the Final Rules at Sections 60.765(b) and 60.36f(b) state that the landfill owner/operator "must place each well or design component as specified in the *approved* design plan as provided in § 60.767(c) (emphasis added)." Additionally, monitoring provisions at Sections 60.766(d) and 60.37f(d) require that a landfill owner/operator complying with the GCCS operational standards by using a device other than a non-enclosed flare, an enclosed combustor, or treatment system *must* provide information satisfactory to the Administrator, and that the Administrator must review and approve it or request additional information. Likewise, where the landfill owner/operator seeks to employ alternatives to the operational standards, test methods, compliance provisions or other aspects of the Final Rules, the landfill owner/operator *must* submit those alternatives to the Agency in the design plan. 40 C.F.R. § 60.767(c)(2) and § 60.38f(d)(2). Thus, even though key implementation requirements are contingent on design plan approval, the Final Rules do not suspend a landfill's compliance obligations pending that approval, leaving the landfill with little choice but to take the risk that EPA has identified in its rule language.

These contradictory requirements are paralyzing for affected facilities that have prepared and submitted GCCS design plans in good faith. In light of the requirements in the Final Rules at Sections 60.762(b)(2)(ii) and 60.33f to seek permits, award contracts, install and start up a GCCS within 30 months of the regulatory trigger event, a landfill owner or operator is placed into an untenable situation: either face potential enforcement risk for missing the 30-month compliance deadline, or face potential financial *and* enforcement risk for installing and operating a multi-million-dollar gas collection system in accordance with a design plan that is later disapproved.

3. EPA's Design Plan Approval Process Subjects Affected Facilities to Unclear Compliance Obligations and Untenable Financial and Enforcement Risk

The Final Rules' design plan approval process creates a circumstance in which affected facilities are subject to risk of enforcement regardless of which course of action they take and through no fault or failure of their own. Indeed, the Final Rules conclude the confusing design plan approval process with the following statement:

> In the event that the design plan is required to be modified to obtain approval, the owner or operator must take any steps necessary to conform any prior actions to the approved design plan and any failure to do so could result in an enforcement action.

40 C.F.R. § 60.767(c)(5) and 40 C.F.R § 38f(d)(5).

This language is unintelligible, and notably, was not included in any of EPA's rulemaking proposals. As an initial matter, EPA does not explain how one can achieve the feat of conforming prior actions to a newly imposed requirement. Second, EPA does not explain whether the resulting enforcement risk is retroactive, prospective, or both. Certainly, the threat of retroactive enforcement for good-faith actions taken pursuant to a design plan that an agency declined to review contravenes basic principles of fairness and due process. Finally, EPA failed to even acknowledge the significant financial risk associated with installing a multi-million dollar system that may later (maybe years later) be determined insufficient. This risk is particularly relevant for landfills that propose site-specific alternatives. Indeed, the Final Rules readily acknowledge that:

> Because of the many site-specific factors involved with landfill gas system design, alternative systems may be necessary. A wide variety of system designs are possible, such as vertical wells, combination horizontal and vertical collection systems or horizontal trenches only, leachate components, and passive systems.

40 C.F.R. § 60.767(c)(6) and 40 C.F.R. § 60.38f(c)(6). Thus, although EPA clearly acknowledges the need for alternative designs, and that the landfill owner/operator is required to obtain Agency approval for those designs, EPA makes no commitment to review those alternatives. EPA's response on this issue is insufficient. EPA states:

> Because the initial design can significantly affect the long-term operation of the landfill GCCS, and that design is site-specific, the EPA has retained the design plan approval process to provide flexibility to the sites on designing an appropriate system, while also providing a level of regulatory oversight *before the system is installed* in order to minimize scenarios where an improperly designed system is constructed and installed.

EPA, Responses to Public Comments on EPA's Standards of Performance for Municipal Solid Waste Landfills and Emission Guidelines and Compliance Times for Municipal Solid Waste Landfills: Proposed Rules, 965 (hereinafter "Response to Comments Document") (emphasis added). Far from minimizing these risks for regulated entities, EPA's design plan approval process creates enforcement risk where none should exist and expressly does not ensure any level of regulatory oversight before the GCCS is installed. Because the GCCS requirement is the centerpiece of the Final Rules, ambiguity and conflicting provisions concerning GCCS design plan approval cause the Final Rules to lack the most fundamental element of a properly functioning regulatory system, which is to provide fair and timely notice of the compliance obligations to which a regulated entity is subject, in this case via approval of required regulatory documents. *See generally, United States v. Trident Seafoods*, 60 F.3d 556 (9th Cir. 1995); *Gates & Fox Co. v. OSHRC*, 790 F.3d 154 (D.C. Cir. 1986); *General Electric v. U.S. EPA*, 53 F.3d 1324 (D.C. Cir. 1995). If GCCS design plan approval is a required component of a rule, then agency review and approval or denial must also be a rule requirement, so that a regulated entity can move forward with implementation, confident that it has been apprised of its compliance obligations. The Final Rules fail to provide this essential regulatory element.

4. EPA Must Correct the Rules to Require Affirmative Agency Approval in a Timely Manner

Petitioners have observed a demonstrated failure by agencies to review, approve, or even acknowledge design plan submittals under the existing Subparts WWW and Cc. WM and Republic estimate that only about 40% of their landfills operate pursuant to an approved design plan due to lack of timely action by EPA and state authorities. Accordingly, Petitioners urge EPA to initiate a rulemaking to address this problem under the Final Rules. In that context, we again ask EPA to eliminate the need for agency review and approval of GCCS plans, which is a system that has simply not worked to date. Instead, Petitioners recommend that delegated authorities should be allowed to rely upon a licensed, third-party professional engineer (“PE”) certification of design plans and revisions in lieu of an agency review and approval process. Petitioners recommend that certified plans be maintained onsite for inspection and/or submittal to the implementing agency. This approach is consistent with sixty-two other Clean Air Act rulemakings identified in Petitioners’ Supplemental Comments attached at Appendix A.

Reliance on a certification by a licensed, third-party PE in lieu of agency approval would also be consistent with the approach EPA finalized in the Agency's recent NSPS rulemaking impacting the Oil & Natural Gas Sector. *See* EPA, *Oil & Natural Gas Sector: Emission Standards for New Reconstructed, and Modified Sources*; *Final Rule*, 81 Fed. Reg. 35824, 35942, 35848 (June 3, 2016) (finalizing standards allowing for PE certification of closed vent system design and technical infeasibility to connect a pneumatic pump to existing control device). In the event that EPA continues to believe that design plan review and approval is necessary, we ask the Agency to consider a defined timeframe for such review and a deemed approval in the event that the reviewing agency fails to respond in a timely manner.

C. Non-Producing Areas

Petitioners request that the Agency initiate a rulemaking proceeding to provide compliance flexibility in landfill areas with declining gas flows. Such flexibility is critically important to landfills required to implement the more stringent 34 Mg/year non-methane organic compound ("NMOC") emission threshold. In the Final Rules, EPA failed to address three critical issues: (1) the Final Rules do not allow for the capping, removal, or decommissioning of portions of a GCCS in non-producing areas; (2) the term "closed area" is too narrowly defined, which in turn limits the utility of the 1% NMOC exclusion; and (3) the Final Rules do not allow the use of surface emission monitoring ("SEM") to demonstrate that capping, removal, or decommissioning of a GCCS is appropriate based on-site specific surface methane concentrations.

1. The Final Rules Should Allow for the Capping, Removing, and Decommissioning of GCCS From Non-Producing Areas of Active and Closed Landfills

In the Final Rules, EPA restricts capping, removing, or decommissioning of a GCCS to entire closed landfills and does not allow for capping, removing, or decommissioning[11] of portions of a GCCS in closed or non-producing *areas* of otherwise active landfills or closed landfills. *See* 40 C.F.R. § 60.762(b)(2)(v); 40 C.F.R. § 60.33f(f). In other words, EPA does not allow for partial removal or decommissioning of a GCCS at any landfill, closed or open. At proposal, EPA acknowledged and requested comment on how non-producing areas of the landfill (*i.e.*, areas that are no longer generating landfill gas), could be excluded from gas collection and control requirements and whether the criteria for capping or removing a GCCS in Subparts WWW or Cc are appropriate. *See* 79 Fed. Reg. at 41783 & 41792. In the 2015 Supplemental Proposal, EPA proposed criteria for capping and removing a GCCS from the entire closed landfill, or portions of an active landfill.

In the Final Rules, however, EPA only allows for removal of a GCCS from entire closed landfills, *and not non-producing areas*. In the preamble to the Final Rules, EPA states that the Agency intended to provide flexibility to landfills with declining gas production by allowing landfills to demonstrate that a GCCS cannot operate for 15 years and should be removed. *See* 81 Fed. Reg. at 59357-58 & 81 Fed. Reg. at 59302 ("EPA is retaining the requirement to operate the GCCS for 15 years, but is providing flexibility to address declining gas flows in areas where the GCCS has not operated for 15 years."). Petitioners appreciate the inclusion of this option, but note that EPA has completely failed to achieve its goal of providing flexibility to *areas* with

[11] Petitioners note that we have repeatedly requested that EPA define the term "decommission" as used in the Final Rules, but EPA has refused to do so. We again request that the Agency provide a definition for "decommission" that provides a stepdown procedure or options for suspending operation of individual collectors or portions of the GCCS system in areas with declining gas flows.

declining flows by finalizing removal criteria that only allow for GCCS removal or decommissioning in entire closed landfills.

By excluding from the Final Rules an option for decommissioning or removing a portion of a GCCS in non-producing areas, EPA has ignored Petitioners' and others' repeated concerns about declining gas production. *See e.g.*, WM 2014 Comments at 17-19; WM 2015 comments at 12-13; Small Business Advocacy Review Panel, Final Report on EPA's Planned Proposed Rules Standards of Performance for Municipal Solid Waste Landfills and Review of Emissions Guidelines for Municipal Solid Waste Landfills (July 21, 2015) (hereinafter "SBARP Final Report"). EPA has not explained why the Agency has arbitrarily limited GCCS decommissioning or removal to entire closed landfills, other than to note that such change was based on the Agency's consideration of public comments. However, Petitioners have not identified any comments in the rulemaking docket that question EPA's proposed approach to allow for removal or decommissioning of portions of a GCCS in nonproducing areas.

Without such flexibility, landfills with areas of declining gas production will face significant hardships associated with the maintenance of a GCCS in those areas, including an inability to comply with wellhead parameters in the Final Rules, risk of pulling ambient air into the GCCS and damaging the system, and significant use of fossil fuels to maintain flare operation, none of which provide any emission reduction or other environmental benefit. Petitioners request that EPA initiate a notice and comment rulemaking to allow for removal or decommissioning of GCCS in nonproducing areas of landfills, whether closed or active.

2. EPA's Definition of "Closed Area" Is Needlessly Narrow

The Final Rules allow the landfill owner/operator to use actual gas flow measurements to demonstrate that "closed areas" may be excluded from GCCS coverage because they contribute less than 1% of a landfill's total NMOC emissions. However, EPA's definition of "closed area" in the Final Rules is unnecessarily restrictive as it includes only areas that are physically separated from active portions of a landfill: Under the Final Rules, EPA has defined "closed area" to mean a:

> separately lined area of an MSW landfill in which solid waste is no longer being placed. If additional solid waste is placed in that area of the landfill, that landfill area is no longer closed. The area must be separately lined to ensure that the landfill gas does not migrate between open and closed areas.

40 C.F.R. § 60.761; 40 C.F.R. § 60.41f. Therefore, under the Final Rules, separately lined areas may be excluded from control upon a showing of less than 1% of NMOC contribution using actual flow rates. *See* 40 C.F.R. § 60.769(a)(3)(ii)(B).

EPA's decision to define "closed area" so narrowly fails to provide landfills with declining gas flow much needed flexibility, particularly in light of the stringent 34 Mg/year NMOC emission threshold in the Final Rules, and is based on the mistaken premise that physical separation is needed to prevent gas migration from closed areas. In response to the 2015 Supplemental Proposal, Petitioners urged EPA to expand its definition of "closed area" to include areas with low gas flow, even if such areas are not physically separated from active areas by means of a physical barrier. Petitioners stated that EPA's concern about gas migration from an unclosed area with a GCCS to a closed area without a GCCS was unfounded because landfill gas travels from areas of high pressure to areas of low pressure. *See e.g.* Republic 2015 EG Comments at 29 ("EPA's concern that gas could migrate from an unclosed area (with GCCS) to a closed area (without GCCS) is unfounded because landfill gas travels from areas of high pressure to areas of low pressure, not the other way around.").

In justifying its decision not to expand the definition of "closed area" in the Final Rules, EPA relies on the same unsupported assertion from the 2015 Supplemental Proposal, stating in the Response to Comments Document that:

> the EPA has retained the requirement that closed areas of open landfills must be physically separated (e.g., separately lined) . . . because [EPA] continue[s] to believe that landfill gas can migrate between areas of the landfill. As described in the [2014 Proposal], measurements might not accurately reflect actual emissions from the given landfill area because gas could be moving underground and escaping or being collected from an adjacent section of the landfill.

Response to Comments Document at 223. EPA further states that Petitioners failed to provide additional data that gas migration will not occur. *See id.* But additional data is unnecessary to confirm the laws of physics, which unquestionably dictate that gas would instead migrate from the closed area toward the open area with the GCCS, to the extent that it would move at all. EPA has not offered any data to support its unfounded assertion that gas migration will occur.

Petitioners request that EPA undertake a notice and comment rulemaking to correct the definition of "closed area" in the Final Rules to eliminate physical separation as a necessary criterion. A revised definition of "closed area" would allow nonproducing areas to take advantage of actual flow data to demonstrate that such areas contribute less than 1% of the landfill's NMOC emissions. This same definition of "closed area" should be used by EPA when revising the GCCS removal criteria to allow for removal or decommissioning of portions of a GCCS from nonproducing areas, as discussed above.

3. The Final Rules Should Allow for Surface Emission Monitoring to Support Removal or Decommissioning of a GCCS

In the 2015 Supplemental Proposal, EPA proposed to allow owners/operators to use SEM for purposes of determining when a GCCS can be removed or partially removed. 80 Fed. Reg. at 52150. Nevertheless, under the Final Rules, the Agency has not included SEM as a basis to demonstrate that site specific conditions warrant removal of GCCS or portions thereof. *See* 40 C.F.R. § 60.33f(1)(f) & 40 C.F.R. § 60.764(1)(f) (excluding SEM from GCCS removal criteria). The unavailability of SEM for GCCS removal significantly increases the burden of the Final Rules' more stringent 34 Mg/NMOC emission threshold and magnifies concerns for landfills with declining gas production. Without the option to use SEM to demonstrate that GCCS removal or decommissioning is appropriate, the 34 Mg/year NMOC emission threshold will further delay the point at which a landfill may remove controls, even when site-specific conditions would warrant removal.

EPA's decision to exclude the option of using SEM from the GCCS removal criteria in the Final Rules significantly and unnecessarily reduces the flexibility available to landfills with areas of declining gas flows and is contrary to the numerous comments submitted to EPA by diverse stakeholders. *See e.g.* WM 2015 Comments; National Association of Clean Air Agencies, Comments on 2015 Supplemental Proposal (Docket ID EPA-HQ-OAR-2003-0215-0197; EPA-HQ-OAR-2014-0451-0187) ("NACAA 2015 Comments").

The SEM criteria for GCCS removal or decommissioning presented in the 2015 Supplemental Proposal addressed key concerns raised by Petitioners for the past twelve years regarding a step-down for GCCS operations due to declining flow.[12] Many areas of landfills with declining flows struggle to maintain sufficient gas flow to operate their control systems, even under the 50 Mg/year threshold established under Subparts WWW and Cf. At the lower 34 Mg/year threshold, landfill owner/operators will need to use increasing amounts of fossil fuel to maintain flare operation, which *increases* emissions of GHG and other pollutants, a result clearly

[12] *See* Docket ID Numbers EPA-HQ-OAR-2014-0451-0037, EPA-HQ-OAR-2003-0215-100, EPA-HQ-OAR-2003-0215-017, EPA-HQ-OAR-2003-0215-0055, EPA-HQ-OAR-2003-0215-0057 and EPA-HQ-OAR-2003-0215-0058, EPA-HQ-OAR-2014-0451-0176; *see also* SWANA, Letter to JoLynn Collins, EPA Waste and Chemical Process Group (Docket ID EPA-HQ-OAR-2003-0215-003).

inconsistent with the purpose of the Final Rules. Therefore, Petitioners urge EPA to allow landfill owners and operators the option to use SEM to demonstrate that GCCS removal is appropriate.

EPA's only explanation for removing such necessary flexibility from the Final Rules is that several commenters objected to the use of SEM for GCCS removal demonstrations. *See* 81 Fed. Reg. at 59357. However, the Agency ignored the majority of comments that supported the use of SEM for GCCS removal demonstrations, including comments submitted by the National Association of Clean Air Agencies ("NACAA"), a national, non-partisan, association of air pollution control agencies in 40 states, the District of Columbia, four U.S. territories and 116 metropolitan areas with air quality professionals. *See generally* NACAA 2015 Comments. In fact, of the over 200 comments in the combined dockets for the Final Rules, less than a handful of commenters explicitly raised concerns with the use of SEM for determining when a GCCS or portions of it could be capped, removed or decommissioned.

EPA has not explained why the Agency relied on comments from so few entities to justify removing the SEM criterion and ignored supporting comments from numerous, diverse stakeholders with substantial experience implementing EPA's CAA Section 111 rules. Accordingly, Petitioners request that EPA initiate a rulemaking to revise the Final Rules to allow for SEM for purposes of demonstrating the appropriateness of GCCS removal and decommissioning, based on site-specific conditions.

D. EPA Should Adopt a Clear Definition of Cover Penetrations

In its 2014 Proposal, EPA sought to "clarify" that "all cover penetrations must be checked during quarterly surface monitoring." 79 Fed. Reg. at 41804. However, that proposal actually represented a significant change to current requirements, as noted by several commenters. *See e.g.* Republic 2015 EG Comments at 5-7; WM 2015 Comments at 25-27.

Whereas Subparts WWW and Cc only require monitoring "where visual observations indicate elevated concentrations of landfill gas, *such as* distressed vegetation and cracks or seeps in the cover," the Final Rules add to the end of that provision "*and all cover penetrations*." *Compare* 40 C.F.R. § 60.753(d) *with* 40 C.F.R. § 60.763(d). The Final Rules also state that an owner/operator "must monitor *any openings*." *Id.*

With the addition of the phrase "and all cover penetrations," EPA has shifted the focus away from "visual observations [of] elevated concentrations of landfill gas" (with cracks and seeps as just examples), to a different focus on cover penetrations, regardless of whether such penetrations exhibit any visible signs of landfill gas. Given that very few cover penetrations do exhibit visual signs of elevated concentrations, the effect of EPA's change forces landfill owners and operators to monitor "all cover penetrations" instead of only monitoring where visual observations suggest that monitoring is warranted. Thus, EPA has fundamentally altered the surface monitoring requirement. Far more than a mere "clarification" of existing requirements, EPA's "all cover penetrations" provision is entirely new and potentially burdensome, and commenters opposed it.

But perhaps the most disconcerting aspect of this new requirement is the lack of any clear definition of the "cover penetrations" that all landfills must now monitor. Although EPA's new provision certainly expands the monitoring requirement far beyond its previous scope, the lack of a definition of "cover penetration" leaves uncertain the full scope of this new requirement. Taken literally, the requirement to monitor "all cover penetrations" could be interpreted to require landfills to monitor every single stake in the ground, including every fence and sign post, of which most landfills have thousands. Furthermore, EPA's use of the term "any openings" is an ambiguous extra term that adds further confusion to EPA's intended meaning of "cover penetrations." In addition to providing a definition of "cover penetrations," the Agency must remove the reference to "any openings" in the Final Rules to avoid creating undue confusion.

EPA has recognized that a completely literal interpretation of "cover penetrations" was not intended. Specifically, EPA noted in the preambles to the Final Rules that "[c]over penetrations include wellheads, but do not include items such as survey stakes, fencing or litter fencing, flags, signs, trees, and utility poles." 81 Fed. Reg. at 59288. EPA also confirmed more broadly in the Response to Comments Document that "cover penetrations" is only intended to include "component[s] of the GCCS system or leachate collection and control system that completely passes through the landfill cover into waste, such as wellheads, leachate risers, and manholes." Response to Comments Document at 745. This more limited definition of "cover penetrations" is logical—a "cover penetration" should not present a significant emissions concern if it does not reach the waste mass, and most do not, so only those deep enough to reach waste warrant monitoring.

Although EPA's clarification in the preambles to the Final Rules is helpful and appreciated, Petitioners are concerned that some risk of confusion remains without a codified definition of "cover penetrations." Therefore, Petitioners respectfully request that EPA convene a rulemaking proceeding to adopt a clear definition of "cover penetrations" into the regulatory text to codify the guidance that EPA has provided in its preambles.

IV. Petition for Reconsideration

Pursuant to Section 307(d)(7)(B) of the CAA, EPA "shall convene a proceeding for reconsideration of [a] rule and provide the same procedural rights as would have been afforded had this information been available at the time the rule was proposed" so long as the party seeking reconsideration can demonstrate: (1) "that it was impracticable to raise such objection" during the public comment period or that "the grounds for such objection arose after the period for public comment (but within the time specified for judicial review)"; and (2) "such objection is of central relevance to the outcome of the rule." 42 U.S.C. § 7607(d)(7)(B). An objection "is of central relevance to the outcome of [a] rule" when that objection "provides substantial support for the argument that the regulation should be revised." *Coalition for Responsible Regulation, Inc. v. EPA*, 684 F.3d 102, 125 (D.C. Cir. 2012). EPA's Final Rules present several issues that meet these two criteria. As set forth herein, several aspects of the Final Rules were added after proposal, which fundamentally change the considerations addressed by commenters at proposal and significantly increase the compliance burden and overall impact of the Final Rules. Therefore, EPA must convene a reconsideration proceeding on the issues identified in this Section IV.

In addition, EPA's Final Rules are unlawful because EPA failed to provide adequate notice of many critical aspects of them. The United States Court of Appeals for the District of Columbia ("D.C. Circuit") has held that lack of notice claims are subject to the CAA reconsideration process, and so Petitioners raise those claims here as well. *See EME Homer City v. EPA*, 795 F.3d 118, 137 (D.C. Cir. 2015). With regard to the notice that EPA is required to provide in promulgating CAA rules, the D.C. Circuit has consistently held that EPA does not satisfy the Act's notice and comment requirement when the final rule is not the "logical outgrowth" of the proposed rule. *See e.g. Envtl. Integrity Project v. EPA*, 425 F.3d 992, 996 (D.C. Cir. 2005); *Northeast Maryland Waste Disposal Authority v. EPA*, 358 F.3d 936, 951-52 (D.C. Cir. 2004). A requirement in a final rule is the logical outgrowth of a proposed rule only if "interested parties should have anticipated that the change was possible, and thus reasonably should have filed their comments on the subject during the notice-and-comment period." *Northeast Maryland Waste Disposal Authority*, 358 F.3d at 952. The "logical outgrowth doctrine does not extend to a final rule that finds no roots in the agency's proposal because something is not a logical outgrowth of nothing." *Envtl. Integrity Project*, 425 F.3d at 996. EPA's Final Rules fails to meet the D.C. Circuit's standard for adequate notice, and thus should be reconsidered for that reason, as well as the substantive issues explained in more detail below.

A. Tier 4

The Tier 4 provisions of the Final Rules provide an alternative for determining when a landfill must install a GCCS after it has exceeded the NMOC emission threshold of 34 Mg/year based on modeled emissions. The Tier 4 methodology is based on a demonstration that site-specific surface methane emissions remain below 500 ppm, and thereby justify postponing the requirement to install a GCCS. Although the Tier 4 methodology was generally included in the Proposed Rules, the Final Rules include certain critical elements of Tier 4 that were not subject to notice and comment, are of central relevance to the Final Rules, and must be subject to reconsideration.[13]

At proposal, EPA characterized the Tier 4 methodology as a "flexibility" that could allow a landfill to potentially mitigate the impacts of the new 34 Mg/year NMOC emission threshold if site-specific conditions allowed, while at the same time encouraging early adoption of emission reduction strategies and best management practices such as oxidative cover practices and early gas collection or control to minimize surface emissions. *See e.g.* 80 Fed. Reg. at 52115-16 & 80 Fed. Reg. at 52127-28. EPA further described Tier 4 as the result of EPA's outreach to small entities who were concerned with their ability to comply with the lower NMOC emission threshold. *See* 80 Fed. Reg. at 52128.

[13] Certain aspects of the Tier 4 issues identified in Section IV.A.3, below, were subject to public comment. Nevertheless, such issues add to the burden associated with EPA's approach to Tier 4 in the Final Rules and significantly reduce the method's intended flexibility. As a result, Petitioners request that EPA address such issues in conjunction with a reconsideration proceeding on the other Tier 4 issues identified in this section.

Many stakeholders including Petitioners, the Small Business Administration, state agencies, and environmental groups submitted comments in favor of Tier 4. Commenters agreed with EPA's analysis that a workable Tier 4 option would incentivize early adoption of methane reduction practices like alternative covers and early installation of collection and control equipment.[14] However, the changes to the Tier 4 methodology that are discussed herein have resulted in a method that is fundamentally different and more burdensome than the proposed Tier 4 that was broadly supported by diverse stakeholders. Such changes permanently alter the availability and utility of Tier 4, thereby removing much of EPA's intended flexibility from the Final Rules and providing no incentives to drive early emission reductions, which undermines the Agency's purpose in developing Tier 4 in the first instance.

At proposal, Tier 4 was available to any landfill with NMOC emission rates above 34 Mg/year. *See* 80 Fed. Reg. at 52148, 52152. In the Final Rules, however, EPA for the first time restricted the use of Tier 4 to landfills with modeled NMOC emission rates between 34 and 50 Mg/year using Tiers 1 or 2. *See* 40 C.F.R. 60.764(a)(6) & 40 C.F.R. 60.35f(a)(6); *see also* 81 Fed. Reg. at 59355 (describing 50 Mg/year cap on Tier 4 methodology as "change" to proposed Tier 4). EPA also introduced in the Final Rules a requirement that when average wind speeds exceed 4 mph and wind gusts exceed 10 mph, landfills must use undemonstrated wind barrier technology when conducting Tier 4 SEM. 40 C.F.R. § 60.764(a)(6)(iii)(A); 40 C.F.R. § 60.35f(a)(6)(iii)(A). In order to determine whether a wind barrier is required during a Tier 4 sampling event, the Final Rules mandate that a landfill must measure wind speeds with an anemometer. *Id.* EPA has also imposed burdensome notification requirements for Tier 4

[14] *See e.g.* Environmental Defense Fund, Comments on 2015 Supplemental Proposal, Docket ID EPA-HQ-OAR-2003-0215-0204 & EPA-HQ-OAR-2014-0451-0181; NACAA 2015 Comments; U.S. Small Business Administration's Office of Advocacy, Comments on 2015 Supplemental Proposal, Docket ID EPA-HQ-OAR-2003-0215-0187 & EPA-HQ-OAR-2014-0451-0155; WM 2015 Comments.

monitoring based on weather-related cancellation events, which require landfill owners and operators to notify EPA or the relevant state administrator no later than 48 hours before a scheduled Tier 4 monitoring event if such event needs to be postponed due to weather conditions. *See* 40 C.F.R. § 60.767(l); 40 C.F.R. § 60.738(m). These aspects of Tier 4 were not subject to public comment and, as set forth herein, have fundamentally changed the nature of the proposed Tier 4, making the method unrecognizable from that which EPA proposed and industrial, environmental, and governmental commenters favored.

1. Tier 4 Should Not Be Limited to Landfills With Modeled NMOC Emission Rates Between 34-50 Mg/year

The proposed Tier 4 would have been available to all "landfills that exceed modeled NMOC emission rates using Tiers 1, 2, or 3" as a way "to demonstrate that site-specific surface methane emissions are low." 80 Fed. Reg. at 52102. A landfill that could demonstrate that surface emissions are "below 500 parts per million (ppm) for 4 consecutive quarters would not trigger the requirement to install a GCCS even if Tier 1, 2, or 3 calculations indicate that the 34 Mg/yr threshold has been exceeded." 80 Fed. Reg. at 52102. Under the Final Rules, however, Tier 4 is limited to sites with modeled NMOC emission rates between 34 and 50 Mg/year using Tiers 1 or 2. *See* 40 C.F.R. §§ 60.764(a)(6) and 40 C.F.R. 60.35f(a)(6).

EPA seeks to justify the limitation of Tier 4 to sites with modeled NMOC emission rates between 34 and 50 Mg/year by arguing that the limitation was necessary to "avoid[] a potential conflict between what is required under [the Final Rules] and what is required by [the Landfill NESHAP]." 81 Fed. Reg. at 59355 & 81 Fed. Reg. at 59298-99. EPA's rationale for restricting Tier 4 to landfills with modeled NMOC emissions between 34 and 50 Mg/year because of a potential conflict with the Landfill NESHAP is not a compelling justification; it is not based on a well-supported technical rationale, and is instead based only on the Agency's half-hearted attempt to ensure that its own regulations can be applied in harmony. As set forth in Section III above, EPA failed to address the inconsistency between the Landfill NESHAP and the Final Rules, and in the case of Tier 4, simply altered its applicability criteria in a manner that fails to fully address that inconsistency.

Limiting Tier 4 to sites between 34 and 50 Mg/year will adversely affect a substantial number of landfills subject to the Final Rules. EPA has identified only 105 (12 Subpart XXX sites and 93 Subpart Cf sites) of the total 1142 combined sites that will be subject to either Subpart XXX or Cf that are expected to have NMOC emissions between 34 and 50 Mg/year at up through 2025. This total is less than 10% of all sites affected by the Final Rules. *See* 81 Fed. Reg. at 59362 (Table 2) and 81 Fed. Reg. at 59305 (Table 2). WM, for instance, has identified only seven existing landfills with modeled NMOC emission rates between 34 and 50 Mg/year using Tiers 1 and/or 2, and which would be eligible to use Tier 4. WM has identified an additional seven sites with modeled NMOC emission rates currently below 34 Mg/year using Tiers 1 and/or 2, which WM anticipates will exceed the 34 Mg/year NMOC emission threshold in the next few years. Such landfills may be eligible to use Tier 4 if their modeled NMOC emission rates do not exceed 50 Mg/year. At all other WM landfills, Tier 4 would be unavailable regardless of the site-specific surface methane emissions at those sites. This is an inequitable result and conflicts with the intended purpose of Tier 4 to provide flexibility and encourage the early adoption of emission reduction strategies.

2. New Wind-Related Restrictions On Tier 4 Monitoring Are Unsupported

EPA proposed to limit the use of Tier 4 when the average wind speed exceeds 5 miles per hour and the instantaneous wind speed exceeds 10 miles per hour. *See* 80 Fed. Reg. at 52135-36. The Petitioners, among other commenters, submitted comments urging EPA not to finalize the proposed wind-speed restrictions, which Petitioners identified as unsupported by the available science and unduly restrictive. *See e.g.* WM 2015 Comments at 15-16. Neither Petitioners nor any other commenters submitted comment on use of a wind barrier as an alternative to the wind-speed restrictions because there was no indication in any of EPA's proposals that would suggest wind barriers were under consideration. Nevertheless, in the Final Rules, EPA replaced the proposed wind restriction with a requirement to use a wind barrier whenever "average wind speed exceeds 4 miles per hour or 2 meters per second or gust exceeding 10 miles per hour." 40 C.F.R. §§ 60.764 (a)(6)(iii)(A) & 40 C.F.R. 60.35f(a)(6)(iii)(A). EPA must reconsider use of the wind barrier and related obligations because EPA has failed to support the wind-speed restrictions with required and relevant analysis, has not undertaken to demonstrate that wind-barrier technology is available to be implemented at subject landfills, and has greatly underestimated the increased burden such requirements will impose on sites with low site-specific surface emission rates.

a. Lack of Scientific Basis for Wind-Speed Restrictions

In the Final Rules, EPA fails to provide a justifiable rationale for the need for wind speed restrictions and to explain why the Agency decided to lower the average permissible wind speed for conducting Tier 4 monitoring from 5 mph to 4 mph. In fact, EPA's only discussion of average permissible wind speed is borrowed from the 2015 Supplemental Proposal, in which EPA notes that the Agency included the wind speed restrictions in the Final Rules "because air movement can affect whether the monitor is accurately reading the methane concentration during surface monitoring." 81 Fed. Reg. at 59356; 81 Fed. Reg. at 59298. EPA's conclusory statement regarding the impacts of air movement on SEM is not supported and thus provides insufficient justification for lowering the Tier 4 wind speed restrictions and requiring use of wind barriers. Although EPA states that the Agency has "concerns about whether monitors could accurately read methane concentrations or provide representative results" in windy conditions, EPA fails to provide quantitative information to confirm that the accuracy and representativeness of SEM results are compromised in windy conditions. *Id.* The closest the Agency comes to providing a technical rationale is found in EPA's responses to interagency comments in which EPA attempts to justify the wind speed restrictions by referring to best practices guidance for the Agency's leak detection and repair regulations ("LDAR") and by providing a graphic from a non-peer-reviewed web blog purporting to show a relationship between measured carbon dioxide and wind speeds. *See* EO 12866 OMB correspondence on NSPS and Emission Guidelines Reviews for MSW Landfills (EPA-HQ-OAR-2003-0215-0238), pages 1513-1514 out of 3499 (hereinafter "Interagency Response to Comments Document"). These inappropriate comparisons do not justify the wind speed restrictions in the Final Rules as they are not related to SEM at landfills and EPA has not attempted to explain how they support such restrictions.

In addition to the Agency's failure to develop evidence demonstrating the need for wind restrictions on Tier 4 monitoring, EPA's assumptions about the impacts of wind speed on SEM results is misplaced. The Final Rules require probe placement during a Tier 4 monitoring event at no more than 5 cm (2 inches) above the landfill surface, thereby making it unlikely that wind or turbulence would interfere with the monitoring device. First, there is likely to be vegetation in landfill areas that would implement Tier 4 monitoring.[15] Given the tendency for herbaceous vegetation to act as a wind barrier, increasing friction and reducing turbulence, the monitoring device would be shielded when placed as required at 5 cm (2 inches) above the surface. Second,

[15] *See generally* Daniel P. Duffy, *Layer Upon Layer – Landfill covers come in many types and configurations*, Forester Daily News (Oct. 27, 2013) (available at http://foresternetwork.com/daily/waste/layer-upon-layer/); The Interstate Technology & Regulatory Council – Alternative Landfill Technologies Team, *Technical and Regulatory Guidance for Design, Installation, and Monitoring of Alternative Final Landfill Covers* (Dec. 2003) (available at http://www.itrcweb.org/GuidanceDocuments/ALT-2.pdf); Assal Edwar Haddad, *Use of Vegetative Mulch As Daily And Intermediate Landfill Cover* (2011) (Doctoral Thesis) (available at http://stars.library.ucf.edu/cgi/viewcontent.cgi?article=3042&context=etd).

wind speeds are typically stronger at higher altitudes and weaker closer to the surface because structures, trees, vegetation and other items create barriers that slow down the wind. The fact that wind speeds increase at higher altitudes also calls into question the utility of using an anemometer that is 10 meters above the ground, as it is unlikely that wind speeds at 10 meters above the ground would provide relevant data for surface measurements. Further, the installation of a single anemometer at each landfill (many of which encompass hundreds of acres) is unlikely to be representative of wind speeds across the entire landfill, given differences in topography, and the influence of surrounding forests, fields, and physical structures.

b. Wind-Speed Restrictions Are Unduly Burdensome

In addition to failing to articulate a justifiable basis to impose wind speed restrictions on Tier 4 monitoring, EPA severely underestimates the impacts such restrictions will have on the regulated community. An analysis of wind speed data for 292 cities provides data on average annual wind speed and seasonal (or quarterly) wind speeds across the United States.[16] Los Angeles is the only city in the data set that has an average wind speed under 4 mph for all four quarters of the year. Put another way, 291 cities (or more than 99% of cities in the dataset) have average seasonal wind speeds consistently above 4 mph and would therefore be required to use a wind barrier in order to conduct Tier 4 monitoring. This analysis is consistent with the memorandum by Eastern Research Group ("ERG") on the California Landfill Methane Rule ("CA LMR"), which concludes that 72% of landfills could not comply with the CA LMR's 5 mph wind speed restriction for surface monitoring and required a permanent alternative compliance option. *See* ERG, *Analysis of Surface Exceedances from California Landfills under the New Source Performance Standards and the California Landfill Methane Rule*, 4 (July 2015)

[16] WeatherDB, "Find Average Wind Speed across the US, accessed on October 11, 2016, https://wind-speed.weather.db.com

(Docket ID EPA-HQ-OAR-2003-0215-0233). Thus, it is clear that EPA's establishment of a wind speed restriction of 4 mph will require the use of a wind barrier by almost any landfill owner/operator who intends to implement Tier 4 to demonstrate that site-specific methane surface emissions are below 500 ppm.

This profound impact is compounded by the fact that EPA has not developed a consistent methodological approach to the use of wind barriers. Although almost every landfill that uses Tier 4 will be required to employ wind barrier technology, EPA has provided no direction on how to implement the wind barrier requirement in a consistent manner across the United States. EPA has indicated that the Agency intends to provide guidance on this topic, but as of yet has failed to take required actions to ensure that this approach can be properly implemented by the regulated community. *See* 81 Fed. Reg. at 59342 and 81 Fed. Reg. at 59291 ("Although we are aware of the use of wind barriers in the field, the EPA intends to provide additional guidance on their use."). As an example of an aspect of Tier 4 that may prove unworkable in practice, Petitioners note that the requirement to place the sampling probe "no more than 5cm above the landfill surface" as based on "a mechanical device such as with a wheel on a pole" may be infeasible. 40 C.F.R. § 60.764(a)(6)(iii); 40 C.F.R. § 60.35f(a)(6)(iii). Landfills tend to have uneven surfaces covered by vegetation and other obstacles. EPA also states that the wind barrier must surround the surface emission monitor and must be placed "on the ground" to ensure that wind turbulence is blocked. *See* 81 Fed. Reg. at 59373; 81 Fed. Reg. at 59317. Petitioners are not aware of any wind barrier capable of being placed on the ground that would not also prohibit the required probe placement at no more than 5cm above the landfill surface. Petitioners also note that EPA has not demonstrated that the wind barrier is compatible with Section 8.3.1 of Method 21, which the Final Rules require Petitioners to follow to meet the Tier 4 requirements.

See 40 C.F.R. § 60.764(a)(6)(iii); 40 C.F.R. § 60.35f(a)(6)(iii). Furthermore, Petitioners believe that use of a mechanical device on a wheel would result in the wind barrier breaking away from the monitoring setup, or damaging the analyzer probe. These concerns underscore the fact that EPA should have developed a consistent methodological approach to the use of wind barriers and demonstrated the feasibility of Tier 4 before finalizing the Final Rules.

EPA has also not provided a single piece of evidence in the Final Rules or related dockets substantiating that wind barriers will work reliably at a majority of landfills. EPA purports to have included the wind barrier requirement to allow landfills to conduct Tier 4 monitoring in windy conditions. However, the Agency has not demonstrated that the use of such barriers will provide for consistent and reliable SEM results.

EPA's 48-hour cancellation requirement is an added burden, requiring the landfill owner/operator to rely on a weather forecast 48 or more hours in advance of a planned Tier 4 monitoring event to determine if it should be cancelled due to weather conditions. 40 C.F.R. § 60.767(l)(2); 40 C.F.R. § 60.38f(m)(2). The notification requirement that EPA has inserted in the Final Rule ignores the reality that weather forecasts change often and significantly. Instead of making a timely determination whether to proceed with Tier 4 monitoring on a given day, an owner/operator may be forced to make a decision to cancel Tier 4 monitoring events two or more days before the event, simply to avoid making a weather-related cancellation less than 48 hours before the scheduled date due. Landfill owners and operators cannot be expected to predict the weather and must be given the flexibility to assess changing weather conditions prior to monitoring. But the current approach makes it significantly more likely that Tier 4 monitoring events will be delayed frequently due to uncertainty about weather conditions, thereby complicating the coordination efforts necessary to use Tier 4, increasing the compliance burden and potentially leading to missed quarterly monitoring events.

For all of the foregoing reasons, Petitioners request that EPA reconsider the following aspects of the Final Rules: (1) the limitation on the use of Tier 4 to landfills with modeled NMOC emission rates between 34 and 50 Mg/year; and (2) the Tier 4 wind speed restrictions and associated wind barrier requirement because these changes have altered the fundamental nature of Tier 4 in a manner that Petitioners could not have foreseen.

3. Other Tier 4 Issues

In addition to the issues previously discussed in this section, Petitioners have identified a number of other issues in the Tier 4 provisions of the Final Rules that were subject to public comment, but that EPA has failed to address and that further limit the flexibility the Agency intended to provide to landfills through the inclusion of Tier 4. We request that the Agency consider the following aspects of Tier 4 in conjunction with the reconsideration proceeding requested above.

a. Tier 4 Monitoring Procedures Should Include Corrective Action

The Final Rules do not provide a corrective action period for Tier 4 monitoring exceedances, thereby rendering Tier 4 unworkable and undercutting EPA's stated intention of encouraging the early adoption of alternative control techniques. In their comments, Petitioners urged EPA to include a single, 10-day corrective action period for each exceedance of the 500 ppm methane emission threshold. Petitioners stated that without a single, 10-day corrective action opportunity, Tier 4 would be less effective as a good predictor of the appropriate timing for GCCS installation, and that landfill owner/operators will be less likely to use Tier 4 if a single exceedance results in the obligation to install a GCCS. *See e.g.* NWRA & SWANA 2015 Comments at 18; WM 2015 Comments at 14-15.

Numerous states and the Small Business Advocacy Review Panel agreed with Petitioners' comments about the need for a corrective action concept to accompany Tier 4. Specifically, the Small Business Advocacy Review Panel concluded in its report on the proposed Final Rules that "Tier 4 should allow for corrective action when surface emissions above 500 [ppm] are identified, consistent with corrective action provisions for quarterly surface monitoring. Without corrective action allowances, the usefulness of Tier 4 is limited." SBARP Final Report at 7-8.

EPA has not stated a justifiable rationale for its decision to exclude from the Final Rules a 10-day corrective action period for Tier 4 exceedances. Instead, EPA explains its action with the unsubstantiated claim that a single exceedance of the "500 ppm threshold . . . would be indicative of higher emissions than would normally be expected at a landfill" and that "landfill conditions warrant installation of a GCCS." 81 Fed. Reg. at 59355. In the Agency's Response to Comments Document, EPA further explains that it is "not allowing for corrective action as part of the Tier 4 demonstration to ensure that landfills employ operational practices that minimize emissions." Response to Comments Document at 564. Such statements are simply incorrect; a single surface emission exceedance that can be corrected is most likely an indication of a localized anomaly in cover or other site-specific factors and *not relevant* to a general conclusion as to overall levels of surface emissions throughout a landfill.

EPA's explanation fails to recognize that the lack of a corrective action concept in Tier 4 will render Tier 4 impracticable to use, and will discourage the adoption of early emission reduction strategies such as oxidative covers and early gas collection and control.

Thus, EPA must revise Tier 4 to allow for a single, 10-day corrective action period prior to requiring a landfill to begin the process of installing a GCCS.

b. The Final Rules Should Be Clarified to Address When Landfills Are Permitted to Use Tier 4

At proposal, a landfill owner/operator would have been permitted to use Tier 4 after a demonstration with Tier 1, Tier 2, *or* Tier 3 that the landfill's NMOC emission rates are above the GCCS installation threshold. *See* 80 Fed. Reg. 52102 & 52112. Under the Final Rules, however, it is unclear what emissions modeling method a landfill owner/operator must use before it may implement Tier 4 monitoring. For example, in the test methods and procedures section of the Final Rules, "Tier 4 is allowed only if the landfill owner or operator can demonstrate that NMOC emissions are greater than or equal to 34 Mg/yr but less than 50 Mg/yr using Tier 1 *or* Tier 2," suggesting that a landfill need not conduct both Tier 1 *and* Tier 2 before moving on to Tier 4, and that Tier 3 measurements are not relevant to Tier 4 implementation. 40 C.F.R. § 60.764(a)(6); 40 C.F.R. § 60.35f(a)(6). Another provision in the Final Rules, however, states that landfill owners and operators may use Tier 4 if Tier 1, Tier 2, *or* Tier 3 show a calculated NMOC emission rate between 34 and 50 Mg/year. *See* 40 C.F.R. § 60.762(b)(2) & 40 C.F.R. § 60.33f(e)(2). Adding further to the confusion, the Final Rules state that the annual Tier 4 surface emission report must include, *inter alia*, "the results of the most recent Tier 1 *and* Tier 2 results in order to verify that the landfill does not exceed 50 Mg/yr of NMOC." [17] 40 C.F.R.

[17] This provision in the Final Rules may suggest that a landfill will conduct yearly Tier 1 and Tier 2 measurements to verify that estimated NMOC emissions continue to remain between 34 and 50 Mg/year, the results of which must be included in the annual Tier 4 surface emission reports. Landfill owners and operators must not be expected to conduct annual Tier 1 and Tier 2 monitoring after a landfill has begun implementing Tier 4. A requirement to conduct annual Tier 1 and Tier 2 testing would be inconsistent with the use of Tier 4, which more accurately accounts for emissions by measuring site-specific surface methane concentrations. Furthermore, EPA has not considered the costs that would be associated with an annual obligation to conduct Tier 1 and Tier 2 tests after moving on to Tier 4. Thus, EPA must clarify that landfills using Tier 4 need not conduct annual Tier 1 and Tier 2 tests. EPA must further clarify that only the initial Tier 4 surface emission report must include the results of any Tier 1 or Tier 2 test.

§ 60.767(c)(4)(iii); 40 C.F.R. § 60.38f(d)(4)(iii). EPA must revise the Final Rules to clarify for landfill owners and operators exactly what methods a landfill must perform prior to implementing Tier 4 monitoring.

c. The Final Rules Should Be Clarified to Address the Timing of GCCS Installation and Operation for Sources Using Tier 4

Under the Final Rules, landfills meeting the rules' design capacity thresholds are required to submit a GCCS design plan within one year of the first NMOC emission rate report in which the modeled NMOC emission rate exceeds 34 Mg/year using Tiers 1, 2, or 3, and to install and operate a GCCS within 30 months of the first NMOC emission rate report in which the modeled NMOC emission rate exceeds 34 Mg/year using Tiers 1, 2, or 3. *See* 40 C.F.R. §§ 60.762(b)(2) & 767(c); 40 C.F.R. §§ 60.33f(b)(1) & (e)(2), 38f(d). However, a landfill using Tier 4 must submit a GCCS design plan within one year of the first measured concentration of methane of 500 parts per million or greater from the surface of the landfill, and must install and operate a GCCS within 30 months of the most recent NMOC emission rate report in which the NMOC emission rate equals or exceeds 34 Mg/year based on Tier 2. 40 C.F.R. § 60.764(a)(6); 40 C.F.R. § 60.35f(a)(6). By linking GCCS installation and operation for sources using Tier 4 to the Tier 2 NMOC emission rate report rather than the triggering surface methane exceedance under Tier 4, EPA has reduced the amount of time a Tier 4 source has to install and operate a GCCS.

Under this framework, sources using Tier 4 will have less than 30 months – in some cases significantly less – to install and operate a GCCS. A landfill using Tier 4 will necessarily measure a surface methane emission exceedance *after* submitting its "most recent" NMOC emission report. For example, a landfill may measure a surface methane exceedance nearly 12 months after submittal of an NMOC report, but before a new NMOC emission report is due.

Under this scenario, that Tier 4 source would only have around 18 months to install and operate a GCCS. Clearly EPA could not have intended this inequitable situation for Tier 4 sources, which further reduces the incentives to use Tier 4 and adopt early emission reduction strategies. Thus, EPA must revise the Final Rules to clarify that Tier 4 sources would be required to install and operate a GCCS 30 months from the date on which a surface methane exceedance of 500 ppm is measured using Tier 4.[18]

d. The Final Rules Should Clarify the Process for Submitting Annual Tier 4 Surface Emission Report

The Final Rules state that the initial Tier 4 surface emission report "must be submitted annually, starting within 30 days of completing the fourth quarter of Tier 4 surface emissions monitoring that demonstrates that site-specific surface methane emissions are below 500 [ppm] methane." 40 C.F.R. § 60.767(c)(4)(iii) & 40 C.F.R. § 60.38f(d)(4)(iii). The Final Rules further state that in the event that Tier 4 monitoring reveals a surface exceedance of 500 ppm methane, a Tier 4 surface emissions report must be submitted "within 1 year of the first measured exceedance." *Id.* It is not clear if EPA intends this to be a separate surface emission report than the one required to be submitted annually.

Petitioners urge EPA to clarify the surface emission reporting requirements for Tier 4 sources, and recommend that EPA require the initial report to be submitted following the 4th quarter of SEM, with annual submissions thereafter. Petitioners further urge EPA to allow Tier 4 sources a minimum of 60 days to submit the initial report, instead of the 30 days currently

[18] Petitioners submitted comments to EPA urging the Agency to fix inconsistencies in the proposed Final Rules as to the timing of GCCS design plan development and installation for Tier 4 sources. In the Response to Comments Document, EPA claims to have "revised the final NSPS and Emission Guidelines to make the submittal dates clear" for Tier 4 sources. Response to Comments Document at 546. However, EPA's revisions have created additional confusion and burdens for sources choosing to use Tier 4.

included in the Final Rules. This additional time is necessary to account for the volume of information that must be included in such reports.

In addition, Petitioners believe that EPA has mistakenly included the language in the Final Rules that requires a landfill to submit a Tier 4 surface emission report within one year of a measured exceedance. Once a landfill measures surface methane concentrations above 500 ppm, Tier 4 monitoring is no longer permitted under the Final Rules, and the landfill is required to begin the process for installation and operation of a GCCS. Thus, there is no reason to submit a Tier 4 surface emission report in such a situation. Petitioners request that EPA clarify the submittal requirements for Tier 4 surface emission reports.

e. Tier 4 Recordkeeping Requirements Should Be Reduced

Under the Final Rules, landfills that employ Tier 4 must "keep for at least 5 years up-to-date, readily accessible records of all surface emissions monitoring and information related to monitoring instrument calibrations." 40 C.F.R. § 60.768(g); 40 C.F.R. § 60.39f(g). Such records must include, *inter alia*, a timestamp of "each surface scan reading . . . detailed to the nearest second, based on when the sample collection begins" and a "log for the length of time each sample was taken using a stopwatch (e.g., the time the probe was held over the area)" and the location "of each surface scan reading" showing "coordinates using an instrument with an accuracy of at least 4 meters." *Id.*

EPA has failed to articulate a basis to require such records. The obligation to maintain timestamp and location records *for all surface emission readings*, not only methane readings at or above 500 ppm, will be a significant burden. Typically, SEM is performed by a single technician. However, the timestamp and location records will increase the manpower necessary to perform SEM, increasing costs of Tier 4 and further limiting the intended flexibility the method is meant to provide to subject landfills. For example, a single technician will not be able to operate the surface monitoring device, a stopwatch, and a GPS device at the same time. Additionally, EPA has failed to demonstrate the availability of GPS devices with accuracy of four meters. Petitioners believe that the current practice of placing flags at monitoring locations is more accurate, and would not be improved upon by the use of a GPS device. EPA should streamline the recordkeeping requirements associated with Tier 4.

f. EPA Failed to Consider the Costs Associated With Tier 4

Despite the fundamental changes to Tier 4 that have been highlighted above, EPA has completely failed to consider the costs associated with Tier 4 in the Final Rules. A review of the Interagency Response to Comments Document shows that commenters urged EPA to consider the costs of Tier 4 in the Final Rules. EPA claimed that the Agency lacked necessary data and that "the cost to conduct a Tier 4 analysis is site specific depending on the acreage of each landfill opting to pursue Tier 4 monitoring. Due to all of these uncertainties the EPA has not costed out Tier 4." Interagency Response to Comments Document at 422 out of 3499. EPA further noted that it decided not to determine the costs of Tier 4 because Tier 4 is voluntary.

EPA's explanation that the Agency failed to consider costs because Tier 4 is a site-specific, voluntary methodology is unpersuasive. Given the prescriptive nature of the final Tier 4, it is not clear what EPA means when the Agency says that an analysis of Tier 4's costs would be site specific – all regulations have "site-specific" costs associated with their implementation. Furthermore, despite EPA's claims that the site-specific nature of Tier 4 makes quantifying costs too difficult, Petitioners have identified a number of factors EPA could and should have considered to determine the costs of Tier 4, including (1) capital costs for all newly required equipment; (2) costs for surveys, perhaps on a "per acre" basis; and (3) additional expenses associated with cancelled monitoring surveys due to wind-related issues, additional surface monitoring technicians, etc. EPA must account for the costs of Tier 4.

B. Liquids Addition Reporting

EPA has conceded that the Agency does not have sufficient data to impose separate standards on landfills that add liquids. *See* 81 Fed. Reg. at 59345 & 81 Fed. Reg. at 59289 ("EPA did not receive sufficient data to support a separate subcategory for landfills adding leachate or other liquids."). Nevertheless, under the Final Rules, a landfill with a design capacity of 2.5 million megagrams and 2.5 million cubic meters or more that has recirculated leachate or added liquids based on a Resource Conservation and Recovery Act ("RCRA") Research, Development, and Demonstration ("RD&D") permit within the last 10 years must prepare and submit an annual report that contains voluminous information about liquids addition practices ("Annual Liquids Addition Report"). 40 C.F.R. § 60.767(k); 40 C.F.R. § 60.38(f)(l). EPA did not introduce the concept of the Annual Liquids Addition Report until the Final Rules, thus providing no notice or opportunity to comment on the new reporting requirement.

Although EPA acknowledged in both the 2014 Proposal and 2015 Supplemental Proposal that the Agency was considering the development of alternative requirements for landfills that add liquids, EPA never proposed that such landfills would be subject to additional reporting obligations under the Final Rules in the absence of substantive compliance obligations. In the 2014 Proposal, EPA solicited comments as to whether the Agency should consider reducing the design capacity threshold and/or initial lag times for landfills located in a wet climate, or that recirculate leachate or add other liquids to the landfill. *See* 79 Fed. Reg. at 41808. EPA's solicitation of comments failed to provide clear notice of what exactly EPA was considering. In the 2015 Supplemental Proposal, EPA further solicited comment on alternative design thresholds and lag times for landfills located in wet climates or that add liquids. *See* 80 Fed. Reg. at 52137-38. At no point during the notice and comment period, however, did EPA propose an annual reporting obligation exclusively for such landfills.

Given that EPA did not provide an opportunity to comment and has acknowledged that EPA currently cannot justify separate standards for landfills that add liquids, EPA must convene a reconsideration proceeding to allow comment on this issue.

1. Annual Reporting Requirement is Unduly Burdensome

EPA appears to have based the adoption of the liquids addition reporting requirements in part on a mistaken understanding of the relative impact of the Annual Liquids Addition Report. EPA stated in the preambles to the Final Rules that "EPA believes many landfills . . . already keep [liquids addition] records and may submit reports containing quantities of liquids added. So, the effort to track these additional data is expected to be minimal." 81 Fed. Reg. at 59350; 81 Fed. Reg. at 59295. EPA is mistaken, however, as the Annual Liquids Addition Report will require Petitioners to expend significant effort that far exceeds any benefit of such report. The Annual Liquids Addition Report imposes new and extensive recordkeeping requirements that are materially different and substantially more burdensome than what is required of landfills recirculating leachate or operating bioreactor landfills pursuant to RCRA RD&D permits and Subpart HH of EPA's Mandatory Greenhouse Gas Reporting Program (40 C.F.R. Part 98).

The Annual Liquids Addition Report imposes new and extensive recordkeeping requirements in the Final Rules that are materially different than those typically required by RD&D permits. EPA estimates that approximately 30 MSW landfills operate with RD&D permits, of which WM operates five. *See* Revision to the Research Development and Demonstration Permits Rule for Municipal Solid Waste Landfills, 81 Fed. Reg. 28720-28724, 28721 (May 10, 2016) ("There are approximately 30 facilities currently operating with RD&D permits."). Thus, EPA incorrectly assumes that many landfills keep records of liquids addition pursuant to RD&D permits. Additionally, those landfills that do operate under RD&D permits are expected to provide data in a materially different manner than would be required under the

Annual Liquids Addition Report. Based on Petitioner's experience, RD&D permits typically require a moisture balance calculation that accounts for total liquids added to the waste mass including leachate recirculated, precipitation, and leachate collected. States generally require this moisture balance to be reported by landfill phase or bioreactor cell. Because liquids are typically added at the working face of the landfill or active phase, this area tends to be a moving phase over the course of a year, making it difficult to translate into a calculation of surface area and thereby determine waste in place. Thus, the Agency's assumption that many of the data elements in the Annual Liquids Addition Report are tracked as part of a leachate management or RD&D permit is false and significantly underestimates the burdens associated with converting such data to a format that is compatible with the Annual Liquids Addition Report.

In addition, pursuant to the GHG Reporting Program, MSW landfills that exceed applicability thresholds must qualitatively report to EPA if the site recirculated leachate in the past 10-year period. Specifically, 40 C.F.R. § 98.346(a) requires an owner/operator to include in a report "an indication of whether leachate recirculation is used during the reporting year and its typical frequency of use over the past 10 years (e.g., used several times a year for the past 10 years, used at least once a year for the past 10 years, used occasionally but not every year over the past 10 years, not used)." If a subject facility did recirculate leachate in the calendar reporting year, then that site must collect data on the total volume of leachate recirculated and use this volume to determine which k-value to use for the reporting year (if applicable) according to Table HH-1 of 40 C.F.R. 98 Subpart HH.[19] Sites also report the annual waste acceptance

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[19] Footnotes a and b to Table HH-1 state the following:

"[a]Recirculated leachate (in inches/year) is the total volume of leachate recirculated from company records or engineering estimates divided by the area of the portion of the landfill containing waste with appropriate unit conversions. Alternatively, landfills that use leachate recirculation can elect to use the k value of 0.057 rather than calculating the recirculated leachate rate.

rates, along with a characterization of the waste types (e.g., MSW, construction and demolition debris, and inert materials); however, Subpart HH does not require recordkeeping or reporting of volume of leachate recirculated, surface area where leachate has been recirculated over the course of a year, or quantity of waste disposed in areas of leachate recirculation, and such data cannot be readily extracted from Subpart HH reports. Further, reporting on leachate recirculation practices only commenced with the 2010 reporting year.

Given the differences between liquids reporting pursuant to RCRA RD&D Permits and the GHG Reporting Program, EPA incorrectly assumes that landfills already keep the information required by the Annual Liquids Addition Report and as a result greatly underestimates the burdens associated with such report.

2. The Final Rules Should Not Include a Reporting Obligation That is Unrelated to Any Compliance Obligation

As discussed above, EPA has acknowledged that the Agency "did not receive sufficient data to support a separate subcategory for landfills adding leachate or other liquids," and as a result decided not to adopt separate compliance requirements for landfills that add liquids. *See* 81 Fed. Reg. at 59345; 81 Fed. Reg. at 59289. Instead, EPA states in the Final Rules that "it is appropriate to further assess emissions from wet landfills prior to taking additional action." *Id.* Thus, EPA intends for the Annual Liquids Addition Reports to "inform potential action on wet landfills in the future." *Id.* EPA should not include reporting obligations that, by EPA's own acknowledgement, are unrelated to operative requirements in the Final Rules. Such obligations are arbitrary and capricious given that they bear no relationship to the rules at issue, and are unsupported by EPA's own data.

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[b]Use the lesser value when precipitation plus recirculated leachate is less than 20 inches/year. Use the greater value when precipitation plus recirculated leachate is greater than 40 inches/year. Use the average of the range of values when precipitation plus recirculated leachate is 20 to 40 inches/year (inclusive). Alternatively, landfills that use leachate recirculation can elect to use the greater value rather than calculating the recirculated leachate rate."

EPA's authority to promulgate recordkeeping and reporting requirements is limited by Section 114 of the CAA. Section 114 allows EPA to require reporting for the following purposes: (1) developing regulations under Sections 110, 111, 112, or 129 of the CAA; (2) determining if a regulated entity is in violation of a CAA rule; or (3) carrying out a provision of the Act. *See* 42 U.S.C. § 7414(a). Although EPA has stated that the Annual Liquids Addition Reporting requirements are intended to inform potential future action, the Agency has failed to articulate why additional information is needed, having already determined that the creation of a subcategory for landfills that add liquids is not warranted. During the notice and comment period, EPA requested information about landfills located in wet climates or that add liquids. Based on the information submitted by the numerous commenters, EPA was unable to form a basis to impose separate regulations on such landfills. *See* 81 Fed. Reg. at 59345; 81 Fed. Reg. at 59289. Given that fact, it is unreasonable to require landfills to submit data when EPA has no basis to presume that such data would support separate standards. Furthermore, EPA clearly acknowledges in the Final Rules that the Annual Liquids Addition Reports are unrelated to any compliance obligation in the Final Rules.

Given the absence of any compliance obligation for landfills that add liquids, the inclusion of a free-standing reporting obligation within the Final Rules serves no compliance purpose and therefore is inconsistent with the provisions of Section 111 and cannot be justified under Section 114. EPA has not explained how an on-going reporting obligation for landfills that add liquids is consistent with the regulatory development aspects of Section 114. Furthermore, the Annual Liquids Addition Report is unnecessary given EPA's efforts to comprehensively address landfills that add liquids in the Agency's forthcoming revisions to RCRA Subtitle D, Part 258.[20]

On reconsideration, EPA should remove the Annual Liquids Addition Report from the Final Rules.

C. Corrective Action Timeline Procedures

In the 2015 Supplemental Proposal EPA requested comments on the submittal of corrective action timelines. However, EPA's proposal did not include a specific schedule for submitting alternative timeline requests because EPA believed that investigating and determining the appropriate corrective action, as well as the schedule for implementing that corrective action, should be site specific and depend on the reason for exceedance. *See* 80 Fed. Reg. at 52126. In their comments, which addressed this subject, Petitioners agreed with EPA that corrective action schedules should be site specific.

However, the Final Rules contain a highly complex and prescriptive schedule for corrective action. The mandated schedule generally gives owners or operators only 60 days to investigate, determine appropriate corrective action, and implement the corrective action. If an exceedance cannot be corrected within 15 days, then a root cause analysis must be conducted within 60 days of the initial exceedance. Further, an implementation schedule is required for exceedances that will take longer than 60 days to complete the corrective action(s) as soon as practicable, but no more than 120 days. The regulatory provision that EPA adopted in the Final Rules to require this particular schedule for corrective action was not available for comment.

[20] In July 2016, EPA announced that the Agency will be requesting "information and data on the performance of wet landfills." EPA, 2016 Regulatory Agenda (available at http://www.reginfo.gov/public/do/eAgendaviewRule?pubId=201604&RIN=2050-AG86).

The original landfill rules (40 C.F.R. Subparts WWW and Cc) require the landfill owner/operator to take corrective action for exceedances on a set schedule and request alternative timelines as needed. The Final Rules, however, differ in that the schedule is far more complex and now require a root cause analysis and submission of a corrective action plan—new elements that EPA has never required previously and that were not included in any of EPA's proposals. *See* 40 C.F.R. § 60.765(a)(3)&(5); 40 C.F.R. § 60.36f (a)(3)&(5).

Rather, EPA's new complex corrective action requirements and procedure actually appear to be a response to a comment submitted by Republic, asking for an entirely different corrective action procedure, one that eliminates the approval process altogether to avoid the concerns that arise when EPA and states fail to issue their approval in a timely manner. Although Republic supported an approach that would include a root cause analysis and reporting of certain events, Republic did not support any requirement for the submission of corrective action plans for approval. *See* Republic 2015 EG Comments at 13. Thus, the corrective action requirements in the Final Rules are entirely new—the approach was never proposed by EPA or any commenter. Moreover, EPA's Final Rules do not address the primary focus of Petitioners' comments on the corrective action process—*i.e.*, Petitioners' concern that many alternative timeline requests are never approved because of a lack of agency review.

Because EPA provided no notice of its new corrective action requirements and procedure in any proposal, Petitioners could not have commented on it, and EPA's lack of notice constitutes a violation of its rulemaking requirements under the CAA. In addition, because the corrective action component is the primary compliance obligation imposed on landfills to ensure emissions are minimized through good operation of a gas collection and control system, the requirement is clearly of central relevance to the outcome of the Final Rules. Therefore, Petitioners respectfully request that EPA reconsider its new corrective action requirements and procedure to allow Petitioners and the general public an opportunity to comment on it.

As part of the reconsideration proceeding, EPA should evaluate whether preparation of a root cause analysis and submission of a corrective action plan is necessary over and above simply reporting temperature or negative pressure events, as already required under the existing provisions of Subparts WWW and Cc. The root cause and corrective action plan creates additional recordkeeping burden that should only be added if EPA can demonstrate that it will achieve meaningful air qualify benefits. Background documents in the Interagency Response to Comments Document confirm that the approach proposed by Petitioners, not the approach finalized by EPA, would provide the EPA with sufficient assurances that timely and appropriate measures are taken to avoid hazards, such as landfill fires. Conversely, EPA has not yet demonstrated that its new requirements and procedure are needed to ensure proper operation of GCCS or provide any environmental benefits.

EPA should also reevaluate the costs of its new corrective action procedures, given that the Agency failed to conduct an adequate cost analysis as part of the Final Rules. Specifically, EPA appears to have underestimated the number of root cause analyses that its new provision will require. The EPA claims it does not have enough data to estimate how many landfills would need to conduct the root cause analysis each year, but even a cursory and conservative review of data that EPA references in the Interagency Response to Comments Document suggests one exceedance per year per landfill will likely require corrective action and root cause analysis. EPA should therefore review information from the existing program to provide an expected number of reportable incidents, the number of incidents likely to be resolved within the 15 day time period, the number of incidents likely to require a root cause analysis and corrective action application, and the usual time (for State and Federal regulatory authorities separately) for approval and/or response to such application. During the reconsideration proceedings, EPA must accurately reflect the costs associated with the new corrective action procedures.

V. Petition for Administrative Stay of the Final Rules Pending Judicial Review

Petitioners respectfully request an immediate stay of the Final Rules. Pursuant to Section 705 of the APA, EPA may postpone the effective date of a regulation pending judicial review where "justice so requires." 5 U.S.C. § 705. EPA has expressly recognized that the Agency has broad authority under Section 705 of the APA to grant an administrative stay pending judicial review of a final rule that EPA has promulgated pursuant to the CAA.[21] Petitioners are simultaneously filing petitions for review of the Final Rules in the D.C. Circuit, and justice requires that the Final Rules be immediately stayed given the significant substantive and procedural flaws that have been identified in Sections III and IV of this Petition, which have rendered the Final Rules unworkable and unsupportable as presently constituted.

In considering motions to stay pursuant to APA Section 705, the D.C. Circuit considers the following four factors: (1) the likelihood that the party seeking the stay will prevail on the merits of the appeal; (2) the likelihood that the moving party will be irreparably harmed absent a stay; (3) the prospect that others will be harmed if the court grants the stay; and (4) the public interest in granting the stay. *See Cuomo v. U.S. Nuclear Regulatory Comm'n*, 772 F.2d 972, 974 (D.C. Cir. 1985). EPA must consider the same set of factors when deciding to grant a stay

[21] *See* EPA, *Industrial, Commercial, and Institutional Boilers and Process Heaters and Commercial and Industrial Solid Waste Incineration Unit – Final rules; Delay of effective dates*, 76 Fed. Reg. at 28662-28664, 28663 (May 18, 2011) ("EPA notes that it is delaying the effective date of the Major Source Boiler MACT and the CISWI Rule pursuant to the APA, rather than section 307(d)(7)(B) of the Clean Air Act. As explained above, the APA authorizes the EPA to find that justice requires postponing the effective date of a rule when litigation is pending."); see also *Sierra Club v Jackson*, 833 F. Supp. 2d 11, 24 (D.D.C. 2012) ("While the Clean Air Act establishes the process by which either EPA or a court may stay the effectiveness of a rule pending reconsideration, it does not by its terms or by logical implication limit the authority of either an agency or a court to exercise its traditional statutory authority under Section 705 of the APA to stay such rules or regulations pending judicial review.").

pursuant to APA Section 705. *Sierra Club*, 833 F. Supp. 2d at 50-51. Petitioners submit that the grounds for an administrative stay of the Final Rules pending judicial review are compelling in this instance and satisfy the statutory requirements for a stay under APA Section 705.

The Final Rules present precisely the circumstances in which an administrative stay pending judicial review is warranted given the significant regulatory uncertainty caused by the substantive and procedural errors in the Final Rules that have been discussed throughout this Petition. EPA's failure to address the overlapping applicability issues, identified in Section III.A, above, is perhaps the best example of how EPA's errors warrant an administrative stay pending juridical review. First, Petitioners are likely to prevail on the merits in challenging the Agency's unreasonable failure to address the overlapping applicability of the old subparts (WWW and Cc), the new subparts (XXX and Cf), and the Landfill NESHAP because the Final Rules are directly contrary to EPA's stated intent and contrary to CAA Section 111 definitions of "new" and "existing" sources by regulating many landfills as both. Second, Petitioners will incur irreparable harm as a direct result of the Agency's failure to resolve the overlapping applicability of the various standards because Petitioners will be forced to simultaneously comply with different and overlapping provisions from either the new or old subparts, forcing Petitioners to engage in two different sets of activities to ensure compliance with the old and new subparts. Thus, Petitioners will be forced to comply with both the old and new subparts without obtaining any benefit from the regulatory provisions that EPA intended to update and streamline with the Final Rules, and the losses that will result will not be recoverable from EPA in any legal proceeding. Third, no party will be harmed by EPA's decision to grant a stay of the Final Rules pending judicial review because Subparts WWW and Cc (and the state plans implementing Subpart Cc) will remain in effect, thereby ensuring that landfills continue to operate their GCCS and meet the other operational standards of the old subparts, many of which have been carried over into Subparts XXX and Cf. Fourth and finally, granting the stay is within the public interest because, as noted above, EPA's intention to update and streamline the applicable Section 111 standards for MSW landfills has been undercut by the Agency's failure to enact appropriate applicability provisions in the Final Rules.

For all of the forgoing reasons, Petitioners respectfully request that EPA administratively stay the Final Rules rule pending judicial review.

Respectfully submitted,

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APPENDIX A

January 22, 2016

Via Electronic Transmission: ward.hillary@epa.gov
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Re: Docket ID No. EPA-HQ-OAR-2003-0215
Docket ID No. EPA-HQ-OAR-2014-0451

Dear Hillary,

The undersigned organizations representing both private and public landfill owners and operators offer the following supplemental comments to those our organizations have already submitted. After reviewing the comments submitted in response to the U.S. Environmental Protection Agency's (EPA or Agency) Supplemental Proposal for the New Standards of Performance (NSPS) for Municipal Solid Waste (MSW) Landfills and the Proposed Emission Guidelines (EG), we thought it might be helpful to you to clarify and re-emphasize some of the key points made in our earlier comments and reiterated by state officials and other organizations. We understand that the Agency is not required to consider these supplemental comments, as the comment period has closed. Nonetheless, we hope the Agency finds this document useful, and we appreciate your consideration of our supplemental comments as you work towards finalizing the rules.

We Strongly Support EPA's Proposed Removal of the Wellhead Operating Parameters for Temperature and Oxygen/Nitrogen, while maintaining Monthly Monitoring and Recordkeeping

Our organizations are very supportive of the EPA's proposal to eliminate the wellhead parameters for temperature, oxygen/nitrogen and rely on landfill surface emissions monitoring (SEM) requirements in combination with maintenance of negative pressure at wellheads to indicate proper operation of the gas collection and control system (GCCS) and minimize surface emissions.

In our comments, we described our concerns with required wellhead parameters that are counterproductive to optimally operating our gas collection and control systems and reducing emissions. For many years, these wellhead parameters have been among the most significant barriers to earlier installation of gas collection and control measures and in some cases to adequate surface emissions and migration control. We provided numerous examples of state agency determinations as illustrative examples. (See Waste Management Comments on Proposed XXX and ANPRM for EG, September 15, 2014, pg. 24-25, NWRA-SWANA Comments, September 15, 2014, pg. 7-8)

Our nearly two decades of experience implementing Subparts WWW and Cc has demonstrated that the temperature and oxygen/nitrogen parameters are poor indicators of landfill fires or inhibited waste decomposition. To comply with the arbitrary temperature and/or oxygen parameters, sites must often reduce landfill gas (LFG) flow to the affected well, thereby decreasing system performance and increasing potential emissions. Conforming to the wellhead operating parameters imposes significant administrative burdens on both regulatory agencies and the regulated community.

In reviewing the comments received by the Agency, we noted that the National Association of Clean Air Agencies (NACAA), which represents air pollution control agencies in 40 states, DC, four territories and 116 metropolitan areas, also supported eliminating the temperature and oxygen/nitrogen parameters. Additionally, the majority of state agencies and public organizations submitting separate comments including Colorado, Delaware, Georgia, Minnesota, Ohio, four Wisconsin county agencies, and the U.S. Small Business Administration (SBA) all supported eliminating the wellhead parameters for temperature and oxygen/nitrogen.

Several states were silent regarding the EPA's proposal, but strongly supported continued monitoring and recordkeeping of temperature and oxygen/nitrogen data. We also support continued monitoring and recordkeeping for those parameters. Several state commenters raised concerns they would no longer know if a landfill fire occurred; however, the rule requires landfills to report instances when positive pressure occurs in the wells and gas extraction system to avoid a fire. We also believe the Agency could alleviate some state agency concerns by requiring that the monitoring records be kept onsite and available for inspection, and that information suggested by NACAA and the State of Delaware (reporting of oxygen values exceeding 5% and temperature exceedances of 130 degrees F) be included in the facilities' semi-annual reports for informational purposes.

We Support EPA's Proposal with Recommended Amendments to use Tier 4 as an Alternative Approach to Determine when a Landfill must Install and Operate a GCCS, and when a Landfill can Cap or Remove GCCS due to Declining Flow

We strongly support the Agency's proposed use of Tier 4 as an alternative, site-specific emission measurement to determine the appropriate timing for installing and operating a GCCS. We believe that a SEM option will enhance decision-making regarding the timing and approach for controlling landfill gas emissions, and will incentivize sites to implement methane reduction practices as quickly as possible. EPA's proposal to allow use of Tier 4 SEM for landfills looking to cap or remove GCCS due to declining flow is also a welcome approach.

Providing landfill sites with the option to conduct a Tier 4 will more accurately identify changes in gas generation attributable to climate differences, waste age and composition, and other factors and avoids a "one-size-fits-all" with respect to when gas collection is warranted. This will be even more important into the future as we see greater diversion of organics from landfills. In addition, we expect use of a measurement-based approach, as opposed to modeling, will provide a more reliable assessment of emission fluxes, which is particularly important in cases where the results of the available models appear flawed.

All of the undersigned organizations recommended that the Agency's Tier 4 approach be modified to allow for a single, ten-day corrective action period to remedy each exceedance of the 500 part per million (ppm) threshold detected during a Tier 4 monitoring event.

We also urged EPA to delete the specific wind speed criteria and maintain the current Subpart WWW surface monitoring provisions for the performance of Tier 4 (i.e., "typical meteorological conditions").

The comments from states and other public organizations overwhelmingly supported the proposed Tier 4 to determine the appropriate timing for installation and removal of GCCS. The public entities included NAACA, and the States of Delaware, Iowa, Kentucky, New Mexico, Ohio, Oklahoma and

Pennsylvania, the Palm Beach Solid Waste Authority, four counties in Wisconsin, the Texas SWANA chapter and the SBA. The Environmental Defense Fund also commented in support of Tier 4, although they recommended a lower threshold than EPA proposed. The public organizations all supported the EPA proposed threshold of 500 ppm, and elimination of the wind speed limit on use of Tier 4. NACAA and the state and local government commenters discussed the potential implementation barrier the wind speed requirement would pose for using Tier 4. The vast majority of the public organizations, including NACAA also commented in favor of EPA including a brief, one-time corrective action period (e.g., ten-day) to remedy exceedances that can be addressed with simple corrections to landfill cover, or adjustments of the existing GCCS.

We Strongly Support EPA's Proposed Subcategory for Closed Landfills

The undersigned organizations continue to support the proposed subcategory for closed landfills and the proposed expansion of the subcategory to include landfills that close (cease accepting waste) within 13 months after publication of the final EG rules in the Federal Register. It is critical that landfill owners that are planning to cease accepting waste have the necessary time to meet all of the criteria and submit the necessary documentation for a "closed landfill" designation. Closed landfills that are required to control emissions under the existing EG or NSPS WWW would continue to operate the facilities, including GCCS, and reduce emissions in accordance with these rules.

In our review of the comments, none of the 15 state and local regulatory agencies that submitted formal comments, opposed the proposed closed landfill subcategory, nor did NACAA in its formal comments. The Pennsylvania Department of Environmental Protection (PA DEP) and the SBA affirmatively supported the closed landfill subcategory. PA DEP recommended that EPA expand the closed landfill subcategory to allow MSW owners to close within 13 months of final rule publication. The Small Business Administration stated that EPA should allow more landfills to close up until the state or Federal regulations implementing the revised EG are effective, particularly as EPA provided no practical notice to entities when they proposed the closed landfill subcategory that the cut-off date would be 7/17/2014.

Based on gas generation model results for closed landfills that report emissions to federal GHG reporting program, we estimate the proposed change to reduce non-methane organic compound (NMOC) threshold from 50 Mg to 40 Mg will prolong the requirement to operate GCCS another five years, and impose significant costs on landfills at the end of life. Reducing the threshold to 34 Mg/year will prolong operations by eight years.

Many closed landfills struggle to maintain sufficient gas flow to operate their control systems under the 50 Mg/year threshold. At a lower NMOC threshold, landfill owner/operators will need to use increasing amounts of fossil fuel to maintain flare operation. This increases GHG emissions, which conflicts with the Administration's Methane Reduction Plan.

Closed landfills do not generate revenue and many are owned by municipalities, which must pass new costs on to their local taxpayers. Closed site compliance costs are formulated based on settled expectations that new requirements (i.e., lower NMOC threshold) will not be triggered in the absence of a reopening or an expansion. Absent the proposed subcategory, including the 13-month timeframe expansion, closed landfill facilities will face significantly increased compliance costs and administrative burdens.

We Support Streamlining the Design Plan Approval and Update Process

Our organizations supported EPA's conclusion that review and approval of design plans is clearly a burden for many states. Two of our organizations, Waste Management and Republic Services, estimated that only 40 percent of their landfills operate pursuant to an approved design plan, and together the two companies own and operate about 50 percent of the MSW landfills in the U.S. Given this track record, we strongly support the Agency finalizing a process that eliminates the need for state approval of plans, which is a system that has simply not worked. Instead, state and local agencies and landfill owner/operators should be allowed to obtain and rely upon third-party professional engineer (PE) certification of design plans and revisions in lieu of an agency approval process. Certified plans may be maintained onsite for inspection and/or submitted to the implementing agency.

Subpart WWW in discussing design plan approval in Section 60.752 states, "*Because of the many site-specific factors involved with landfill gas system design, alternative systems may be necessary. A wide variety of system designs are possible, such as vertical wells, combination horizontal and vertical collection systems, or horizontal trenches only, leachate collection components, and passive systems.*" No other NSPS rule includes such a statement about site-specific design variables, and this statement supports need for the PE review and certification rather than relying on agency staff unfamiliar with the highly site-specific nature of GCCS design.

A process that relies on independent PE certification would reduce administrative burdens on state agencies, while offering greater regulatory certainty for the regulated community and public. Further, use of state-licensed PEs would simplify the process. Landfill owner/operators have ready access to third-party PEs, who have the requisite experience and expertise in GCCS design, and state certification boards exist to oversee and license PEs.

The vast majority of the state organizations that commented on EPA's proposal for third-party verification of plans, including NACAA, opposed the proposal as we did. Most described third-party verification as expensive, burdensome and unnecessary. While a number of states were loath to give up their design plan approval authority saying it does not pose a burden, the nationwide record of implementing approvals does not support their argument.

Furthermore, EPA and the delegated state agencies' primary oversight of the GCCS system is not at the design plan stage, but rather through the permitting process when a landfill has triggered the need to install a GCCS. Landfills must apply to the regulators for a construction permit, and the state agency must permit control devices associated with the GCCS. This permitting authority gives states the best opportunity for oversight and approval. It is through permitting, as well as required wellhead pressure monitoring, surface emission monitoring, remediation of exceedances and required documentation of GCCS "as-built" conditions (all contained within required semi-annual reports), not review and approval of a conceptual design, which provides regulators ample oversight mechanisms to ensure GCCS is properly installed and operated.

There is significant precedent for submission of site-specific regulatory plans with no requirement for Agency approval. In fact, the proposal to require Agency approval of the both the design plan and treatment system monitoring plan is inconsistent with numerous federal rules that instead require copies (of management, monitoring or operating plans) to be submitted to the agency (no approval required) and/or maintained on site for agency inspection:

- 40 C.F.R. 98 Subpart A– GHG Mandatory Reporting Rule (GHG monitoring plan)
- 40 C.F.R. 60 Subpart Ec – HMIWI (waste management plan)
- 40 C.F.R. 60 Subpart F – Portand Cement Plants (monitoring plan)
- 40 C.F.R. 60 Subpart Ja – Petroleum Refineries (flare management plan)
- 40 C.F.R. 60 Subpart Ka – Storage Vessels (operations and maintenance plan)
- 40 C.F.R. 60 Subpart Y – Coal Preparation and Processing Plants (fugitive dust emissions control plan)
- 40 C.F.R. 60 Subpart GG – Stationary Gas Turbines (parameter monitoring plan)
- 40 C.F.R. 60 Subparts VV, VVa – Equipment Leaks SOCMI (monitoring and inspection plans for pumps, valves, closed vent systems)
- 40 C.F.R. 60 Subpart AAA – Residential Wood Heaters (Manufacturer's Quality Assurance Plan: note this plan is third-party certified)
- 40 C.F.R. 60 Subpart QQQ – Petroleum Refinery Wastewater Systems (plans/specification for various component or system design)
- 40 C.F.R. 60 Subpart AAAA – Small MWC Units (materials separation plan)
- 40 C.F.R. 60 Subpart CCCC – CISWI (waste management plan)
- 40 C.F.R. 60 Subpart DDDD – CISWI EG model rule (control plan, waste management plan)
- 40 C.F.R. 60 Subpart EEEE – OSWI (waste management plan)
- 40 C.F.R. 60 Subpart FFFF – OSWI EG Model rule (waste management plan)
- 40 C.F.R. 60 Subpart IIII – Stationary Compression Ignition Internal Combustion Engines (maintenance plan)
- 40 C.F.R. 60 Subpart JJJJ– Stationary Spark Ignition Internal Combustion Engines (maintenance plan)
- 40 C.F.R. 60 Subpart KKKK – Stationary Combustion Turbines (quality assurance plan, parametric monitoring plan)
- 40 C.F.R. 60 Subpart LLLL – Sewage Sludge Incineration Units (fugitive emissions monitoring plan)
- 40 C.F.R. 60 Subpart MMMM – SSIU EG Model Rule (control plan)
- 40 C.F.R. 60 Subpart OOOO – Crude Oil and Natural Gas Production, Transmission and Distribution (inspection and maintenance plan)
- 40 C.F.R. 60 Subpart QQQQ - Residential Hydronic Heaters and Forced-Air Furnaces (Manufacturer's quality assurance plan: note this plan is third-party certified)
- 40 C.F.R. 60 Subpart TTTT – GHGs for EGUs (monitoring plan)
- 40 C.F.R. 63 Subpart A – General NESHAPs Provisions (SSM plan)
- 40 C.F.R. 63 Subpart EEE – Haz Waste Combustors (emergency safety vent operating plan, Operations and Maintenance Plan, Feedstream analysis plan)
- 40 C.F.R. 63 Subpart HHH – Natural Gas Transmission and Storage (inspection and maintenance plan for control devices, site-specific monitoring design, data collection, and QA plan for monitoring control device)
- 40 C.F.R. 63 Subpart LLL: Portland Cement (site specific monitoring plan
- 40 C.F.R. 63 Subpart OOO: Manufacture of Amino/Phenolic Resins (monitoring plan for leak detection, gas stream flow determination plan)
- 40 C.F.R. 63 Subpart QQQ: Primary Copper Smelting (Operations and maintenance plan for each capture and control device)
- 40 C.F.R. 63 Subpart RRR: Secondary Aluminum Production (operations, maintenance and monitoring (OM&M) Plan for capture/control systems)

- 40 C.F.R. 63 Subpart TTT: Primary Lead Smelting (corrective action plan)
- 40 C.F.R. 63 Subpart VVV: POTWs (inspection and monitoring plan to comply with the standard)
- 40 C.F.R. 63 Subpart XXX: Ferroalloys Production (process fugitive ventilation design plan, outdoor fugitive dust plan, site-specific monitoring plan for CMS)
- 40 C.F.R. 63 Subpart GGGG: Solvent Extraction for Vegetable Oil Production (plan for demonstrating compliance)
- 40 C.F.R. 63 Subpart HHHH: Wet-formed Fiberglass Mat Production (OM&M Plan, performance evaluation plan)
- 40 C.F.R. 63 Subpart IIII: Surface Coating of Automobile and Light Duty Trucks (work practice plan to minimize HAP emissions)
- 40 C.F.R. 63 JJJJ: Paper and Other Web Coating (site-specific monitoring plan for capture system and control device; inspection and maintenance plan for catalytic oxidizer)
- 40 C.F.R. 63 Subpart KKKK: Surface Coating of Metal Cans (Work practice plan; inspection and maintenance plan for catalytic oxidizer)
- 40 C.F.R. 63 Subpart MMMM: Surface Coating of Miscellaneous Metal Parts and Products (work practice plan, site-specific inspection and maintenance plan for catalytic oxidizer)
- 40 C.F.R. 63 Subpart NNNN: Surface Coating of Large Appliances (work practice plan, site-specific inspection and maintenance plan for catalytic oxidizer)
- 40 C.F.R. 63 Subpart OOOO: Printing, Coating, and Dyeing of Fabrics and Other Textiles (work practice plan, sampling plan, and site-specific inspection and maintenance plan for catalytic oxidize, capture system monitoring plan)
- 40 C.F.R. 63 Subpart PPPP: Surface Coating of Plastic Parts and Products (work practice plan, site-specific inspection and maintenance plan for catalytic oxidizer)
- 40 C.F.R. 63 Subpart QQQQ: Surface Coating Wood Building Products (work practice plan, site-specific inspection and maintenance plan for catalytic oxidizer)
- 40 C.F.R. 63 Subpart RRRR: Surface Coating of Metal Furniture (work practice plan, site-specific inspection and maintenance plan for catalytic oxidizer)
- 40 C.F.R. 63 Subpart SSSS: Surface Coating of Metal Coil (capture system monitoring plan, site-specific inspection and maintenance plan for catalytic oxidizer)
- 40 C.F.R. 63 Subpart TTTT: Leather finishing (Compliance demonstration plan)
- 40 C.F.R. 63 Subpart UUUU: Cellulose Products (site specific monitoring plan for CMS)
- 40 C.F.R. 63 Subpart VVVV: Boat Manufacturing (implementation plan for open molding operations)
- 40 C.F.R. 63 Subpart ZZZZ: Stationary RICE (site-specific monitoring plan for CPMS, maintenance plan)
- 40 C.F.R. 63 Subpart FFFFF: Integrated Iron and Steel (Operations and maintenance plan,63.7834)
- 40 C.F.R. 63 Subpart JJJJJ : Brick and Structural Clay Products Manufacturing (Operation, Maintenance and Monitoring Plan)
- 40 C.F.R. 63 Subpart KKKKK: Clay Ceramics Manufacturing (Operation, Maintenance and Monitoring (OM&M) Plan)
- 40 C.F.R. 63 Subpart LLLLL: Asphalt Processing and Roofing Manufacturing (site-specific monitoring plan)
- 40 C.F.R. Subpart PPPPP: Engine Test Cells (inspection and maintenance plan)
- 40 C.F.R. 63 Subpart SSSSS: Refractory Products Manufacturing (OM&M Plan)
- 40 C.F.R. 63 Subpart TTTTT: Primary Magnesium Refining (operations and maintenance plan)

- 40 C.F.R. 63 Subpart UUUUU: Coal and Oil-fired EGUs (site specific monitoring plan 63.10000(d))
- 40 C.F.R. 63 Subpart BBBBBB: Gasoline Distribution bulk terminals, plants, and pipeline facilities (monitoring and inspection plan)
- 40 C.F.R. 63 Subpart QQQQQQ: Wood preserving area sources (management practice plan)
- 40C.F.R. 63 Subpart VVVVVV: Chemical Manufacturing area sources (monitoring plan, includes O&M for control device)
- 40 C.F.R. 63 YYYYYY: Ferroalloys Production facilities for area sources (site-specific monitoring plan)
- 40 C.F.R. 63 AAAAAAA: Asphalt Processing and roofing manufacturing area sources (site specific monitoring plan)

Despite the numerous regulatory precedents noted above, should EPA decide to maintain the requirement that state agencies approve design plans and revisions, we strongly recommend that the Agency incorporate language that provides for automatic approval of plans should a state agency fail to approve or disapprove a plan or revision in writing within 90 days. A precedential example can be found at 40 C.F.R. 63 Subpart MMM Pesticide Active Ingredient Production, which provides the Agency 90 days to approve or disapprove a “precompliance plan” before it is deemed approved.

We Strongly Support the EPA’s Proposed Definition of Landfill Gas Treatment Systems, but Oppose Proposed Agency Approval of Treatment Plans

We support the Agency’s proposed definition of landfill gas, treatment system and believe it supports and promotes projects for beneficial use of landfill gas. However, we oppose the proposal to require agency approval of the treatment system, monitoring plan as part of the GCCS Design Plan. The requirement would create a new and unwarranted burden for the agencies, especially since the treatment systems are site-specific, tailored to the end user specifications, and highly technical.

The Agency proposal is inconsistent with the federal rules listed above, which merely require copies (of management, monitoring or operating plans) be submitted to the agency or maintained on site for agency inspection.

The landfill gas, treatment systems are not subject to emission limits or continuous emissions monitoring, yet EPA proposes to require agency approval, which is more stringent than what EPA has required for sources with actual HAP emission limits and continuous emissions monitoring requirements. We recommend EPA finalize a requirement to prepare a treatment system, monitoring plan and maintain a copy on site for agency inspection as has been promulgated in so many other NSPS and NESHAP rules.

Peer Reviewed Data Show Landfill Gas Collection Efficiencies Ranging from 75 Percent to Over 95 Percent are Defensible

In response to the draft NSPS for landfills, the EPA received comments regarding the collection efficiency of GCCSs. Collection efficiency is an important factor used in calculating the emissions of NMOCs, volatile organic compounds (VOCs), and greenhouse gases (GHG) from landfills. Docketed comments on the proposed NSPS/EG rules (see EPA-HQ-OAR-2014- 0451 and EPA-HQ-OAR-2003-0215) mention collection efficiency at landfills is lower than recent data suggest. Specifically collection efficiencies could be as low as 20 percent (Sierra Club), or 35 percent (ERC, Covanta).

We have reviewed these comments and determined that they do not provide a representative picture of the collection efficiency seen at most landfills operating with current industry state-of-the-practice systems and procedures, specifically those used for compliance with the NSPS/EG.

Inadequacy of Cited Studies

The studies cited by the Sierra Club, ERC, and Covanta do not support claims that typical methane capture is as low as 20 or 35 percent. The studies are not representative of collection systems operated in compliance with the current and proposed MSW Landfill NSPS or EG rules.

Sierra Club Sources

The Sierra Club letter suggests that lifetime LFG collection rates are as low as 20 percent. They reference the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (FAR), which states, "Some sites may have less efficient or only partial gas extraction systems and there are fugitive emissions from landfilled waste prior to and after the implementation of active gas extraction; thus estimates of 'lifetime' recovery efficiencies may be as low as 20%." However, it is clear in the FAR that the 20 percent lifetime recovery rate is not referring to a NSPS compliant system. The FAR estimates collection efficiencies across a broad range of landfills worldwide from highly developed countries with stringent landfill standards (e.g., the U.S.) and far less developed countries with no sanitary landfills or landfill regulatory standards.

The Sierra Club also cites comments from Hans Oonk in the "Expert Review of First Order Draft of Waste Chapter to IPCCS Fourth Assessment Report"; however, his comments confirm that the low end of the gas capture range is not comparable to the collection efficiency achieved at landfills regulated under the current NSPS. He evaluated performance of gas collection systems that were installed at Dutch landfills, not for regulatory purposes, but only to recover gas for energy. Hans Oonk concluded that LFG collection for energy recovery coupled with the requirement to flare additional LFG is a highly effective option for controlling LFG emissions. This hybrid energy and flare system is the industry standard throughout the United States.

Furthermore, lifetime emissions of 80 percent of the gas from a landfill as posited by Covanta, ERC and Sierra Club would almost certainly make compliance with the NSPS/EG impossible. Such high emission rates would result in methane detections during required surface monitoring, and in turn requiring corrective action and expansion of the GCCS to lower surface emissions. Even absent the regulatory requirements for monitoring, the emissions would likely result in significant odors and complaints to local agencies.

The Sierra Club letter claims, "no gas collection can be functional until later when the cell is full and low permeable [sic] final cover is installed." In fact, hundreds of landfills have placed waste in areas with existing gas collection. While this practice may require gas systems to undergo repair, the Sierra Club's claims that "gas collection is also not functional prior to the installation of the final cover," is simply wrong, and lacks a fundamental understanding of how GCCSs are design, installed, operated, and expanded as landfills grow.

The 20 percent recovery value cited in these comments is not representative of U.S. landfills. It may be representative of the average of unregulated landfills worldwide as part of the low end of the range of collection efficiencies, but federal and state landfill requirements results in significantly higher collection efficiency rates at U.S. landfills.

Covanta and ERC Sources

The Covanta and ERC letter cites five sources for the range of collection efficiencies, including:

1. Environmental Commissioner of Ontario, EcoIssues: GHG11 Landfill Methane, http://ecoissues.ca/GHG11_Landfill_Methane
2. Fischedick M. et al. (2014) Climate Change 2014: Mitigation of Climate Change, Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
3. Levis, J., M.A. Barlaz (2014) Landfill Gas Monte Carlo Model Documentation and Results,
4. CalRecycle 2012, Review of Waste-to-Energy and Avoided Landfill Methane Emissions.
5. Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)

We have reviewed each of the cited sources for its appropriateness and representativeness for determining the collection efficiency of landfills in the United States subject to the NSPS/EG.

The first of these citations is a website for the Environmental Commissioner of Ontario (ECO). The ECO cites some studies of LFG collection efficiency and concludes that the default collection efficiency of 75 percent used by the EPA and others is overstated (note: landfills in Canada are not subject to the more stringent requirements of the NSPS/EG). However, the ECO also notes that the IPCC states that LFG collection could be above 90 percent. We note that the comments by Sierra Club, ERC and Covanta omitted the upper end of the range of landfill collection efficiencies cited by the same sources they reference.

The second source (Fischedick M. et al.) states that methane collection efficiencies range from 50 percent to 95 percent. The low collection efficiency rate of 50 percent is appropriate for some landfill collection systems that are not designed for compliance with the NSPS/EG, but are operated to achieve odor control or mitigate LFG migration. However, this type of system is typically found at small or closed landfills that account for a relatively small amount of GHG emissions, and where a comprehensive GCCS would be cost prohibitive.

The third citation (Levis and Barlaz) uses models to analyze methane recovery from different waste types under varied landfilling conditions. While the study indicated that over 80 percent of methane could be emitted, this low methane recovery rate applied to only one waste type (grass clippings), which is a rapidly degrading waste disposed in a bioreactor landfill. Further, the 80 percent emission rate is a worst-case, lifecycle scenario, in a modeled situation with delayed collection. Overall, the methane recovery rate for landfills in the model scenarios for landfills receiving more than 110 centimeters of precipitation per year were greater than 60 percent, and greater than 70 percent for landfills receiving less than 110 centimeters of precipitation per year.

The fourth citation (CalRecycle) is a study of a single landfill in California, which was subject to neither the federal NSPS/EG nor the California AB 32 Landfill Methane Rule (LMR). It is therefore inappropriate to apply conclusions from this single site study to sites complying with NSPS and the LMR. In fact, quite the opposite, this study provides support for why the NSPS/EG rule can be effective at reducing LFG emissions as compared to unregulated conditions.

The fifth citation (WARM guidance) draws on some of the same work as the Levis and Barlaz study discussed above. The WARM guidance determined that better than 50 percent LFG recovery was typical for the national average for most waste types with yard trimmings being the exception. This value in the WARM guidance does not support assertions of a LFG recovery rate as low as 35 percent being representative. The "typical" and "aggressive gas collection" scenarios yield far greater collection efficiencies.

The Covanta and ERC letters also cite *Comparison of First-Order-Decay Modeled and Actual Field Measured Municipal Solid Waste Landfill Methane Data* (Amini, Reinhard, and Niskanen, 2013, Waste Management Vol. 33). This study found that the first-order-decay (FOD) model used to model landfill emissions can underestimate methane generation. However, FOD modeling for GHG emission calculations is frequently inaccurate, providing methane generation estimates that are both too high and too low, depending on the landfill. Furthermore, the landfills evaluated in the study are Danish, and results may not be representative of either the typical waste stream in the U.S. or landfill operations subject to U.S. regulatory requirements.

<u>Available Collection Efficiency Data</u>

The document entitled *Current MSW Industry Position and State-of-the-Practice on LFG Collection Efficiency, Methane Oxidation, and Carbon Sequestration in Landfills* (SWICS, 2009) was developed for EPA and reviewed seven studies of LFG collection efficiency. The analysis distinguished between study data from landfills with collection systems and cover practices compliant with the NSPS/EG rules, and data from landfills not meeting those regulatory standards. Not surprisingly, collection efficiencies were generally lower in non-compliant landfills than collection efficiencies at NSPS-compliant landfills. The SWICS study concluded that the most important factors affecting collection efficiency were cover type and extent of GCCS installation. These conclusions and an approach for estimating collection efficiency based on selected cover types and scope of GCCS installation was adopted with only minor modifications by the EPA for landfills reporting under the federal Mandatory Reporting Rule for GHG (GHGRP) (40 C.F.R. Part 98, Subpart HH).

A more recent study, *The Estimated 100-Year Collection Efficiency for U.S. Landfills* (Stege, A, Proceedings of 2013 SWANA Landfill Gas Conference), reviewed typical landfill operating practices throughout the U.S. The study compiled data from the EPA's Landfill Methane Outreach Program (LMOP) and grouped landfills by owner/operator -- large private, small private, public, and location – with those operating in the California South Coast Air Quality Management District (SCAQMD) and Bay Area Air Quality Management District (BAAQMD) separated due to their more stringent regulatory requirements. The study found that the 100-year LFG collection efficiency for typical landfills across the country was in excess of 80 percent.

In addition to the SWICS and Stege studies, the most recent direct measurement studies indicate that collection and control efficiencies are higher than the assumptions used in FOD models (De La Cruz et al., 2015 draft in final EPA review) (Walker et al., 2014) (Shan et al., 2013) (Green et al., 2012) (Goldsmith et al., 2012) (Chanton et al., 2011) (Green et al., 2009)). Direct measurement studies have also shown that inventory models used by regulators significantly over-estimate landfill methane emissions, as summarized below:

- (Shan et al., 2013) determined collection efficiencies of 91% to >99% based on statistically representative flux chamber measurements at four large California Landfills.

- (Walker et al., 2014) applied direct measurement of methane emissions and oxidation from (Goldsmith et al., 2012) for five California Landfills, four with Mediterranean climates and one with an arid desert climate. Control efficiency for the five landfills ranged from 83-88%. The effects of coverage of the landfill gas collection system and relative size of the working face and daily cover areas was analyzed and negligible.

- (De La Cuz et al., 2015) compared direct measurement of methane emissions from a humid landfill located in Southeastern U.S. with waste aged less than three years to modeled emissions and determined the FOD models predicted 4-17 times high emission rates than measured.

- Mønster et. al. (2015) showed that for 15 Danish landfills, model-predicted emissions were on an average, a factor of 5 greater than the measured emissions.

- (Green et al., 2012) compared direct measurement of four closed landfills without gas collection and found that the measured emissions were only 33%, 12%, 44%, and 17% of the emission rate predicted by the GHGRP (EPA MRR in table below). The corresponding over-prediction of models was by factors of 2.3 to 8.3 greater than the measured emissions. The SWICS methodology (SCS, 2009) which applies a 30% oxidation rate for soil mixtures likewise predicted much lower emission rates than the GHGRP:

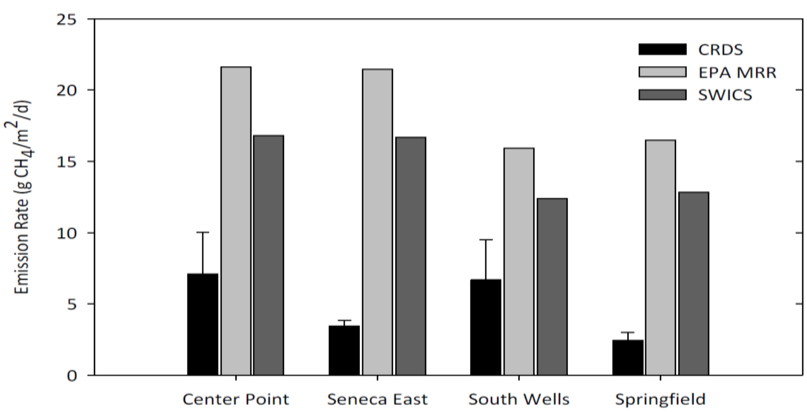

Figure 1. Comparison of Methane Emission Results from CRDS Measurements and Models (error bars represent 1sd)

- Two southern California Landfills were evaluated by research aircraft taking methane measurements in (Peischl, J. et al., 2013). Peischl et al. applied the measured emission rate to each site's footprint and methane collection and combustion data to estimate collection efficiencies of 73% and 77%. Applying an oxidation factor of 38 percent results in control efficiencies of 77% and 80%. These results are considered a lower bound by the researchers because of limitations in accounting for other sources of methane and potential atmospheric effects. Note that (Shan et al., 2013) estimated collection efficiencies at one of these landfills by two different methods of 93.1% and 95.9%.

- A study of three landfills (humid climate located in Southeastern U.S.) measured collection efficiency (ignoring oxidation) based on EPA Method OTM-10 of 73% (70/77), 80.5% (77/89), and 38% (Arcadis, 2012). Waste Management (Kelly et al., 2012) raised the following significant issues with the results from Landfill B (site with 38%):

- Bias toward high methane based on location with respect to an adjacent source (hog farm) and location downwind of LFG wells;

- The landfill installed a new gas collection system shortly after the measurements, so GCCS in place at time of study was not representative of modern landfills with systems operating in accordance with NSPS/EG; and

- There was only one measurement season (summer) as contrasted with the other two landfills, which were separately measured over two seasons.

The results of direct measurement studies refute docketed comments (EPA-HQ-OAR-2014- 0451 and EPA-HQ-OAR-2003-0215) that LFG collection efficiencies are much lower (about 35%-70% over the life of the landfill) than default values in inventory models used by regulatory agencies. Further, they refute comments that claim models of landfill gas emissions often result in significant under-estimation of emissions. There is neither a technical basis, nor direct measurement studies to underpin the claims that typical collection efficiencies are only 35-70%. Furthermore, methane oxidation was not incorporated into the study underpinning these comments, and should be for a more accurate assessment of landfill emissions.

Consistency with Recent EPA Regulations

As noted above, the EPA adopted a modified version of the SWICS methodology for calculating site-wide LFG collection efficiency at landfills under the GHGRP. That methodology uses a collection efficiency of 60 percent for area with daily cover, 75 percent for areas with intermediate cover, 95 percent for areas with final cover, and zero (0) for areas without gas collection. The collection efficiencies already adopted by EPA in federal regulation are significantly higher than the collection efficiencies of 20 and 35 percent advanced by the Sierra Club, Covanta, and ERC.

Direct Measurement

Finally, Covanta suggested in comments that direct measurement of landfill emissions should be incorporated as a requirement in the final standards. The comment letter notes several studies that have used remote sensing technology such as Vertical Radial Plume Mapping (VRPM) and Other Test Method 10 (OTM-10) to measure landfill area emissions.

While the industry agrees that significant fieldwork has been conducted using remote sensing technology, the Covanta comments minimize the challenges in broadly using these methodologies at landfills. For example, the Covanta-funded study, *Quantifying Methane Abatement Efficiency at Three Municipal Solid Waste Landfills* (EPA/600/R-11/033, January 2012) characterizes OTM-10 as a ‘breakthrough in technology” that has “resulted in the ability to more accurately quantify” emissions, but fails to note that the technology requires extensive preparation and characterization of the topography and meteorology at subject landfills. Covanta also references the study to argue for assuming lower LFG collection efficiency rates, although the study does not provide sufficient support.

Waste Management (WM) provided comments to EPA’s Office of Research & Development on the study in a letter dated September 28, 2012 (Kelly et al., 2012). The letter summarized key technical concerns including first, that the limited scope of the research, summarizing five measurement campaigns at only three southeastern landfills, does not provide a sound basis for the document's broad policy conclusions and proposed next steps. Second, WM voiced significant scientific and technical concerns about the measurement methods and physical conditions at the sites, which call into question the validity of the reported measurements.

At EPA's request, WM in a letter to the Office of Air Quality, Planning and Standards, assessed the appropriateness of developing regulatory requirements for the use of the OTM-10 direct measurement technique (August 23, 2011). WM described key challenges in using the technique including that OTM 10 measurements can assess only 5 to 20 percent of the total landfill surface. This makes the technique subject to criticism regarding its spatial representativeness in determining emission rates. WM also described the difficulty in the set-up and use of the TDL equipment due to the complex topography associated with landfills and the strong influence weather (e.g., wind direction and speed, precipitation, barometric pressure) plays on the ability to obtain usable TDL readings. The large source size, heterogeneous source area, and interference from proximate or distant sources of emissions (from an adjacent landfill cell outside the measurement area or a wholly separate site) can create very significant uncertainties in measuring methane emissions at a landfill. Additionally, the process of direct measurement is expensive and may prove cost-prohibitive for widespread practical application.

References

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3. Fischedick M. et al. (2014) Industry. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change
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5. CalRecycle (2012) CalRecycle Review of Waste-to-Energy and Avoided Landfill Methane Emissions
6. Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)
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8. California Air Resources Board (CARB 2009), Staff Report: Initial Statement of Reasons for the Proposed Regulation to Reduce Methane Emissions from Municipal Solid Waste Landfills, Appendix D: Evaluation of Landfill Gas Collection Efficiency, May 2009.
9. Alex Stege, Estimated 100-Year Collection Efficiency for U.S. Landfills.Proceedings 2013 SWANA LFG Symposium
10. Shan, J., Iacoboni, M., and Ferrante, R. (2013); "Greenhouse Gas Emissions from three Southern California Landfill Sites", Solid Waste Association of North America (SWANA) 36th Annual Landfill Gas Symposium, Las Vegas, NV.
11. Walker, S.D., Green, R.B., and Sullivan, P.S. (June 2014); California Landfill Methane Control Efficiency Based on Recent Direct Measurement Studies; Global Waste Symposium 2014, Orlando, Florida

12. De La Cruz, F., Green, R., Hater, G., Chanton, J., Thoma, E., Harvey, T., Barlaz, M. (in final EPA review, 2015); Landfill Methane Emissions: A Comparison of Field Measurement to Gas Production Models.
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15. Peischl, J. et al. (2013); Quantifying Sources of Methane Using Light Alkanes in the Los Angeles Basin, Journal of Geophysical Research: Atmospheres, Vol. 118, 4974-4990.
16. ARCADIS U.S., Inc. (January 2012); Final Report- EPA/600/R-11/033, Quantifying Methane Abatement Efficiency at Three Municipal Solid Waste Landfills, Prepared for: Susan A. Thorneloe U.S. Environmental Protection Agency Triangle Park, NC 27711, Office of Research and Development National Risk Management Research Laboratory, Air Pollution Prevention and Control Division Research.
17. Kelly, K., and Van Kolken Banister, A. (2012); September 28, 2012 comment letter to Richard Shores, U.S. Environmental Protection Agency on "Quantifying Methane Abatement Efficiency at Three MSW Landfills, EPA/600/R-11/033.

Shorter Lag Times for Wet Landfills Are Not Warranted or Justified

We are concerned that EPA is continuing to target "wet" landfills for additional requirements under the proposed NSPS/EG. In our comments on the ANPRM in 2014, we explained why EPA should not reduce the initial lag times for GCCS installation at landfills located in wet climates, landfills that recirculate leachate, or landfills that add other liquids to accelerate waste decomposition. We highlighted ambiguity in the definition of wet landfills, the oversimplification that results from definitions that rely primarily on measured precipitation and leachate levels, and the potential overlap in requirements between the Landfill NSPS/EG and the Subpart AAAA NESHAP.

We believe EPA's proposed definition of wet landfills focuses to narrowly on precipitation and leachate variables, and fails to consider the many other factors that influence moisture content in landfills. Our comments noted that precipitation is not well correlated with landfill moisture levels. Other factors, like waste acceptance rates, the amount of moisture in the disposed waste, cell size, cover type, and cover timing also have a significant impact on landfill moisture levels. We strongly urge EPA to avoid simplistic definitions that fail to account for the complexity of the landfill environment. EPA should not define landfills as "wet" based only on precipitation of over 40 inches per year. EPA should base its approach on sound science and analysis.

Recent research efforts conducted by EPA, in cooperation with solid waste industry and academic researchers (De la Cruz, F.B., Green, R., Hater, G., Chanton, J., Thoma, E., Harvey, T., and Barlaz, M., *Comparison of Field Measurements to Methane Emissions Models at a New Landfill*) at a landfill located in a wet climate (Southeastern U.S.) indicate that FOD models over-predict emissions from waste that is less than four years old by at least a factor of four. The study, to be submitted to the *Journal of Environmental Science and Technology*, compared field measurements (tracer correlation and eddy covariance) to FOD models using a k value of roughly 0.05. The study authors concluded that additional field data on methane production and emissions is necessary to establish a path forward to updating the model parameters and methodology for estimating emissions.

We are also concerned that EPA has failed to provide any discussion of the cost and cost effectiveness of shorter lag time requirements. From our review of other proposed changes to the NSPS and EG, we have concluded that the more stringent requirements come with significantly higher costs. EPA should not finalize shorter lag times at wet landfills without providing additional information to the regulated community and other stakeholders.

Issues Associated with Applicability and Effectiveness Dates, and Implementation Issues

EPA has proposed to change the applicability date from 5/30/1991 to 7/14/2014 for new or modified sources. With this approach, very few sites will be initially subject to the proposed NSPS (Subpart XXX) and majority of sites will be subject to the proposed EG rule (Subpart Cf).

EPA has not followed a consistent approach historically in regards to updating NSPS rules. In some cases, EPA has updated the existing NSPS rule and retained existing applicability dates (40 C.F.R. 60 Subpart Eb[1], 40 C.F.R. 60 Subpart F). In other cases, EPA has retained the existing NSPS and applicability date (40 C.F.R. Subpart G: August 17, 1971 – October 14, 2011) and created a new NSPS rule and applicability dates for affected sources (40 C.F.R. Subpart Ga: after October 2011).
EPA has never created a new EG rule to replace an existing EG rule. Further, EPA has updated EG rules but has not changed the applicability date (40 C.F.R. 60 Subpart Cb[2]).

EPA has now aligned the rule requirements and rulemaking schedule for the NSPS and the EG so there is no substantive difference in requirements between the rules. If EPA were to retain the 1991 applicability date for NSPS sites, then the proposed EG (Subpart Cf), including the Closed Landfill subcategory, could be incorporated in the NSPS (Subpart XXX) and EPA could retain the existing EG, (Subpart Cc) for sites that did not open or modify (expand the landfill) since 1991. This approach would significantly reduce regulatory burden for state and local agencies (they would not be required to prepare state plans or revise existing state rules) and EPA would not be obligated to prepare, issue and implement a Federal Plan.

Effective Date of Final NSPS Rule and Compliance Dates

There is no issue with the effective date of the NSPS rule as long as EPA includes clear and reasonable compliance timelines for submitting new or revised reports. The proposed NSPS rule includes a 90-day compliance timeframe for submitting design capacity reports and NMOC emission rate reports, which is consistent with WWW. The rule continues to assume these are first time reports and does not address whether sites already subject to NSPS WWW requirements must re-submit reports.

Design Capacity Reports
Sites that commenced operation prior to date of the final NSPS XXX rule (and submitted design capacity reports per NSPS WWW/EG Cc requirements) should be exempt from re-submitting design capacity reports. The design capacity report is required only to determine whether a site is subject to

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[1] FEDERAL REGISTER Vol. 71, No. 90 May 10, 2006 pp. 27324-27348
[2] Ibid

the NSPS/EG rule and Title V requirements. This report is not relevant for sites where NSPS/EG and Title V requirements have already been triggered by an exceedance of the design capacity exemption. Furthermore, preparing and submitting the report would add unnecessary burden to the sites and regulatory agencies.

NMOC Emission Rate Reports

Sites that installed GCCS under NSPS WWW/EG Cc requirements should be exempt from re-submitting the NMOC emission rate report. The emission rate report is required only to determine when the site must install a gas system to control NMOC emissions. This report is not relevant for landfills with existing NSPS/EG-required GCCSs and preparation and submittal would add unnecessary burden to the sites and regulatory agencies.

For sites that are currently subject to NSPS WWW but have not triggered NMOC threshold requiring GCCS installation, EPA should continue to require annual or 5-year periodic reports and allow sites to use valid test data for the reports. The rule should not require new Tier 2 or Tier 3 testing if the test data and supporting information is still valid. Sites should have the option to complete additional Tier 2 or Tier 3 testing. Allowing sources to use previous emissions test results to demonstrate compliance with the NMOC threshold, if revised, is consistent with federal rules (40 C.F.R. 60 Subpart Ec) FR Vol. 74, No. 192 October 6, 2009 pp. 51368-51418

GCCS Design Plans and Gas Treatment System Monitoring Plans

Sites that installed GCCS under NSPS WWW/EG Cc requirements should be exempt from re-submitting the GCCS Design Plan. The Design Plan is required only to present a conceptual design of the GCCS that was used as basis to install the existing GCCS; therefore this report is not relevant. Preparation and re-submittal would add unnecessary burden to the sites and regulatory agencies.

EPA offers two criteria for when an affected source must update and submit its design plan: 1) within 90 days of expanding operations to an area not previously covered by the design plan; and 2) prior to installing or expanding GCCS in a manner other than one described in a previously approved design plan. The criteria and timeframes appear reasonable; however, we again urge EPA to provide alternatives to agency approval of Design Plans given the vast number of plans that have received no formal agency approval, which results in compliance uncertainty. The existing rules already require WWW and EG sites to report expansions made to the GCCS on semi-annual basis and to update the as-built maps that reflect current GCCS operations.

Currently, there is no compliance timeframe proposed in NSPS Subpart XXX for submitting a gas treatment, system monitoring plan. As this is a new proposed requirement, we are concerned that the proposed rule offers no transitional compliance period for existing sites with LFGTE projects that trigger Subpart XXX applicability upon expansion or modification. We recommend EPA allow for at least 120 days to prepare a treatment system monitoring plan. We again do not recommend EPA require agency approval of the plans, as further described in previous comments and below.

New Monitoring and Recordkeeping Requirements

If EPA finalizes any changes to monitoring and/or recordkeeping requirements in the NSPS, sites that installed GCCS under WWW requirements will require lead time to install new equipment (where applicable), develop/implement new processes and train staff/third party contractors before the site can comply with the new requirements. It may not be possible for a site to comply immediately upon the publication date of the final NSPS rule nor should EPA expect a site to immediately comply where monitoring and/or recordkeeping requirements are revised. For example, changes to SEM requirements should be implemented in the subsequent calendar quarter after which the rules are published. Assuming the NSPS rule is published in July 2016, a site would implement any new SEM and recordkeeping requirements during the fourth quarter.

The undersigned organizations appreciate your consideration of these supplemental comments and hope the Agency finds them useful as you finalize the MSW Landfill NSPS and EG rules. Please feel free to reach out to us if you have any questions. We look forward to continuing to work with you as we prepare to implement the new rules.

Sincerely,

Waste Management
Republic Services
Advanced Disposal
SCS Engineers
Weaver Consulting Group
Cornerstone Environmental Group
National Waste & Recycling Association
Solid Waste Association of North America
The Sanitation Districts of the County of Los Angeles

Exhibit 2

November 27, 2024

Submitted electronically via https://www.regulations.gov

Vasco Roma, ***roma.vasco@epa.gov***
Office of Atmospheric Protection, Climate Change Division
Office of Air and Radiation
U.S. Environmental Protection Agency

Re: Use of Advanced and Emerging Technologies for Quantification of Annual Facility Methane Emissions under the Greenhouse Gas Reporting Program;

Docket ID No. EPA-HQ-OAR-2024-0350

Dear Mr. Roma:

The National Waste & Recycling Association (NWRA) is pleased to submit the following comments to the *Request for Information on the Use of Advanced and Emerging Technologies for Quantification of Annual Facility Methane Emissions under the Greenhouse Gas Reporting Program*; Docket ID No. EPA-HQ-OAR-2024-0350 (hereinafter, the "RFI").

NWRA represents companies and professionals in the solid waste industry. NWRA is a not-for-profit trade association representing private solid waste and recycling collection, processing, and management companies that operate in all fifty states. Our members strive to deliver collection, composting, recycling, and disposal services that are protective of the environment in a safe, science-based, and technologically advanced manner. It is important that regulatory policy enables us to continue to deliver these essential services. NWRA's members own and operate municipal solid waste landfills governed by EPA's Greenhouse Gas Reporting Program ("GHGRP") rules at 40 C.F.R. Part 98, Subpart HH (hereinafter, "Subpart HH").

NWRA has long been partners with EPA in developing data, methods and best practices governing the operation of municipal solid waste landfills, including the development of emission estimates and data governing the quantification of greenhouse gas emissions associated with our members' operations. We have been active participants in the rulemaking process for Subpart HH, and likewise are pleased to participate in responding to this RFI.

I. Background to NWRA Comments

NWRA and its members have been active participants in the GHGRP since its inception in 2009. Importantly, and most relevant to the RFI, NWRA has been very engaged in providing feedback to EPA relating to the recent revisions to Subpart HH encompassed within the rule entitled *Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule,* 89 Fed. Reg. 31802 (April 25, 2024), docket No. EPA-HQ-OAR-2019-0424 (hereinafter, the "2024 Subpart HH Revisions"). NWRA submitted comments to two Notices of Proposed Rulemakings underlying the 2024 Subpart HH Revisions; *Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule,* 87 Fed. Reg. 36920-37119 (June 21, 2022) (hereinafter the "Data Quality Improvements Proposal"), and *Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule,* 88 Fed. Reg. 32852 (May 22, 2023) (hereinafter the "Supplemental Proposal").

The 2024 Subpart HH Revisions are highly relevant to the subject matter of the RFI, because EPA's decision to lower default landfill gas collection efficiency values set forth in Table HH-3 in the 2024 Subpart HH Revisions was based entirely on EPA's assessment of papers and data released by environmental advocacy organizations and others asserting, based on emerging measurement technologies, that actual landfill gas emissions are higher than previously reported in the GHGRP.[1] NWRA disagrees with this assertion, and with EPA's action in lowering the landfill gas collection efficiency values in Table HH-3. NWRA's members have committed considerable time and resources in assessing the capabilities of emerging measurement technologies and in so doing have engaged with a broad suite of technology vendors, academics and agencies. While we believe that emerging measurement technologies may be useful in providing additional tools for the detection of landfill gas emissions, most of them are not yet ready for wide-scale deployment in the regulatory context, and do not meet the data quality objectives and criteria necessary for the quantification of landfill gas emissions or required use in rulemaking. For these reasons, NWRA submitted a Petition for Reconsideration in response to the 2024 Subpart HH Revisions on June 24, 2024, a copy of which is attached hereto as Exhibit 1. Importantly, EPA has granted NWRA's Petition for Reconsideration of the 2024 Subpart HH Revisions, and we look forward to working collaboratively with EPA toward the continued improvement of data quality and reporting under the GHGRP.

In reviewing NWRA's comments herein, we ask EPA to carefully consider the following overarching principles that underpin our detailed responses. Each of these is critical to a full and fair evaluation of emerging measurement technologies and their potential application to municipal solid waste landfills:

- Municipal solid waste landfill operations are unique and pose challenges that are not experienced in the oil and gas context in measuring greenhouse gas emissions. Thus, EPA's assessments and regulatory determinations for oil and gas facilities cannot be imposed upon municipal solid waste landfills without significant additional evaluations and methods development.

[1] *See* 89 Fed. Reg. at 31855–56. Notably, EPA asserted in the preamble to the RFI that EPA "did not take final action to incorporate advanced measurement technologies in the April 2024 final rule. . ." revising Subpart HH due to "limitations in existing technologies" even though its reduction of collection efficiencies were directly informed by third party advocacy using these technologies. *See* RFI, 89 Fed. Reg. at 70178.

- For the municipal solid waste landfill sector, emerging measurement methods encompass a variety of technologies that differ in approach and have shown a wide range of accuracy in detection and quantification when compared to known release rates.

- Given the nature of landfill gas emissions, emerging measurement technologies are currently incapable of detecting emissions at the same level of precision as in the oil and gas sector.

- Point in time observations cannot be appropriately or reliably quantified and compared to annualized reported emissions.

- At this time, emerging measurement technologies are not transparent, open-source or standardized.

- At this time, emerging measurement technologies can be used only as a tool to support landfill gas collection and control practices, in conjunction with site-specific data using more established means.

- Site-specific data using established methodologies are critical to the accurate quantification of landfill gas emissions and cannot be replaced by emerging measurement technologies.

In light of the importance of these principles to NWRA's response to the RFI, and to avoid overlap in our responses to EPA's individual questions in the RFI, we have organized our comments around these principles, as set forth below, and have attempted to indicate throughout this document which RFI questions are most relevant to each comment.

II. Specific Comments in Response to RFI

A. Municipal solid waste landfills, and their emissions, are unique.[2]

EPA has begun to deploy emerging measurement technologies for purposes of detecting methane emissions from oil and gas sources, including through the "Super-Emitter Program" incorporated into the New Source Performance Standards / Emission Guidelines for that sector. While the program envisions a verification and certification process for third-party measurement technologies, it is our understanding that no such technologies and third parties have completed the verification and certification process. In addition, we understand that significant challenges remain in terms of meeting EPA's objectives for this and other emerging measurement programs. Some of these challenges are addressed in a submittal by Veritas, which is an initiative developed by GTI Energy experts in collaboration with a broad range of stakeholders, to develop and refine a standardized, science-based, technology-agnostic, measurement-informed approach to calculating and reporting methane missions for the natural gas industry. Veritas identifies and

[2] The text in section is responsive and relevant to each of the questions contained in EPA's RFI. All of the questions are contained in Appendix A, attached hereto.

seeks to address current challenges relating to intermittent emissions; identification, attribution and quantification for events that are below detection limits; and standardization for quantification methodologies, among others.[3] The challenges that are identified for the oil and gas sector are even more attenuated, and must be examined closely, before any such technologies could be considered for inclusion in regulatory structures for municipal solid waste landfills.

There are several important distinctions between greenhouse gas emissions from landfills and from the oil and gas sector, all of which are important for purposes of considering the potential use of emerging technologies for detecting, measuring, and quantifying emissions in upcoming rulemakings pertaining to landfills.[4]

First, landfill gas and natural gas have different compositions and different characteristics. Landfill gas is comprised of roughly half methane and half carbon dioxide. In contrast, natural gas is comprised of 100% methane. Landfill gas is slightly heavier than air, influencing its dispersion and behavior differently than methane, which is significantly lighter than air. In addition, landfill gas emissions occur due to the decomposition of organic waste that is already a part of the carbon cycle, whereas oil and gas emissions are primarily the result of extracting, processing, and transporting fossilized carbon from underground shale areas and introducing that carbon into the carbon cycle.

Emission rates also differ significantly between landfills and oil and gas facilities. Leaks at oil and gas facilities tend to occur at a relatively constant rate under significant positive pressure. Landfill gas collection and control systems, on the other hand, are generally maintained at negative pressure, thereby causing any leaks to be released at near-atmospheric pressure. Leaks at landfills are ephemeral and can vary significantly depending on a number of factors, including construction activities, atmospheric and meteorological conditions, operational fluctuations, and diurnal and seasonal considerations.

Moreover, municipal solid waste landfills and oil and gas facilities are operated in an entirely different manner, wherein some emissions are expected and intrinsic to landfill operation. By contrast, emissions from oil and gas facilities are not intrinsic and can be mitigated and/or avoided with proper management and controls. Whereas oil and gas facilities are static, municipal solid waste landfills are continuously under construction—the working face is consistently moving, new cells are being built, old cells are being closed, and other cells are undergoing placement of intermediate cover. Accordingly, landfill gas emissions are expected to occur over the active life of the landfill as a result of such construction.

In addition to the ephemeral nature of leaks and the constant state of construction at landfills, landfill gas emissions are also highly influenced by the topographic nature of landfills. For example, landfills may have an abundance of hills, ditches, high areas, and low-lying areas, each with their own unique "micro-climate." As a result, landfill gas acts according to the micro-meteorological factors where it is emitted, including significant variance of windspeed,

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[3] *See* Veritas Comment, EPA-HQ-OAR-2024-0350-0021.

[4] Although the RFI is for the express purpose of considering emerging measurement technologies in the context of the GHGRP, NWRA is also aware of EPA's intent to commence a rulemaking process to revise the New Source Performance Standards ("NSPS") and Emission Guidelines ("EG") governing municipal solid waste landfills.

temperature, and barometric pressure at the surface of the landfill versus higher up in the atmosphere. Moreover, landfill gas tends to travel along the surface of the ground outward. As landfill gas moves downhill, it tends to pool, impinging on and complicating attempts to quantify it using aerial techniques. More specifically, when landfill gas pools, measurement technologies tend to inaccurately overestimate emissions. To further complicate the behavior of landfill gas, ground-level vegetation and other physical interferences exercise influence over the movement of landfill gas. Accordingly, landfill gas plumes behave in a non-Gaussian manner (i.e., skewed and uneven). In contrast, the topography of oil and gas exploration wells tend to be relatively uniform, allowing plumes of methane to follow Gaussian distribution (i.e., spread from a continuous point in a predictable pattern of dispersion). EPA should prioritize characterizing and evaluating the impacts of topographic conditions on landfill gas behavior, and in turn, emissions quantification.

As a result of these differences, emission detection techniques have historically differed across both industries. For roughly thirty years, landfill emissions have been calculated under the GHGRP using a *modeled* approach—the applicable formulas use: 1) the difference between the estimated landfill gas generated and the amount collected; or 2) an assumed collection efficiency is applied to the collected gas to estimate uncaptured emissions. From a work practice standpoint, under the NSPS/EG rules, fugitive emissions from covered areas are detected and mitigated by conducting Surface Emissions Monitoring ("SEM") utilizing a modified EPA Method 21 to detect a methane concentrations at the surface of the landfill. At oil and gas facilities, emissions are measured utilizing a variety of techniques including direct measurement with sensors installed at key points, such as valves and compressor stations, to continuously monitor and detect leaks. Oil and gas facilities also use Method 21, but instead of SEM, portable gas analyzers measure specific components around equipment such as pumps, valves and flanges. Accordingly, oil and gas facilities are able to directly *measure* emissions, due entirely to the fact that their facilities are constructed and operated in a manner that imposes little to no uncertainty with respect to detecting, measuring, and quantifying emissions directly.

For all of the above reasons, the approaches to detecting, quantifying and reducing emissions from landfills and from oil and gas facilities must likewise differ. These differences have directly informed NWRA members' experience with emerging measurement technologies and our comments to the RFI questions set forth below.

B. Emerging measurement technologies are being evaluated at municipal solid waste landfills.[5]

NWRA and its members have been deeply engaged in the evaluation of various emerging measurement technologies, including fixed sensor, handheld equipment, drone, aircraft and satellite. These types of technologies may utilize various detection techniques, as follows:

- Mobile Gaussian Plume Assessment ("MGPA") utilizes a high-performance methane analyzer deployed in a vehicle and carried along transects at the fenceline or further downwind, alongside geolocated wind speed and direction measurements.

[5] The text included in this section is responsive to RFI Question 1.a.i.

- Mobile Tracer Correlation Emission Assessment ("MTCEA") involves a controlled release of a non-reactive gas, such as sulfur hexafluoride or acetylene, that is easy to detect and distinguish from other gases emitted by the landfill, so that correlation can be made with target gases and the tracer gas can be used to estimate emissions of the target gases.

- Gas mapping light detection and ranging ("LiDAR") uses a pulse beam of radiation that reflects off the ground surface, and back to the aircraft where a specialized receiver detects and analyzes the special signature of light absorbed or scattered by methane in the atmosphere, with a resulting column measurement that can be used for detection or quantification.

- UAV Column Sensor Emission Assessment ("UCSEA") is a UAV-mounted Tunable Diode Laser that emits a narrow beam of light at a wavelength appropriate to detect methane by using its special signature. The laser is carried on the underside of the UAV and is directed towards the ground. The laser beam reflects off the ground and back to the UAV. During its travel, the beam interacts with the gas molecules and some of the light is absorbed at specific wavelengths corresponding to the molecular absorption lines of methane. The technology is often called TDLAS, Active TDLAS, or a "column-type" sensor. Measurements are retrieved in ppm*m.

- UAV Point Sensor Emission Assessment ("UPSEA") uses a drone with a mounted TDLAS, MOS, or other point measurement sensor for landfill gas quantification. In the method, the UAV flies repeated horizontal transects perpendicular to the wind direction and repeats the measurements at different altitudes to paint in a screen or curtain. Sometimes called a "flux plane" measurement, the method sees wind speed, temperature and pressure values interpolated across the plane, after which the interpolated values are used in a mass balance equation to solve for emission rate.

- Airborne Point Sensor Emission Assessment ("APSEA") uses high-performance gas analyzer mounted in a small aircraft. Flying stacked orbits at a radius slightly larger than the site. Orbits are repeated at progressively higher altitudes until the aircraft reaches the top of the surface-mixed layer. Wind values may be measured in the air, or wind estimates are procured from databases. The wind and methane concentration are interpolated onto a flux screen around the site, and the flux rate is solved using mass balance equation.

- Remote Point Sensor Emission Assessment ("RPSEA") consists of freestanding stations around the landfill perimeter in which various environmental sensors are used to measure wind speed, wind direction, temperature, pressure, and humidity. Methane detection is done using a metal oxide (MOS) sensor. Another type uses an open path Fourier Transform infrared (FT-IR) spectrometer. Algorithms are used to continually assess facility emission using an inverse source dispersion model, or similar.

- Satellite Imaging Sensor Emission Assessment ("SISEA") uses a satellite-mounted sensor to take a series of images and collect methane column measurements for individual pixels. The images are merged, and an interference pattern is created which allows the quantification and detection of methane emissions at facility scale.

- Lagrangian Emission Assessment ("LEA") combines the type of truck-based sampling used in MGPA but pairs the measurements with a different post-processing algorithm. Lagrangian models are commonly used to predict source location probabilities and can be used to calculate emission rates for either point or area-based sources. Normally, Lagrangian models are applied to tower-based measurements, but can be adapted to a mobile setting, as if the tower were moving through the domain.

See, *Hossian* et. al., *A Controlled Release Experiment for Investigation Methane Measurement Performance at Landfills* (2024) ("First EREF Controlled Release Study").[6]

Each of these technologies was evaluated in a comprehensive landfill study by the Environmental Research & Education Foundation ("EREF") at the Petrolia Landfill in Canada between November 6, 2023, and November 14, 2023. The following technologies and platform types were assessed in the study:

Table 1: Summary of methodologies that participated in the controlled release study

Technology Identifier	Technology Type	Platform Type	Sensor	Method	R&D ?
A	Quantification/ Detection	Truck	LGR	MGPA	No
B	Quantification	Truck	LICOR	MGPA	No
C	Quantification/ Detection	Drone	TDLAS	UPSEA	No
D	Quantification	Drone	Mid-IR LDS	UPSEA	No
E	Quantification	Truck	Picarro	MTCEA	No
F	Quantification	Aircraft	Picarro	APSEA	No
G	Quantification/ Detection	Helicopter	LiDAR	LiDAR	No
H	Quantification/ Detection	Satellite	Spectrometer	SISEA	No
I	Quantification	Fixed	EM27	RPSEA	Yes
J	Quantification	Fixed	Metal Oxide	RPSEA	Yes
K	Quantification	Fixed	Metal Oxide	RPSEA	Yes
L	Detection	Drone	TDLAS/ Laser Falcon	UCSEA	No
M	Detection	Drone	TDLAS/ Laser Falcon	UCSEA	No
N	Quantification/ Detection	Truck	LGR	LEA	Yes

[6] A copy of the First EREF Controlled Release Study is attached hereto as Exhibit 2.

The primary findings from the First EREF Controlled Release Study can be summarized as follows:

- MTCEA provided good quantification estimates while being flexible to operate in various weather conditions.
    - One vendor evaluated
    - Average uncertainty of ± 20%
- Gas Mapping LiDAR can detect source leaks to 1-3 kg/hr with 90% probability
    - One vendor evaluated
    - Average uncertainty of ± 45%
- UPSEA can only operate in conditions with no precipitation and windspeed below 12 m/s.
    - Two vendors evaluated
    - Combined average uncertainty of ± 48%
- UCSEA reported high number of false positives (False positive fraction > 0.79) with limited visibility when measuring active emission points on slopes
    - Two vendors evaluated
    - Leak detection only
- RPSEA has not been validated by any other studies for use in landfill applications.
    - Three vendors evaluated
    - Average uncertainty of ± 39% in the best-case scenario
- MGPA methodologies were limited by a compressed timeline. Further studies are required to include necessary time for replication.
    - Two vendors evaluated
    - Average uncertainty of ± 43%
- APSEA consistently underestimated emission rates with low bias where predicted emission rates were only 52% of actual values and required meteorological conditions (*i.e.*, low cloud cover, windspeed from 2-6 m/s, good solar insolation) that allowed for a plume to rise and disperse.
    - One vendor evaluated
- SISEA can detect large emission events at or above 300 kg/hr and requires little to no cloud cover and wind speeds less than 10 m/s
    - One vendor evaluated
- LEA overestimated emissions in most cases and is a methodology typically applies in a tower-based system
    - One vendor evaluated

The First EREF Controlled Release Study evidences variability across technology types and even across vendors within specific technology types. The study provided insight on how these technologies operated and performed at a closed landfill setting and provides a baseline for future controlled release studies. Pictorial depictions of the First EREF Controlled Release Study results are shown in the following:

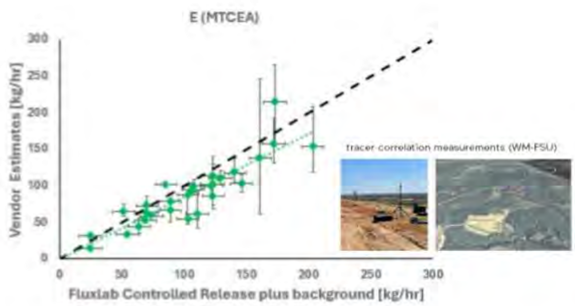
EMISSIONS MEASUREMENT KEY LEARNINGS

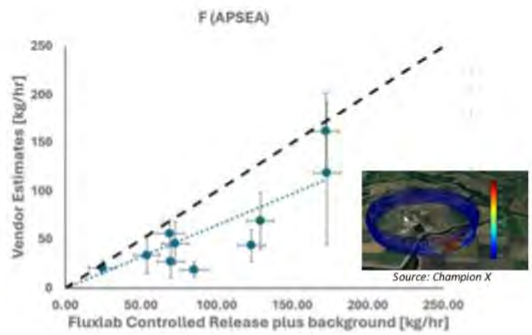
EREF 1st Controlled Release Study

Quantification Results: Mobile Tracer Correlation and Aircraft Mass Balance

Mobile Tracer Correlation– good alignment with true release rates but complex and limited by accessible roads

Aircraft Mass Balance– some alignment but limited by weather conditions and cost





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*Aerial Point Sensor (APS)

EMISSIONS MEASUREMENT KEY LEARNINGS

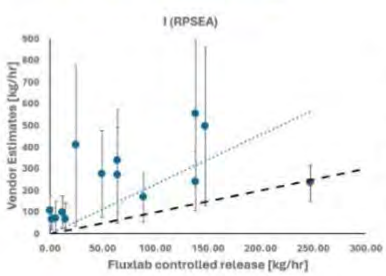
EREF 1st Controlled Release Study

Fixed sensor quantification results varies between vendors

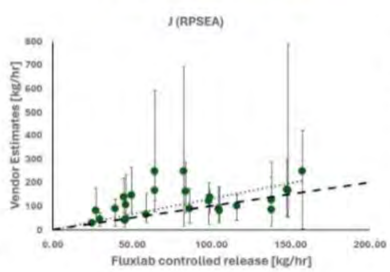
Source: Champion X

Algorithms were developed for Oil and Gas and still under development for landfills
Take-away: fixed sensors aren't there yet; deeper dive needed into vendors

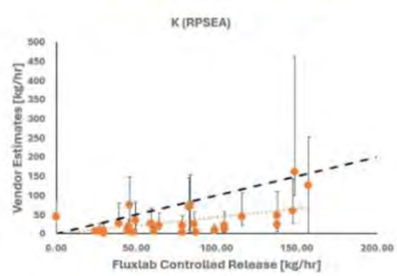
Over-estimating



Aligns Generally



Under-estimating



13 * Remote point sensor emission assessment

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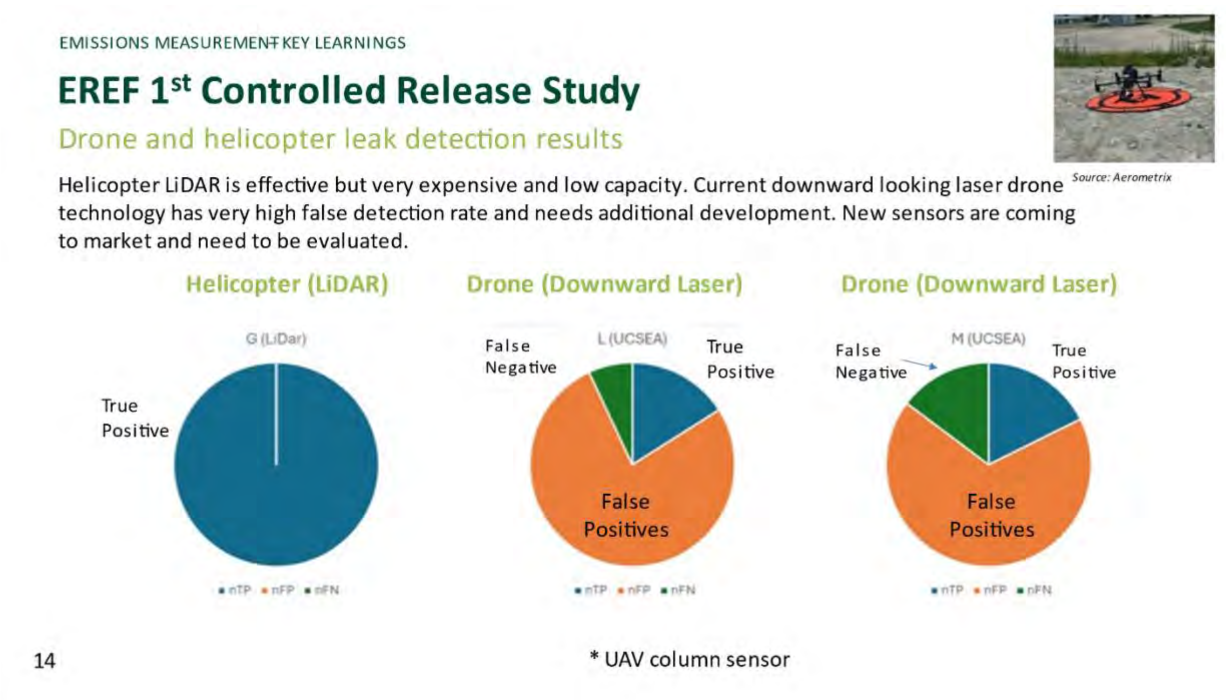

A second controlled release study is underway at the closed Petrolia Landfill to further evaluate these technologies and their vendors. The infrastructure to support releases was improved prior to the second study in order to allow multiple future controlled release studies and allow greater access to vendors to the area of the release. In particular, burying gas-piping intended to allow foot patrols of the area, and ground-based follow-up observations that are a part of some vendor service offerings. Additional invitations to vendors, and adjustments to the study protocol (e.g., higher rates for some planned release windows) were completed to allow more technology vendors to participate. The primary objectives of this Second Controlled Release Study are listed as follows:[7]

- Conduct a comparative assessment of multiple landfill emissions measurement technologies at a single site simultaneously;
- Determine the accuracy of these technologies via controlled, known release of methane;
- Assess annualized costs of utilizing these technologies at different frequencies on sites of different size;
- Evaluate variability in accuracy under different site conditions (.e.g. weather, temperature, season, etc.) *(NOTE: this objective may be considered optional or as a 2nd phase effort depending on additional cost/time needed to complete it)*.

In addition to the technologies studied by EREF, several of NWRA's member companies have engaged directly with technology vendors to evaluate the use and accuracy of satellite, aerial, drone and fixed measurements on a site-specific basis. Some findings are summarized below, but overall highlight a current lack of consistency and reliability among technologies, and an understanding that no one technology can be useful without contemporaneous site operational

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[7] NWRA will share the Final Report of the Second EREF Controlled Release Study when it becomes available. NWRA will similarly share the details and reports regarding a third controlled release event scheduled to occur in the spring of 2025.

data to accurately quantify emissions.

Finally, EPA hosted a Municipal Solid Waste Landfill Technology Workshop ("Technology Workshop") in October 2024 in Research Triangle Park. With over 100 participants, the Technology Workshop highlighted both the potential future promise but also the current gaps in readiness of these technologies to be deployed as regulatory compliance monitoring tools. Although the Technology Workshop materials have not yet been made public, NWRA urges EPA to closely evaluate them in context of the RFI.

C. Emerging technologies are currently incapable of detecting emissions at municipal solid waste landfills with the same level of precision as in the oil and gas sector.[8]

Due to the differences described above, emerging measurement technologies are currently incapable of detecting municipal solid waste landfill emissions at the same level of precision or certainty as in the oil and gas sector.

Oil and gas sector emissions are generally easier to detect than landfill gas emissions. First, as noted earlier, oil and gas emissions themselves tend to be either: routine or continuous leaks from processing equipment that (as an equipment class) can be known to leak (*i.e.*, compressor shaft seals, flange connections, etc.); or some kind of non-routine, episodic failure in a location that may or may not be prevalent. For the first type, routine methane detection of processing equipment and flange attachments would likely identify any emission points, leading to precise corrective action, as they are required to do. Because these emissions usually happen as part of a mechanical process at relatively stable and continuous process status, their emission rate can be relatively easily quantified. *See infra* Section II.D. For episodic emissions, monitoring—such as continuous fence line and periodic drone, plane, or satellite scanning—can give some assurance that these events will be detected, or that no non-routine emissions have occurred. But again, because the oil and gas operations are happening at known/recorded process status, once identified the leak event can be somewhat readily quantified. These types of monitoring are also useful due to the geographic nature of oil and gas operations; there are many facilities that are not regularly manned, so fence line and aerial campaigns can collect data very efficiently.

Landfill emissions, however, are neither so reliably detected nor quantified. First, there are generally two areas of landfill emissions: emissions that are recently referred to by EPA as "intrinsic" emissions, such as those that relate to the landfill working face, maintenance activities, and diffuse emissions through landfill cover; [9] and discrete emission sources such as cover system failures, gas extraction issues, and infrastructure leaks, flare issues, or venting due to malfunctions (including both install and failure).[10]

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[8] The text included in this section is responsive to RFI Questions 1.a. and 2.

[9] Members of EPA's Office of Research and Development ("ORD") have referred to these emissions as "intrinsic" or "expected" in that they can be partially controlled but never eliminated. *See e.g.*, EPA webinar materials, *Airborne Survey-Methane from U.S. Landfills*, at slide 13, attached hereto as Exhibit 3.

[10] ORD has referred to these emissions as "fugitive" in that they are more easily dealt with via the "find-and-fix" method. *Id*.

Intrinsic emissions are ephemeral and vary significantly depending on a number of factors, including construction activities, topography, weather, barometric pressure, and diurnal and seasonal considerations. Due to the diffuse and variable nature of landfill emissions, fence line type sensors can have variable reliability in detecting and locating, and low emissions rates are challenging for plane and satellites to detect. Episodic “fugitive” emissions can be somewhat easier to locate, as operators are typically immediately aware of or become aware of discrete infrastructure failures through olfactory and visual inspection as well as routine gas collection and control system monitoring.

Aerial and satellite methodologies are limited by diurnal and seasonal considerations and fail to account for micro-climate fluctuations that occur as a result of topographic differences across landfills. The following figure evidences the behavioral impact that complex topography has on landfill gas emissions:

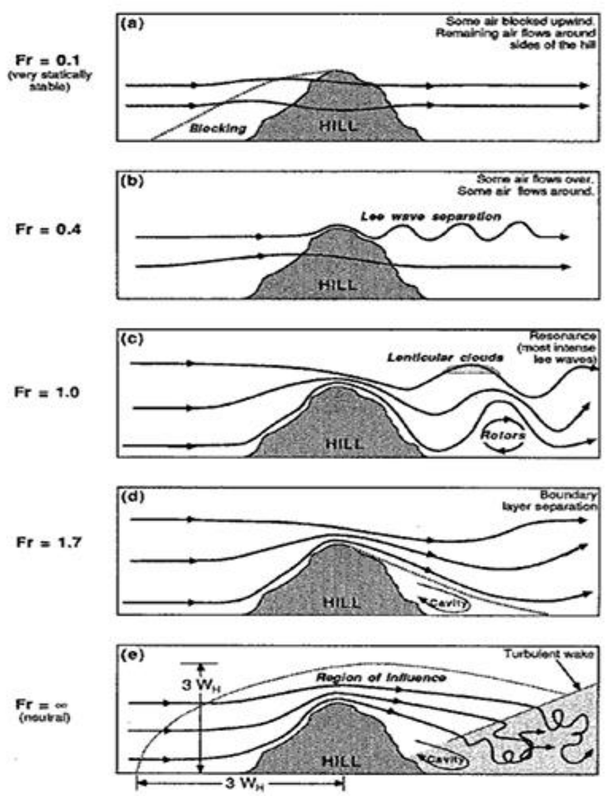


Figure 3: Idealized flow over an isolated hill. Different stability conditions are defined by the values of the Froude number Fr=U/(NL), where U is the wind speed, N the Brunt-Vaisala frequency and L is the length scale of the hill (from Stull, 1988, p. 602, fig. 14.4). [Reprinted with kind permission from Kluwer Academic Publishers]

See Finardi, et al., *Wind Flow Models over Complex Terrain for Dispersion Calculations*, at 8 (1997).

EPA has also acknowledged that aerial and satellite technologies are limited in their detection capacity, particularly with respect to "diffuse area sources."[11] Moreover, remote sensing technologies are limited by cloud cover and surface reflectivity anomalies as well as wind speed and direction. Satellite orbital hours vary by season and geographic location—for example, the orbital schedule for nine satellites over Colorado in November 2024 were all within a 5-hour window. In addition, aircraft flights must be "carefully planned and operated" in order to "capture plumes accurately," making them unsuitable for unpredictable landfill emissions and putting them directly at odds with the very nature of landfills, whose working face is constantly moving and whose cells are constantly under construction. Direct in-situ aerial sampling is similarly situated. Though it is capable of capturing both point sources and diffuse area sources, flight and sampling conditions must be "ideal"—that is, wind speed and direction are moderate and steady and turbulence and precipitation are limited—in order to achieve the greatest accuracy. Both remote and direct in situ technologies are hindered by their threshold detection capabilities.[12]

UAV technologies, including UCSEA and UPSEA, were evaluated in the First EREF Controlled Release Study, but have not been validated for use in the oil and gas sector. The study concluded, with respect to UCSEA, that because "[m]ost of the laser beam's transit is of course through atmospheric air containing relatively little methane," "a strong methane enhancement at the surface is diluted by the air above and can be difficult to detect, unless the sensor has very high precision, or flight altitude is reduced."[13] Vendors at the Technology Workshop indicated that the detection and quantification capabilities of UAV technologies is dependent on suitable wind and meteorological conditions.

Ground-based measurement technologies also have detection limitations. In particular, certain sensor vendors have indicated that sensors cannot account for the complex topography of landfills and typically employ dispersion models that assume flat ground. Additionally, vendors have indicated that additional research is necessary to better understand how their sensor can detect and quantify landfill gas plumes that stay close to the surface of the landfill, as distinct from oil and gas plumes. While fixed, ground-based sensors appear to have promising detection capabilities at 0.1 kg/hr or below, the vendors have acknowledged that their capabilities also depend on ideal wind and meteorological conditions during daytime hours.[14]

While certain of the existing advanced measurement technologies are able to attribute landfill emissions, including UAV technologies, satellite technologies are incapable of attributing detected plumes to specific equipment types, facilities, or processes in an automated manner. Carbon Mapper describes its attribution process as one considering two criteria: "high concentration—typically a spatially tightly constrained area of maximal constrained area of maximal concentration, indicative of a large gas release," and "plausible RGB/GIS

[11] EPA, Whitepaper No. 6: *Aerial Monitoring for Examining Landfill Methane Emissions*, at 6 (Oct. 2024) ("Remote sensing technologies like AVRIS-NG and GAO are tuned to detect larger point sources and typically cannot detect the lower concentration, diffuse area sources; thus, remote sensing technologies typically do not encapsulate those diffuse emissions into their emission estimates from a site.").

[12] *Id.* at 8.

[13] Exhibit 2, First EREF Controlled Release Study, at 19.

[14] *Id.* at 64.

infrastructure."[15] Carbon Mapper then attributes plumes to "sectors," rather than specific areas within the site.

D. *Point in time observations cannot be appropriately or reliably quantified and compared to annualized reported emissions*[16]

1. General Quantification Difficulties

Existing advanced measurement technologies cannot provide quantified methane emission rates for municipal solid waste landfills using transparent, open-source, and standardized methodologies at this point in time. In fact, no standardized quantification methodologies currently exist for solid waste landfills. As evident from the Technology Workshop, technology vendors apply their own unique—and in many cases proprietary—quantification algorithms in quantifying detected emissions, though it is unclear whether their algorithms can be adjusted to account for the factors unique to municipal solid waste landfills.

In the recently updated NSPS/EG applicable to oil and gas facilities, EPA implemented a "Super Emitter Program."[17] The Super Emitter Program is based on third party detection and reporting of leaks and releases of 100 kg/hr or more of methane from affected facilities (individual well sites, centralized production facilities, compressor stations, and natural gas processing plants). Although the Super Emitter Program envisions an EPA verification and certification process for third-party observers and their technologies, no third parties have been certified for the purposes of the Super Emitter Program, so no lessons can be learned yet from its implementation. Indeed, the National Institute of Standards and Technology ("NIST") has since recognized that there is an "[a]bsence of consistent definitions, best practices, and protocols for plume identification, data quality control, emissions analysis, and independent validation" with respect to greenhouse gas emissions from "energy exploitation and waste" facilities.[18]

EPA's "Super Emitter" requirements for the oil and gas sector are not directly transferrable to landfills because of the differences between oil and gas facilities and landfills. As mentioned earlier, oil and gas emissions tend to happen at physical locations where process data is available, or at least relatively easily approximated. For routine emissions, release quantification is relatively straight forward. Further, oil and gas emissions are predominantly methane. Methane is, by itself, lighter than air, and once released forms a Gaussian plume more easily due to the underlying assumption about gas buoyancy of Gaussian plumes. More specifically, Gaussian dispersion "applies to neutrally buoyant dispersion of gases in which the turbulent mixing is the dominant feature of the dispersion" which is "typically valid only for a distance of 0.1-19 km from the release point."[19] Further, oil and gas infrastructure has limited topographical impacts, allowing wind to help "form" the plume. This means that for episodic emissions, determining where to put fence line monitors is more readily discernable, and aerial

[15] *See* Carbon Mapper Quality Control Description Document, at 5–6.
[16] The text in this section is responsive to RFI Questions 1.a and 1.b.
[17] *See Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review*, 89 Fed. Reg. 16820, 16876–81 (March 8, 2024).
[18] *See* NIST, *Workshop Report: Methane Super-Emitter Consensus Standards Workshop*, at 1 (July 2024).
[19] DANIEL CROWL & JOSEPH LOUVAR, CHEMICAL PROCESS SAFETY: FUNDAMENTALS WITH APPLICATIONS 194 (Andreas Acrivos et al., eds., 2nd ed. 2002).

campaigns have a more predictable "success" rate of quantification. Once identified, the plume can be tied to operational data for straightforward calculation.

In contrast, landfill gas emissions are not so easily detected. For intrinsic emissions, the large size of landfills (often >100 acres) and their topographical features make predicting where fence line monitors should reliably be able to pick up emissions very difficult. Furthermore, because the fence line is usually "far" away, significant dilution occurs and back-tracking to the diffuse emission would be quite difficult without mountains of site-specific topographical modeling and discrete wind data. SEM can more reliably find diffuse emissions but using Method 21 or OTM 51 to quantify or model intrinsic emissions from large areas simply has not been done consistently or reliably. Second, landfill gas is a dense gas that behaves differently than pure methane from oil and gas facilities:

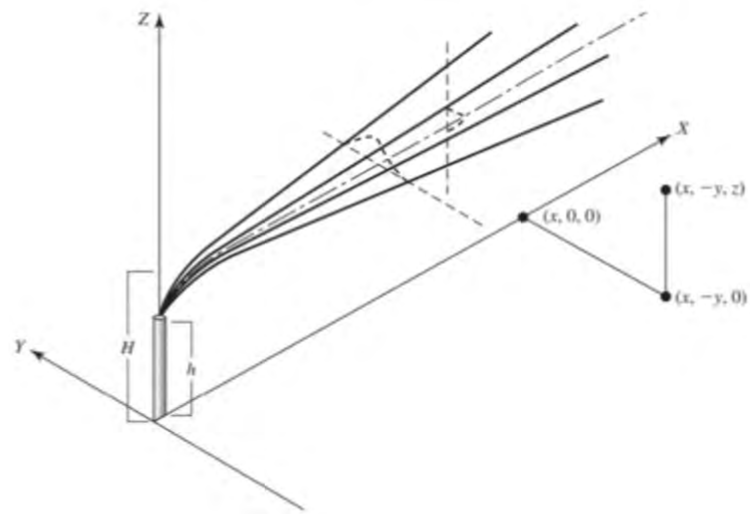
> *Following a typical puff release, a cloud having similar vertical and horizontal dimensions (near the source) may form. The dense cloud slumps toward the ground under the influence of gravity, increasing its diameter and reducing its height. Considerable initial dilution occurs because of the gravity-driven intrusion of the cloud into the ambient air. Subsequently, the cloud height increases because of further entrainment of air across both the vertical and the horizontal interfaces. After sufficient dilution occurs, normal atmospheric turbulence predominates over gravitational forces and typical Gaussian characteristics are exhibited.*[20]

Accordingly, emissions detection and quantification will be limited by the behavior of dense landfill gas, which is also heavily influenced by topographic, atmospheric, and meteorological elements, as described and depicted *supra* in Section II.A.

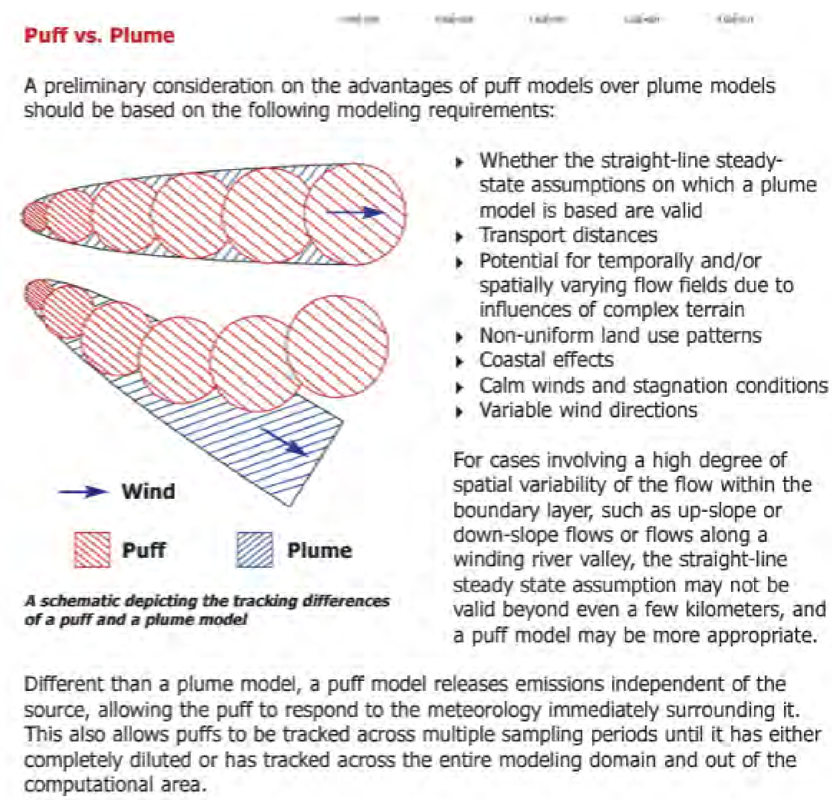
These topographic, atmospheric, and meteorological elements limit the use of technologies whose algorithms employ or assume Gaussian dispersion exists in all detected plumes. The figures below illustrate the difference in dispersion between Gaussian plumes and puff releases:

[20] CROWL & LOUVAR, at 195.

Figure 1. Orientation of the Gaussian plume model.



See Lucas Monteiro Nogueira, Air Pollution and the Gaussian Plume Model (Nov. 15, 2020).



Puff vs. Plume

A preliminary consideration on the advantages of puff models over plume models should be based on the following modeling requirements:

A schematic depicting the tracking differences of a puff and a plume model

- Whether the straight-line steady-state assumptions on which a plume model is based are valid
- Transport distances
- Potential for temporally and/or spatially varying flow fields due to influences of complex terrain
- Non-uniform land use patterns
- Coastal effects
- Calm winds and stagnation conditions
- Variable wind directions

For cases involving a high degree of spatial variability of the flow within the boundary layer, such as up-slope or down-slope flows or flows along a winding river valley, the straight-line steady state assumption may not be valid beyond even a few kilometers, and a puff model may be more appropriate.

Different than a plume model, a puff model releases emissions independent of the source, allowing the puff to respond to the meteorology immediately surrounding it. This also allows puffs to be tracked across multiple sampling periods until it has either completely diluted or has tracked across the entire modeling domain and out of the computational area.

See CALPUFF View, Lake Environmental.

Aerial measurements that rely on Integrated Mass Enhancement (IME) are reported to be less sensitive than Gaussian reverse dispersion calculation; however IME remains sensitive to low wind speeds. The documented approaches to estimating the effective wind speed used for emission rate calculations in literature do not account for landfill topography, surface roughness, and other micrometeorological impacts that may cause low local windspeeds, poor dispersion, and accumulation of methane over time. The accumulated methane will be observable to the aerial and satellite sensors but the assumptions related to wind and related methane dispersion have uncharacterized uncertainty that would bias measurements. Characterizing the these affects, the magnitude of the bias introduced, and strategies for meteorology data collection, limitations on monitoring approaches to avoid bias, or effective measures to overcome bias are a key research priority.

While existing drone campaigns include discrete methane and wind data, with some success, there is a general consensus that additional studies must be conducted to better understand the capabilities of drone detection and quantification. At this time, ORD has recognized the need to supplement all measurements with site-specific operations, meteorological, topographic data, etc. to get the full picture. However, different vendors have their own unique methodologies of incorporating such data, some of which are proprietary, others of which are applicable to oil and gas leak detection and not readily transferrable to landfill emissions.

Detection of episodic or "fugitive" emissions from landfills are subject to the same behavioral and environmental influences as intrinsic landfill emissions. In addition, episodic emissions happen at variable and unpredictable times and locations. Current detection technologies are not rapidly deployable and requisite wind data may not be readily available to track these emissions. Unlike oil and gas pipelines, where process data is readily available, landfills do not possess the granular data at this point in time to apply where such emissions may occur, such as for example, a header break.

Aerial and satellite detection of emissions from municipal solid waste landfills will be limited in accordance with the detection threshold of the relevant technology. Vendors have indicated that satellite technologies cannot detect emissions at rates below 100 kg/hr.[21]

2. Extrapolating point-in-time measurements into hourly and annual emission rates is inappropriate.

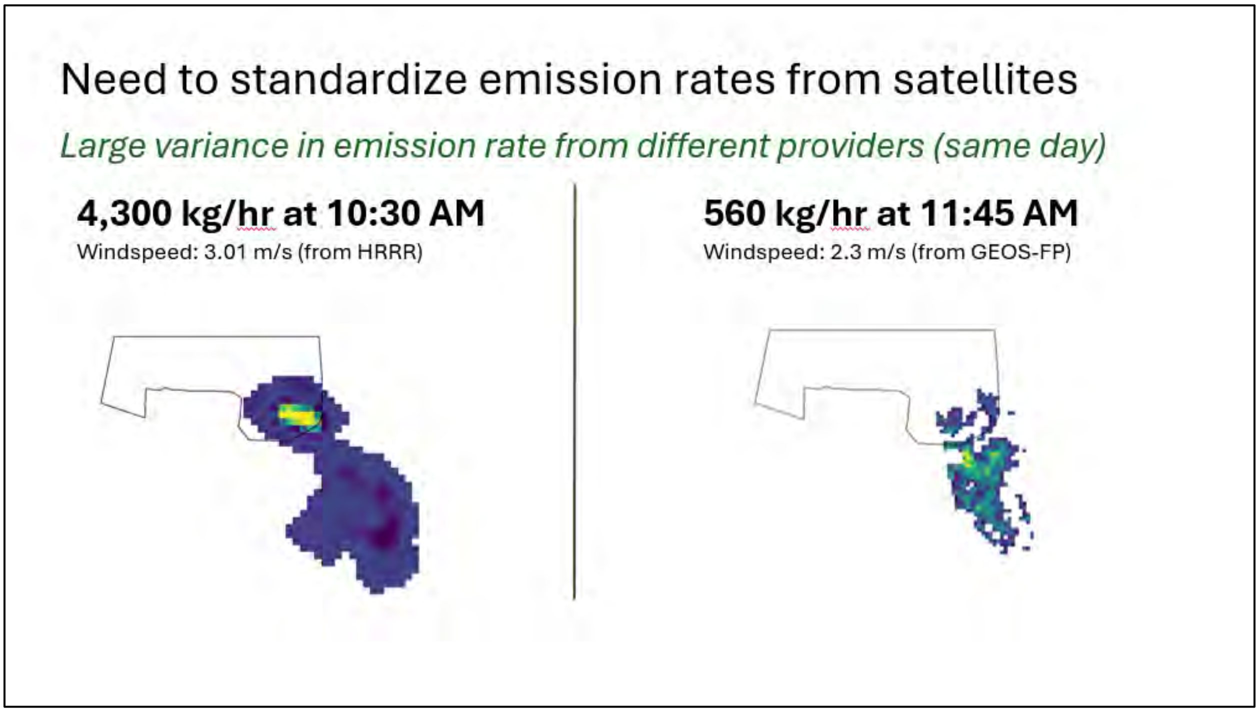
Though emerging measurement technologies purport to be capable of providing hourly and annual total methane emission estimates for specific municipal solid waste landfill facilities, there are shortfalls to their approach: (1) the approach does not differentiate between quantification methods for municipal solid waste landfills and oil and gas facilities; (2) the technologies cannot quantify point-in-time emissions rate with great enough certainty; and (3) the methodologies used to extrapolate point-in-time measurements into annual emission rates do not accurately capture emissions from individual facilities.

Vendors of fixed-sensor and UAV drone-based technologies have indicated their ability

[21] These threshold limitations may be resolved with a "stacked" approach, described in further detail *infra* in Section II.F.1. However, additional research and development is necessary to understand the capabilities of such an approach before its use in any regulatory determinations.

to calculate whole-site emissions using a mass balance approach. However, both fixed sensors and UAV technologies have spatial limitations that lead to unacceptable levels of uncertainty. Moreover, vendors of these technologies have not indicated that their approach in detection and quantification is unique to landfills, except for the use of site-specific data—however, how such data is utilized is generally proprietary and likely differs amongst vendors. Republic Services conducted a pilot study to evaluate the capabilities of metal oxide fixed sensors, a type of ground-based continuous emissions monitoring sensor. The specific metal oxide fixed sensors were originally designed for oil and gas facilities with the primary objective to identify significant emission events, with priority given to avoiding false alarms. With respect to landfills, the priority is less about detecting significant events, and more about identifying trends in overall methane emission, such as reductions caused by implementing capture systems. When Republic first deployed metal oxide fixed sensors, the plume model logic was identical to what is used on oil and gas facilities. The largest uncertainty in the plume model calculation is the distance between the sensor and the source, which feeds in to estimating the plume width and height. In February, Republic tested a new implementation of that distance estimate that ultimately did not yield significantly better results. From these learnings, an improved landfill model that eliminates the source to sensor distance in calculating the plume width needs to be developed and will take several months to deploy to assess the effectiveness of the changes.

With respect to satellite technologies, both Carbon Mapper and GHGSat have made their detection and quantification processes publicly available. However, neither indicate that they use an approach specific to landfills. Moreover, the approaches are not the same, and are therefore unlikely to yield the same results, indicating the need for better standardization amongst the same technologies. This issue has played out in practice when comparing emission rates estimated by one or more vendors evaluating the same plume. For example, as depicted below, at one landfill site, two measurements taken at very close points in time by different satellite measurement vendors were used to calculate very different emission rates. Despite being observed at nearly identical points in time, Vendor 1 calculated an emission rate of 4,300 kg/hr while Vendor 2 calculated an emission rate of 560 kg/hr.



Although extrapolation of point in time measurements to hourly and annual emission rates has been done by advocacy organizations using satellite and aerial data, NWRA does not believe that such extrapolation is accurate or appropriate. For example, a landfill methane emission map made available on EDF's website[22]would suggest large discrepancies between GHGRP reported emissions and emissions quantified using aerial and satellite measurements. However, a close review of the data reveals several points which tend to undermine these conclusions.

EDF extrapolated data from Carbon Mapper and TROPOMI to calculate hourly annual emission rates, without disclosing its calculations and methodology and explaining its decision not to include additional publicly available data from Carbon Mapper's database (e.g., EMIT data). Moreover, the very process of extrapolating point-in-time measurements to calculate an hourly annual emission rate irreconcilably clashes with the nature of emissions reported under the GHGRP. In particular, the emissions reported under the GHGRP are not annualized hourly emission rates, nor does the nature of landfill emissions lend itself to an assumed hourly rate. Further, there is limited value in reducing one or more remote observations to an assumed hourly emission rate based on a very limited data set - as the limited data set itself is evidence that more observations would likely lead to more agreement between reported and observed values.[23]

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[22] Environmental Defense Fund, *America's Hidden Landfill Emissions*, https://landfills.edf.org/interactive/ (last visited Nov. 22, 2024).

[23] As generally noted by *Cusworth, et al*., correlation between GHGRP reported values and values derived from remote measurements increase with increased numbers of measurements. Cusworth, et al., *Quantifying methane emissions from United States landfills*. 383 SCIENCE 1499, 1503 (2024) ("On average, aerial emission rates were a factor of 2.7 higher than GHGRP for all landfills and a factor 1.4 higher for landfills with 10+ unique overpasses.").

Moreover, there are several unexplainable transcription errors between the underlying data and the public-facing aspects of the map that have resulted in the display of emission rates that cannot be made sense of. And finally, even if the comparison of derived emission rates are taken at face value, the map would tend to show that many landfills are overreporting data when detection-derived values are compared to GHGRP reported values.

Thus, while particular vendors may have applicable internal standardization processes that would enable them to calculate annual emission rates, such calculations may not be meaningful where the applied processes and algorithms are not verifiable or consistent amongst technologies and are not transferrable among various sites. Quantification approaches for municipal solid waste landfills, if used for any regulatory purpose, for consistency should be limited to use of specific methodologies depending on the type of technology being deployed catering specifically to municipal solid waste landfills (*i.e.*, is not source agnostic). Until a consistent standardization process for each technology type exists that is unique to municipal solid waste landfills, these technologies are not ready for implementation into the municipal solid waste landfill regulations.

a. Too much uncertainty exists with respect to the detection and quantification abilities of emerging technologies to justify any regulatory switch from a modeled quantification approach to a measured one.

Under the GHGRP, as well as for other regulatory purposes, landfills have applied a modeled approach to emissions quantification. The modeled approach has been periodically updated; most recently in the 2024 Subpart HH Revisions. The finalized updates to Subpart HH are scheduled to become effective on January 1, 2025, and include revisions to emissions calculation equations applicable to landfills so as to account for periods of time where facilities' gas collection and control systems are not operating "normally." Accordingly, emissions of landfill gas that will occur as a result of operational inconsistencies and "large release events"—which EPA's ORD has referred to as "fugitive" or episodic emissions—will be accounted for within the updated modeled approach under the GHGRP. *See* Supplemental Proposal, 88 Fed. Reg. at 32877. These revisions will be implemented within 40 C.F.R. § 98.343, which includes several equations used to model methane emissions from municipal solid waste landfills. Equation HH-6 is used to "calculate CH4 emissions from the modeled CH4 generation and measured CH 4 recovery":

$$\text{Emissions} = \left[\left(G_{CH4} - \sum_{n=1}^{N} R_n\right) \times (1 - OX) + \sum_{n=1}^{N} \left\{R_n \times \left(1 - \left(DE_n \times f_{Dest,n}\right)\right)\right\}\right] \qquad \text{(Eq. HH-6)}$$

$F_{Dest,\,n}$ was revised to mean the following:

> Fraction of hours the destruction device associated with the nth measurement location was operating during active gas flow calculated as the annual operating hours for the destruction device divided by the annual hours flow was sent to the

destruction device. *The annual operating hours for the destruction device should include only those periods when flow was sent to the destruction device and the destruction device was operating at its intended temperature or other parameter indicative of effective operation. For flares, times when there is no flame present must be excluded from the annual operating hours for the destruction device.*

See 2024 Subpart HH Revisions, 89 Fed. Reg. at 31939 (emphasis added).

Similarly, Equations HH-7 and HH-8 are used to "calculate CH4 generation and CH4 emissions using measured CH4 recovery and estimated gas collection efficiency":

$$MG = \left[\frac{1}{CE}\sum_{c=1}^{C}\left[\frac{\sum_{x=1}^{X} R_{x,c}}{f_{Rec,c}}\right] \times (1 - OX)\right] \qquad \text{(Eq. HH–7)}$$

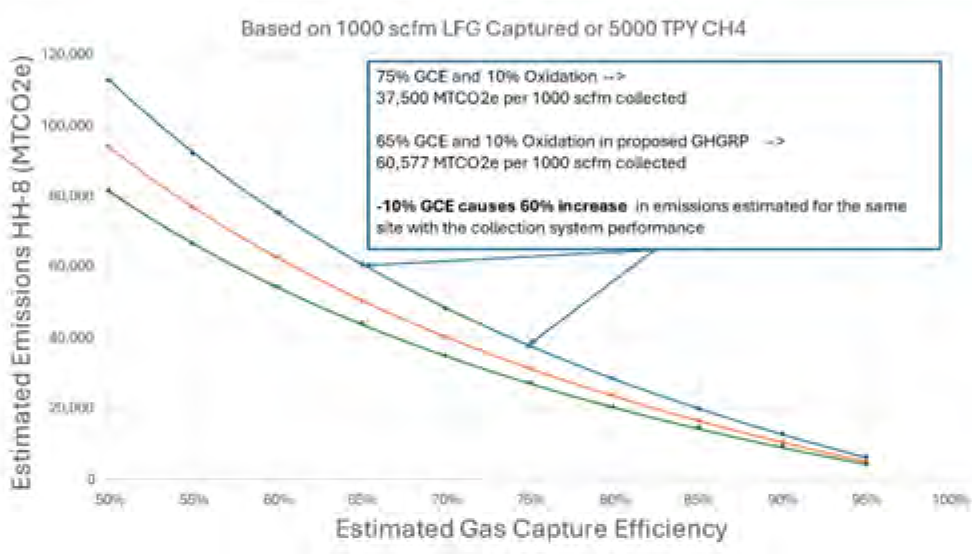
$$\text{Emissions} = \left[\left(\frac{1}{CE}\sum_{c=1}^{C}\left[\frac{\sum_{x=1}^{X} R_{x,c}}{f_{Rec,c}}\right] - \sum_{n=1}^{N} R_n\right) \times (1 - OX) + \sum_{n=1}^{N}\left\{R_n \times \left(1 - \left(DE_n \times f_{Dest,n}\right)\right)\right\}\right] \qquad \text{(Eq. HH–8)}$$

EPA updated the definition of $f_{Dest,n}$ as it pertains to HH-7 and HH-8 in the same way as it pertains to HH-6. Moreover, $f_{Rec,c}$ was updated to mean the following:

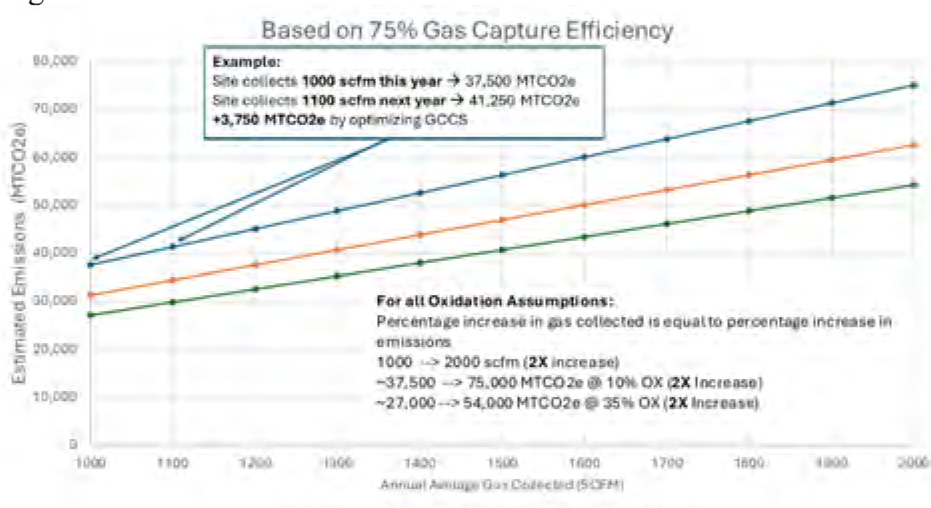
Fraction of hours the landfill gas collection system "c" *was operating normally* (annual operating hours/8760 hours per year or annual operating hours/8784 hours per year for a leap year). *Do not include periods of shutdown or poor operation, such as times when pressure, temperature, or other parameters indicative of operation are outside of normal variances, in the annual operating hours.*

See 2024 Subpart HH Revisions, 89 Fed. Reg. at 31939 (emphasis added).

Accordingly, both the revised definitions of $f_{Dest,n}$ and $f_{Rec,c}$ are intended to account for periods of operational anomalies, so as to reflect when gas collection was reduced and/or when emissions were greater than typical. To the extent that EPA believes that emerging measurement technologies would account for emissions that occur as a result of operational anomalies, it is imperative that EPA understand that those events are already accounted for by the modeled structure under Subpart HH. Indeed, by reducing Table HH-3 collection efficiency values based on assumptions derived from emerging measurement technologies, EPA has vastly overcorrected the perceived impacts of these so-called "large release events," and in so doing, has unfairly penalized landfill owners and operators by removing their ability to demonstrate reductions in emissions correlated with improved performance. As depicted below, the 10% mandated reduction in collection efficiency in GHGRP calculations results in an increase of 60% in reported emissions.



NWRA does not agree with this result or the basis on which it was determined, and believes that the mandated use of a "one-size-fits-all" reduced collection efficiency will tend to undermine, rather than support, incentives for improved site-specific performance. This is due in part to the assumption included in the finalized version of Equations HH-7 and HH-8: where gas collection increases, so does gas production and therefore, gas emissions. Under this assumption, the percentage increase in emissions becomes equal to the percentage increase in gas collected, as shown in the figure below:



In this respect, the 2024 Revisions to the GHGRP actually disincentivize greater gas collection, thereby disincentivizing investment in GCCS and impeding NWRA members' abilities to meet their emission reduction goals.

NWRA pointed out in its Petition for Reconsideration of the 2024 Subpart HH Revisions that satellite technologies currently involve too much uncertainty to justify their use in the regulatory realm.[24] For example, in the *Nesser* study cited by EPA in 2024 Subpart HH Revisions, the authors alleged that 77% of observed landfills underreported GHG emissions. However, 15 of 38 of the observed municipal solid waste landfills with gas collection and control systems were within the reported range of uncertainty.[25] While academic and advocacy papers do include uncertainty values in their supporting data, this detail and its import is often lost in the public-facing messaging surrounding this data, and likewise appears to not have been duly considered by EPA. In short, such large uncertainty values evidences the need for a more accurate approach to calculating annual rates.

Further, as discussed above, the uncertainties associated with each technology evaluated as part of the First EREF Controlled Release Study are varying and too large for justification within a regulatory program. Accuracy and certainty are of the utmost importance in the event EPA seeks to transition to a measured approach and away from the decades-old, modeled approach. EPA should feel justified in doing so only to the extent that emerging technologies prove that they can achieve the required degree of certainty, and can "quantify annual methane emissions under the GHGRP in a robust, transparent, accurate, standardized, and verifiable way."[26]

E. At this time, emerging technologies are not transparent, open-source, or standardized[27]

To the extent that academic papers have attempted to evaluate and quantify municipal solid waste landfill emissions using emerging measurement technologies, their conclusions are not well-founded or technically accurate and therefore cannot support the inclusion of such technologies into regulatory reporting or other requirements. For example, EPA cited to *Nesser*, et al. for the general proposition that "recent aerial studies indicate methane emissions from landfills may be considerably higher than bottom-up emissions reported under subpart HH for *some* landfills" and further noted that such higher emissions may be attributable to "poorly operating gas collection systems or destruction devices and leaking cover systems." [28] However, the *Nesser* study only observed 38 landfills using 2019 satellite (TROPOMI) data at approximately 25 x 25 km resolution to estimate methane emissions for grid cells in the contiguous United States with 2012 reported methane emissions larger than 0.1 Mg /(km year).[29] The study used low spatial resolution satellite data, which makes attributing emissions to specific landfills very difficult.[30] Moreover, the inversion model was not strongly sensitive to landfill

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[24] *See* Exhibit 1, Petition for Reconsideration, at 26.

[25] *Id.* (discussing Nesser et al., *High-resolution US methane emissions inferred from an inversion of 2019 TROPOMI satellite data: contributions from individual states, urban areas, and landfills*, ATMOSPHERIC CHEMISTRY & PHYSICS 5069 (2024).

[26] *See* RFI, 89 Fed. Reg. at 70178.

[27] The text in this subsection is responsive and relevant to all of the questions contained in the RFI.

[28] 2024 Subpart HH Revisions, 89 Fed. Reg. at 31854 (emphasis added).

[29] *Nesser*, et al., at 2, 4. NWRA's concerns regarding the *Nesser* paper can be found in greater detail in its Petition for Reconsideration. *See* Exhibit 1, at 25–28.

[30] Oil and gas researchers have cautioned against using TROPOMI, and satellites generally, for point-in-time measurements. Dubey, et al., *Minimum detection limits of the TROPOMI satellite sensor across North America and their implications for measuring oil and gas methane emissions*, 872 Science of the Total Env't, 2 (2023). ("Due to the quantity of emissions that can be captured in a single overpass, TROPOMI, and satellites in general, should be

emissions, and the authors rely on the 2012 inventory as the default emissions if not enough data was available to produce an optimized estimate. This approach ignores any changes that occurred at individual facilities between 2012 and 2019—potentially leading to the mis-attribution of emissions from sources that did not report in 2012. EPA also cited a paper by *Oonk* et al. to support its contention that "subpart HH underestimates the actual methane emissions released from landfills."[31] But *Oonk* et al. observed landfills in Holland, presented very little site-specific information on the observed landfills, and used the emissions measurement methods that were not well developed at the time, including modeled gas generation, which introduces additional uncertainty.[32] Similarly, EPA's reliance on a paper by *Duan* et al. is misplaced, as the study focused on 23 landfills in Denmark, and noted significant differences between Danish landfills and those in the U.S.[33]

Another paper by *Balasus*, et al. used wind-rotated oversampling of TROPOMI observations for each year from 2019 to 2023 to construct annually averaged methane plumes with 1 × 1 km2 resolution from four large Southeast U.S. landfills using the cross-sectional flux method (*Varon* et al. 2018) to quantify total annual emissions and uncertainties from the individual landfills.[34] The paper concludes that the generation-first model under the GHGRP conforms more with the measured results from the TROPOMI observations but that landfills with gas collection and control systems prefer to utilize the recovery-first model which "yields emissions that are one-quarter of those from the generation-first model[.]"[35] However, the conclusions from *Balasus*, et al. mischaracterize the relationship between Equations HH-6 and HH-7 and 8. The paper fails to acknowledge that landfills cannot use the recovery-first model under Equations HH-7 and HH-8 unless they have GCCS. Landfills do not have a GCCS until there is sufficient waste in place. Equation HH-6 is based on tonnage, which means that calculated emissions will ramp up quickly during initial operation.

Landfills generally begin installing GCCS infrastructure when they reach intermediate grades and elevations. Upon and after installation of GCCS infrastructure, landfills, of course, begin gas capture. When a landfill develops sufficient GCCS coverage across its footprint, Equations HH-7 and HH-8 can be appropriately used to calculate fugitive methane emissions. Considerable thought is taken as to when it becomes appropriate to transition away from the use

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used with caution. There is little use in using TROPOMI for a single measurement, but sustained measurements over a long period of time have great benefit. This optimal use of TROPOMI should be reflected in the policies that are developed moving forward.").

[31] 2024 Subpart HH Revisions, 89 Fed. Reg. at 31855.

[32] Oonk, H., *Efficiency of landfill gas collection for methane emission reduction. Greenhouse Gas Measurement and Management*, 129 (2012), https://doi.org/10.1080/20430779.2012.730798.

[33] NWRA commented extensively in its Petition as to the issues associated with EPA's reliance on the *Duan* et al. paper. *See* Exhibit 1, at 28–30 (discussing Duan, Z., et al., *Efficiency of gas collection systems at Danish landfills and implications for regulations*, 139 WASTE MANAGEMENT 270 (2022).

[34] Balasus, N., et al., *Satellite monitoring of annual US landfill methane emissions and trends* (Pre-publication) (2024).

[35] *Id.* at 1. It is important to reiterate that TROPOMI uses a low spatial resolution satellite data, making attribution to specific landfills difficult. Studies geared toward the oil and gas sector have stated that TROPOMI is less suitable for quantifying emissions from individual facilities than another satellite. Dubey, et al., *Minimum detection limits of the TROPOMI satellite sensor across North America and their implications for measuring oil and gas methane emissions*, 872 SCIENCE OF THE TOTAL ENV'T, 2 (2023). Moreover, TROPOMI is in sun-synchronous orbit so sites are observed as a single, non-representative time of day.

of HH-6 and to the use of Equations HH-7 and HH-8, in order to avoid grossly underreporting a recovery-first value. While there is a discrepancy between the results of Equation HH-6 versus Equation HH-8, it is not as distinct as *Balasus* alleges. And while another study by *Stark* et al. iterates the position that more operators "preferentially select the [Equation HH-8] method over the [Equation HH-6] method," the study acknowledged that "the purpose within GHGRP for having two different emissions estimation methods is to give the operators flexibility if good operating practices are employed that would likely result in decreased emissions from the site." *Stark* et al. also opined that the "default values for many of the parameters of the [Equation HH-6 approach]" themselves "retain high uncertainty."[36]

Moreover, as landfills start to reach maturity, incoming tonnage remains consistent, thereby causing the results of Equation HH-6 to "level off" to some extent, reducing the discrepancy between the results of Equation HH-6 and HH-8. As landfills reach final capacity, incoming tonnage begins to decrease, causing the results of HH-6 to "ramp down." As gas flows remain constant for a number of years post-closure, the results of Equation HH-8 do not decrease significantly—as a result, the use of Equation HH-8 causes overreporting compared to HH-6.

Balasus et al. wrongfully assumes that landfill operators simply pick the equation leading to lower resulting emissions. In reality, operators use site-specific knowledge to utilize the equations in the way that most appropriately comports with the actual conditions at the landfill. Often times, operators chose the more conservative outcome. For example, a WM landfill that stopped accepting waste five years ago and is fully capped, still reports significant calculated emissions due to gas production under Equation HH-8, despite the fact that HH-6 would result in nonexistent or even negative emissions. In addition, *Balasus* et al. used a method for quantifying emissions based on oversampling the low-resolution data—and this method has *not* been validated in any setting, particularly via controlled release or with other site-specific methods. The *Balasus* et al. study was also purposely conducted at four isolated landfills, to avoid interference of emissions from other, nearby sources. But this approach fails to acknowledge the realities facing many existing, operational landfills: namely, that emissions from nearby sources may indeed be misallocated to landfills.[37] There are agricultural sources of methane adjacent to one or more landfills that are contributing to the methane observations that are not discussed in the paper. Accordingly, EPA should not rely on *Balasus* et al. when considering whether and how to alter the modeling scheme under the GHGRP or dispense with it entirely by switching to a measured approach.

EPA has also indicated its intent to rely on a paper by *Cusworth*, et al.[38] But the conclusions in *Cusworth*, et al. support the contention that advanced measurement technologies are not primed for use in detecting, quantifying, and extrapolating annual emissions from municipal solid waste landfills without further research and development. Indeed, *Cusworth*, et al. concludes that "direct measurements of CH4 emissions at landfills to date using surface or aircraft instruments have largely been limited to a small number of facilities due primarily to

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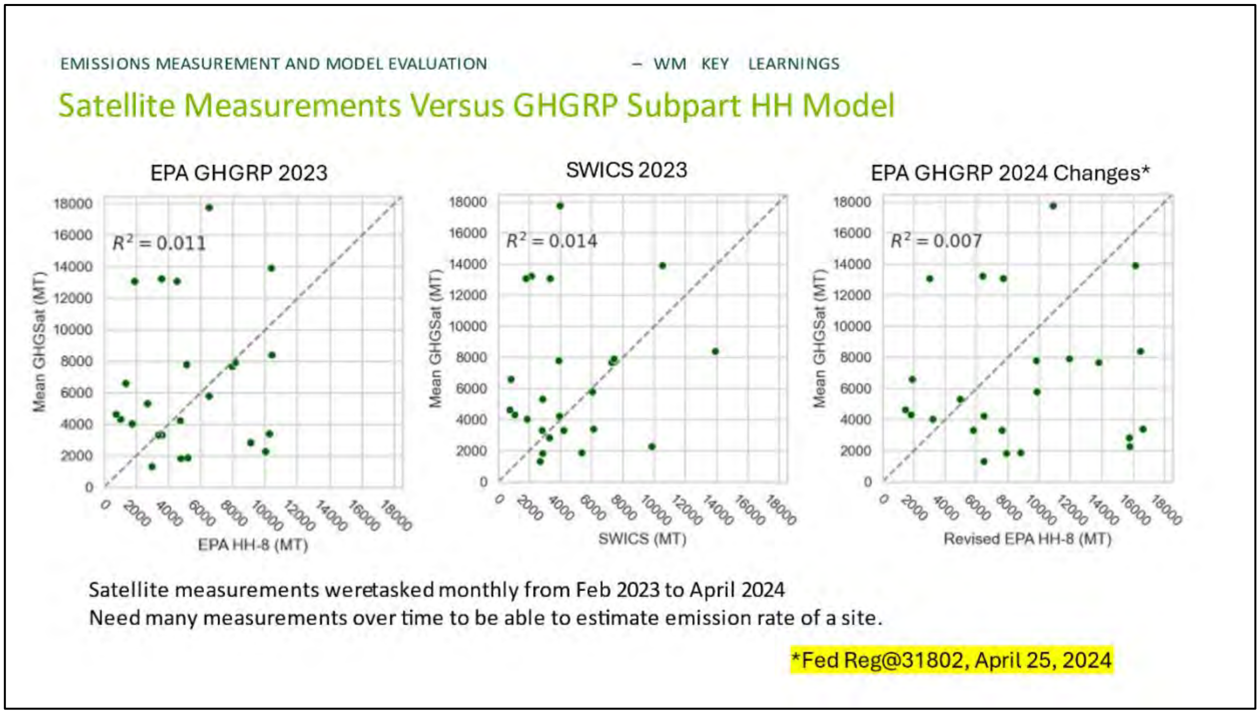
[36] *See* Stark et al., *Investigation of U.S. landfill GHG reporting program methane emission models*, 186 WASTE MANAGEMENT 86-93, at 87-88 (2024).
[37] *See* Nesser, et al. at 5079 (stating that some emissions from "co-located" oil and gas facilities may have been "misallocated" to the studied landfill).
[38] Cusworth, et al., *Quantifying methane emissions from United States landfills*. 383 SCIENCE 1499, 1499 (2024).

cost, which has resulted in incomplete spatial and temporal sampling. Given the diversity of operational and environmental factors driving landfill emissions, these observational limitations lead to continued uncertainty in this sector's contribution to regional, national, and global CH4 emission inventories, which can complicate assessing the efficacy of emission mitigation efforts."[39]

Each of these studies tended to focus on larger landfills above certain emission rates; they are therefore not representative of the national body of existing landfills subject to regulation under the GHGRP or NSPS/EG. For example, the *Nesser*, et al. paper does not include landfills with reported 2019 emissions below 300 kg.hr—approximately half of the landfills reporting under the GHGRP fall within this category.

Site-specific studies by NWRA members have also demonstrated the limitations of emerging measurement technologies for landfill gas emission quantification. In one example, WM undertook a twenty-five landfill study, using satellite measurements taken monthly from February 2023 to April 2024, to compare emissions quantified under pre-2024 GHGRP method, using the collection efficiencies required by the 2024 Subpart HH Revisions, and using Solid Waste Industry for Climate Solutions ("SWICS") Methodologies.[40] The comparison showed mixed results in terms of correlation, including that some sites would be overreporting, and some underreporting relative to both GHGRP methods. As a general matter however, the 2024 Subpart HH Revisions tended to result in more overreporting than underreporting when compared to data derived from emerging measurement technologies. In addition, of the three methodologies, SWICS was most consistent with data derived from satellite measurements, and as explained below is most responsive to real-time operational observations at municipal solid waste landfills. WM's study results are depicted below.

[39] *Id.*
[40] The SWICS model is discussed in greater detail *infra* in Section II, Subsection I.



F. *At this time, emerging technologies can be used as a tool to support landfill gas collection and control practices, in conjunction with site-specific data.*[41]

1. A "stacked" or "tiered" approach to the use of emerging technologies would allow for research and development as well as a better understanding of landfill emissions.

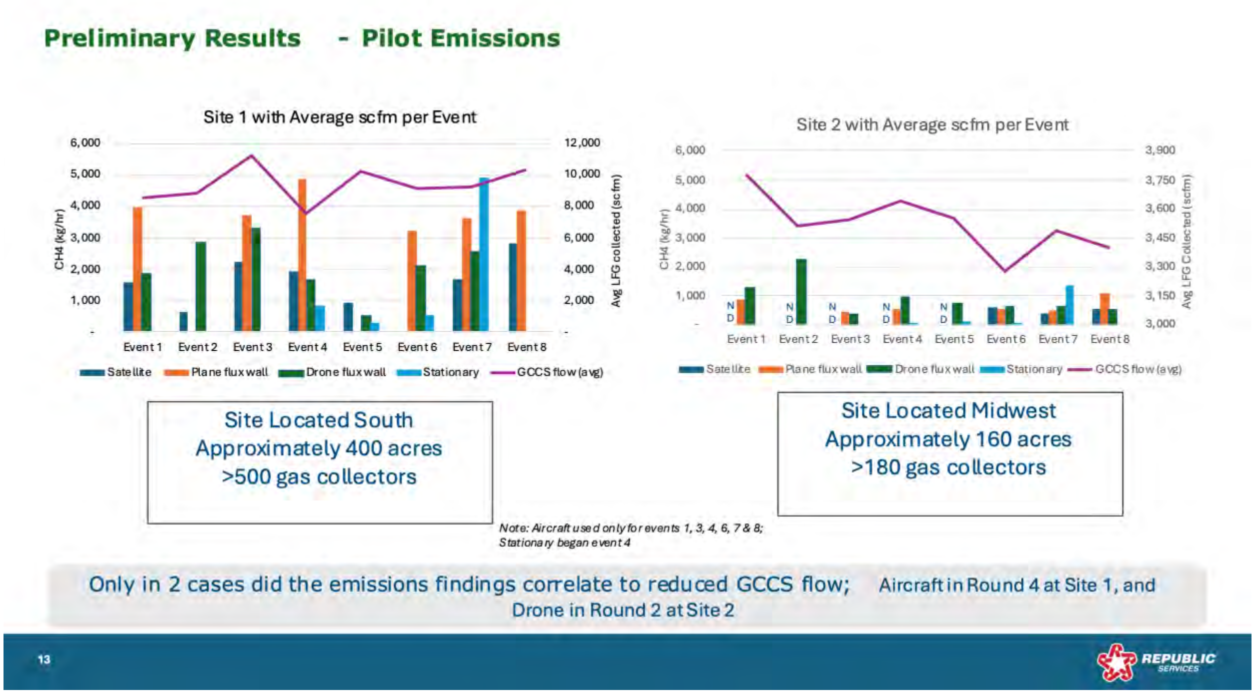
Representatives from EPA's ORD noted in their presentation at the Landfill Workshop that emerging measurement technologies are poised for a "stacked" or "tiered" approach at this time. This conclusions reflects those of recent scientific studies.[42] When asked what the "ideal" stacked approach would look like, ORD's representatives stated that satellite images should be supplemented with ground-level data from continuous sensors and UAV devices.

At this time, it remains unclear how a stacked or tiered approach could be implemented into the various regulatory programs, and whether and how remote sensing or direct measurement aerial technologies would be used for specific purposes—*i.e.*, to replace the use of Method 21; to detect large emission events; to quantify annual emission rates for reporting purposes. To the extent that these technologies could be utilized in the near-term, such uses should comport with existing work practices under applicable rules, particularly as means to replace or bolster Method 21 for SEM. This approach aligns with ORD's indication that the

[41] The text in this section is responsive to RFI Questions 1.c; 3.b; and 3.c.
[42] *See Cusworth, et al.*, at 1503 ("On average, aerial emission rates were a factor of 2.7 higher than GHGRP for all landfills and a factor 1.4 higher for landfills with 10+ unique overpasses. Consistent with this study, independent assessments of US emission inventories have indicated a needed 1.25 to 1.5 scaling of waste emissions to reconcile inventories with in situ ground-based measurements and coarse resolution satellite observations.")

technologies are poised to aid in the understanding of fugitive or episodic emissions in the near-term, and intrinsic emissions in the long-term.[43] NWRA agrees that the technologies may be useful for find-and-fix approaches, wherein Method 21 could be supplemented with UAV devices to help identify the origin of fixable emissions so as to apply a timely response and correction. This approach would fit more squarely within the NSPS/EG realm of regulations, rather than the GHGRP.

A stacked approach could be valuable for understanding annual emissions, but additional research and development is necessary to understand how it could fit within the regulatory scheme of the GHGRP and to what extent, if any, such stacked data could be utilized to quantify emissions. As indicated by ORD representatives, UAV and ground-based devices could be used to verify the emissions detected by satellite and aerial images. To account for the detection threshold limitations of satellite devices—which typically cannot identify emissions events less than 100 kg/hr—UAV and ground-based technologies could be used to collect more consistent data at lower detection thresholds. However, the protocol, algorithms, and procedures would be needed to integrate estimates of methane emissions for sources emitting below detection thresholds, and would need to produce correlated data. Such correlation has not yet been observed by NWRA and its members. As one case in point, Republic Services sought to correlate contemporaneous data collected at two sites by various technologies, and saw wide disparities in the resulting estimates, as depicted below:



These disparities are attributable to the lack of standardized methods, detection limits that vary by technology, unique algorithms for processing atmospheric data, and challenges posed by weather, topography, diurnal impacts and ongoing construction. Initial findings also indicate the

[43] *See* Exhibit 3, EPA webinar materials, *Airborne Survey-Methane from U.S. Landfills*, at slide 13.

size of the landfill may impact the uncertainty of the emissions.

Ultimately, researchers have concluded that a "method that can measure both the diffuse and point-source emissions from landfills" does not exist and "is needed to validate or refute the current GHGRP approaches."[44] And, rather than shift entirely from a modeled to measured approach, researchers suggest that the emerging technologies be developed to "improve the models" instead.[45] This idea—that " a combination of technologies (i.e., on-site sensors and possibly satellite or aerial platforms) are needed to better quantify annual emissions from MSW landfills"—comports with ORD's indication that technologies are only poised for a "stacked" approach at this time.[46]

G. EPA's verification process of advanced measurement technologies should comport with the standards applicable to Other and Alternative Test Methods.[47]

EPA currently employs a multi-step process for standardizing regulatory test methods. Test methods must first be designated as an Other Test Method ("OTM"), and then an Alternative Test Method, before EPA can point to it as a Reference Method for compliance purposes within the NSPS or NESHAP programs. To go from an OTM to an Alternative Test Method, the EPA must be assured that the test method alternative provides "a determination of compliance status at the same or greater stringency as the test method specified in the applicable regulation," which should be shown by including the results of a Method 301 (Validation of Pollutant Measurement Methods from Various Waste Media) validation and justification for not using the regulation's specified method, which compares the test method against a validated reference test method to determine the method's bias and collecting multiple or co-located simultaneous samples to determine the method's precision.

The only methodologies currently approved as Alternative Test Method to Method 21 so as to satisfy the SEM requirements under the NSPS/EG is ALT-150/OTM-51: *Approval to Use Unmanned Aerial System Application as an Alternative to Method 21 for Surface Emission Monitoring of Landfills*. Because ALT-150 was approved in accordance with EPA's procedures, its implementation is the only transparent, open-source, standardized option that exists among the new advanced measurement technologies. However, Method 21 is applicable to SEM requirements under the NSPS/EG, rather than as a means to quantify emissions for the purpose of calculating annual emissions.[48]

EPA should continue to employ this or a similar process with respect to other technologies that it into future rulemakings, so as to provide clarity on how the technologies should be deployed and what they aim to achieve from a regulatory standpoint. Namely, EPA should employ a similar multi-step approval process for any technologies purporting to (1) be a viable alternative to Method 21 for SEM; (2) be capable for use in detecting large-scale

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[44] *Stark et al.*, at 91.
[45] *Id.*
[46] *Id.* at 92.
[47] The text under this section is responsive to RFI Questions 3.a and 3.b.
[48] OTM-58A is in draft form and uses a mass balance approach to quantify whole site emissions. NWRA applauds EPA on its collaboration with Champion X in developing additional test methods; however, OTM-58A is not scalable, and a scalable methodology should be high priority for landfills.

emissions events, or (3) be suitable for quantifying emissions and/or calculating an annual emission rate. EPA developed a streamlined process applicable to oil and gas facilities, which can be found under 40 C.F.R. § 60.5398b(d). If EPA intends to move forward with new technologies for landfills, EPA must consider developing a similar process, which would allow for the qualification of "alternative" test methods that can be utilized for compliance purposes even after the rule has become effective. This process allows for the continued development of appropriate technologies without rushing to implement emerging technologies into regulatory programs before they are sufficiently ready. In establishing this process, EPA should prioritize its goal to "peer review of all scientific and technical information that is intended to inform or support Agency decisions is encouraged and expected."[49] This is especially important for verifying and standardizing technologies for emissions detection, quantification, and extrapolation into annual emission rates as no current validated reference method exists.

Further, standards and protocols implemented to ensure that emerging measurement technologies provide annual total, source-specific, methane emissions in a transparent and standardized way should not be source or technology agnostic. As stated above, there are stark, important differences between oil and gas facilities and municipal solid waste landfills. These differences would make source agnosticism among standardized methods wholly inappropriate, as the detection and quantification of oil and gas emissions from landfills is subject to a different set of considerations than methane emissions from oil and gas facilities. As an example, Carbon Mapper has indicated that it cannot automate source attribution when evaluating its satellite and aerial images, and must do so manually in order to distinguish emissions from oil and gas facilities versus those from landfills.[50] Accordingly, without the capability to distinguish between and attribute emissions from landfill and oil and gas facilities, source agnosticism is not an appropriate option. In fact, TROPOMI satellite research has shown that the imaging may attribute emissions from oil and gas facilities to nearby landfills: "[o]ur landfill attribution approach, which relies on a prior estimate from 2012, may therefore misallocate emissions to the Puente Hills Landfill instead of to co-located oil and gas operations." [51] As such, the development and standardization of advanced technologies must be made as specific as possible to municipal solid waste landfills in order to be primed for regulatory use.

Standards and protocols should be specific to the type of method used rather than be technology agnostic. At this point in time, nearly all of the emerging technologies available require further development and refinement. There are significant differences between the purported algorithms employed by ground-based, fixed sensors compared to UAV technologies, compared to aerial technologies, compared to satellite technologies including, but not limited to, implementation of meteorological and atmospheric data using anemometers, conversion methodologies, algorithms employed to calculate emission rates, and algorithms employed to extrapolate data into annual emission rates. Many of these algorithms are proprietary and/or still in the process of being developed. Moreover, until it becomes clear whether and how EPA intends to implement advanced technologies into the regulatory programs, a comment on technology agnosticism is inherently incomplete.

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[49] EPA. *Peer Review and Peer Involvement at the U.S. Environmental Protection Agency*, (Jan. 2006) https://www.epa.gov/sites/default/files/2015-01/documents/peer_review_policy_and_memo.pdf
[50] *See* Carbon Mapper Quality Control Description Document, at 5–6.
[51] *Nesser*, et al., at 5079.

H. Other limitations relating to the use of advanced technologies for GHGRP reporting purposes [52]

The greatest limitation to using advanced measurement technologies under the GHGRP would be the transition from a modeled to measured approach of emissions quantification. This transition would require reconciling the bottom-up emissions estimates that the industry has utilized since the beginning of the GHGRP with the top-down approach that would be applied in a measured system, the limitations of which are set out at length above.

Costs present another major barrier and limitation to switching to a measured approach under the GHGRP. In directing EPA to create the GHGRP, Congress stated that a "comprehensive and effective national program of mandatory market-based limits and incentives on emissions of greenhouse gases" should be implemented to "slow, stop, and reverse" emissions in such a way which does not "significantly harm the United States economy."[53] Congress issued an accompanying joint statement directing EPA to use its existing authority under the federal Clean Air Act, 42 U.S.C. § 7401 *et seq.*, to develop the mandatory greenhouse gas reporting rule. EPA finalized its first version of the GHGRP on October 30, 2009, utilizing its information-gathering authority under Section 114 of the Clean Air Act.[54]

Accordingly, in issuing and revising the GHGRP, EPA has traditionally considered costs of compliance. Costs of compliance will depend on whether and how EPA implements the use of advanced technologies into regulatory determinations. For example, if EPA provides that certain technologies can be used as alternatives to Method 21 to conduct quarterly SEM, then cost of compliance could consider the baseline estimates in accordance with the dollar amounts revealed in the First EREF Controlled Release Study, set forth below:[55]

MGPA 1	$5,000/day
MGPA 2	$5,000/day
UPSEA 1	$5,000-8,000/day
UPSEA 2	$5,000-8,000/day
MTCEA	$5,000/day
APSEA	$14,000/day
LiDAR	$14,000/day
SISEA	$3,000-6,500/package
RPSEA 1	$7,000-30,000/year
RPSEA 2	$7,000-30,000/year
RPSEA 3	$7,000-30,000/year
UCSEA 1	$5,000-8,000/day

[52] The text in this section is responsive to RFI Question 3.c.
[53] 121 Stat. 1844, 2152, Pub. Law 110-116 (Dec. 26, 2007).
[54] *Mandatory Reporting of Greenhouse Gases*, 74 Fed. Reg. 56260, 56264 (Oct. 30, 2009).
[55] It is important to note that these rates were estimated particular to the study and may not be transferrable to practical implementation in the regulatory context. Moreover, the costs listed fail to account for vendor-specific context. For example, one drone may be able to fly a single site in one day, whereas another vendor may take five days to fly the same site.

UCSEA 2	$5,000-8,000/day
LEA	$5,000/day

However, as stated previously, the correlation between the GHGRP reported emissions and emissions quantified using aerial and satellite technologies increases with additional measurement events.[56] Thus, it is unclear, at this point, how often municipal solid waste landfills could be subject to utilizing such technologies for the purposes of calculating annual emission rates. The costs could become exorbitant and unreasonable. For the purposes of calculating annual emission rates under the GHGRP, until it becomes clearer whether any technologies can be capable of detecting and quantifying emissions with an acceptable degree of accuracy and certainty, and how often measurements would be necessary to capture a substantiated and trusted annual emission rate, NWRA cannot speculate further on costs. Regardless, landfills provide an essential public service and should not be subject to unwarranted, unreasonable costs associated with advanced measurement technologies until and unless the compliance methodologies using such technologies proves to be certain and accurate enough to justify the accompanying costs.

I. Site-specific data is critical to the quantification of landfill gas emissions, and cannot be replaced by emerging measurement technologies.[57]

The members of NWRA are proposing a tool that relies on readily available site-specific information to calculate annual emissions inventories that would be sensitive to the implementation of good practices to reduce emissions. The Solid Waste Industry for Climate Solutions (SWICS) represents a group of practitioners that most recently worked to update the guidance document titled *Current MSW Industry Position and State-of-the-Practice on LFG Collection Efficiency, Methane Oxidation, and Carbon Sequestration in Landfills Version 2.2*, Revised January, 2009, and the *Methane Oxidation Addendum 2012* dated November, 2012. The updated version of guidance and associated excel tool is expected to be available in late 2024 or early 2025.

The guidance document describes how the proposed values for collection efficiency, methane oxidation, and methane destruction could be used to replace the current CARB and USEPA default values for collection efficiency (75%), methane oxidation (10, 25, 35% based on cover), methane destruction (98 - 99%). This document also provides the best estimates of carbon storage in landfills although it is not used as part of the model for estimation of methane emissions.

An important element of this update is the proposed excel tool or landfill emissions model (LEM) rating matrix which is an effort to standardize (e.g., quantify) the professional judgement using operations parameters that are typically collected and available at landfills with a GCCS. In order to use previous versions of the SWICS guidance on emission calculations the user was required to use professional judgement (aka qualified judgement) to indicate whether the performance of the GCCS cover area was high, medium, or low performance The GCCS rating matrix for each cover area utilizes four gas operations parameters and a specific rating to

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[56] *See* Cusworth, et al., *Quantifying methane emissions from United States landfills*. 383 SCIENCE 1499, 1499 (2024).
[57] The text in this section is responsive to RFI Question 3.

be used for each to determine a total score which correlates to collection efficiency value. Defining the bins for each operations parameter allows tuning of the LEM to determine which landfills cover areas will be represented by one of five categories of performance, High, med-hid, medium, med-low, and low.

The SWICS Team assessed gas operations data from 399 landfills throughout the United States to determine the parameters to be included in the GCCS rating matrix and developed a scoring system derived from statistical analysis of the selected parameters combined with the professional judgement of practitioners from the contributing members of SWICS.

The rating system utilizes the following four gas operation parameters:

- Well Field Density (wells per waste footprint);
- Surface Emission Monitoring Exceedances at/over 500 ppmv methane (exceedances/acre);
- Percentage of Wellfield Positive Pressure Readings (positive readings divided by total readings *100); and
- Percentage of GCCS Uptime (running hours divided by total hours).

It is expected that the output of the LEM will be more comparable across the sector based on organizations and practitioners using the collective professional judgement of the group assembled for this effort and applied through the matrix. Refinements to the scoring bins are expected in future versions of the LEM based upon published evaluations of the operations parameters and GCCS performance.

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NWRA very much appreciates the Agency's consideration of these comments. Should you have any questions about this letter, please contact me at agermain@wasterecycling.org.

Very truly yours,

Anne M. Germain
Chief of Technical & Regulatory Affairs

Attachments:
Appendix A: RFI questions
Exhibit 1: NWRA June 24, 2024 Petition for Reconsideration
Exhibit 2: Fluxlab July 9, 2024 final report on controlled release
Exhibit 3: EPA March 19, 2024 webinar slides

Appendix A:
RFI Questions

1. *Quantification of Annual Emission Rates*
   a. *Detection and Quantification of Atmospheric Methane Emission Events from Advanced Measurement Technology*
      i. What advanced measurement technologies are currently available that can provide quantified methane emission rates using transparent, open-source, and standardized methodologies?
         1. What are the specific quantification approaches that have been used with these technologies and how have these methodologies been demonstrated and validated?
         2. How can these technologies and quantification methodologies be used to provide annual data in a consistent manner for each future year of GHGRP reporting?
         3. Are there specific detection and quantification approaches or methodologies that EPA should or should not consider?
      ii. What performance metrics and thresholds related to quantification would be appropriate to apply to advanced measurement technologies for their incorporation into the GHGRP? What would be a feasible approach for developing these thresholds and metrics?
      iii. Should quantification approaches be limited to use of specific methodologies (*e.g.*, inverse analysis, mass balance) or specific approaches for using ancillary datasets (*e.g.*, standardized interpolation of wind field products)?
      iv. Are there ongoing efforts outside of EPA to develop standards or protocols for methane emissions detection and quantification from advanced measurement technologies that would address any of the questions raised in this RFI?

   b. *Extrapolating Quantified Methane Emission Rates to Calculate Annual Emissions for GHGRP Reporting Purposes*
      i. What advanced measurement technologies are currently available that can provide annual total methane emission estimates for specific regions, facilities, processes, or equipment-level sources, that use transparent, open-source, and standardized methods?
         1. Are these technologies applicable across the entire US and could they provide annual data in a consistent manner for each future year of GHGRP reporting?
         2. Are there specific annual extrapolation approaches or methodologies that EPA should or should not consider?
      ii. What accuracy or uncertainty metrics would be appropriate for GHGRP reporting purposes?
         1. What level of accuracy in reported annual methane emissions should advanced measurement technologies be required to meet?
         2. What sources of uncertainty are necessary to consider?
         3. Are there other specific quality assurance or quality control markers that should be considered to ensure that annual estimates represent the methane emissions from all operational activities

throughout the reporting year, such as specific measurement frequencies or duration?

4. What would be a feasible approach for developing these methods and thresholds?

iii. To what extent should standards and protocols be specific to the type of methods and ancillary data used (*e.g.*, statistical approaches), and to what extent should standards and protocols simultaneously consider the specific type of emission sources being sampled (*e.g.*, large unintended vs. small routine emissions event)?

c. Quantifying Annual Methane Emissions from Emissions Sources Below Detection Limits of Advanced Measurement Technologies

i. What methodologies are currently available for integrating estimates of methane emissions for those sources emitting below technology detection thresholds in an open-source, transparent, and standardized way? Can these methodologies provide annual data in a consistent manner for each future year of GHGRP reporting? Are there specific approaches or methodologies that EPA should or should not consider?

ii. Should these quantification approaches be limited to the use of specific methodologies (*e.g.*, Monte Carlo method) or specific ancillary data sets (*e.g.*, the use of standardized infrastructure or operator data)?

2. Attribution

a. What methodologies are currently available that can attribute quantified methane emission events to specific equipment types (or additionally, specific regions, facilities, or processes) using transparent, open-source, and standardized methods? Are there specific attribution approaches or methodology trees that EPA should or should not consider?

b. What accuracy or uncertainty metrics would be appropriate for GHGRP reporting purposes? For example, what level of confidence in the source attribution would be necessary for advanced measurement technologies to meet GHGRP reporting purposes? What would be a feasible approach to developing these thresholds?

c. To what extent would standards and protocols need to be specific to the type of methods and ancillary data used(*e.g.*, infrastructure data sets) or the type of emission source sampled (*e.g.*, large unintended versus small routine emissions event)?

3. Implementation

a. Structure of Approaches or Protocol

i. What form would standard methods or protocols need to take to ensure that advanced measurement technologies provide annual total, source-specific, methane emissions in a transparent and standardized way? For example –

1. To what extent should standards and protocols be specific to the type of methods used (e.g., satellite, aircraft, ground based)? Would different standards or protocols be necessary for sampling

approaches using single platform versus multi platform measurements? Could standard methods be developed to be technology agnostic?

2. To what extent could standard methods be developed to be source agnostic? For example would standards need to be specific to the type of equipment, process, or emission source sampled (e.g., tanks, flares, pneumatic devices, landfill working face), Or could a set of standards be developed to be more broadly applicable across different GHGRP industry segments?

b. *Verification and Validation of Annual Source-Specific Methane Emission Quantification Methods Using Advanced Measurement Technologies for GHGRP Reporting Purposes*
   i. Are there approaches currently available that could be used to verify that advanced measurement technologies meet specific standards (*e.g.*, independent blind studies, deployment of calibration standards, others)?
   ii. Is it necessary to limit the applicability of advanced measurement technologies to environmental and site conditions that have been previously validated? For example, if an advanced measurement technology has been validated through blind control release testing during which wind speeds ranged from 0.5 to 10 m/s should the technology be limited to measurements within this range of wind speeds? What form of validation could be used to demonstrate whether a technology is applicable across environmental conditions outside of their tested ranges?
   iii. Are there specific types of operator- or facility-specific information that would be useful for improving or validating annual methane emissions quantification or source attribution from advanced measurement technologies?

c. *Other Considerations Related to the Use of Advanced Measurement Technologies for GHGRP Reporting Purposes*
   i. What (if any) are the current barriers or limitations to using advanced measurement technologies beyond what is currently allowed under the GHGRP to quantify annual equipment-level methane emissions at scale in the U.S.?
   ii. What are the cost considerations for implementing different advanced measurement technologies to quantify annual, equipment-, process-, or facility-level methane emissions for GHG RP reporting purposes? If available, cost should be provided in a manner that can be scaled up to different implementation approaches (*e.g.*, cost per site, cost per area covered).
   iii. How are factors such as measurement and analysis cost, complexity, or time burden relevant for determining whether advanced measurement technologies may be appropriate for annual GHGRP application?

iv. Other than methane emissions detection and quantification, and establishing the duration of [large release events] are there additional ways in which advanced measurement technologies could be used to support quantification and reporting of equipment process or facility level methane emissions to the GHGRP (*e.g.*, as a method to identify changes in operating conditions, to supplement specific reported data elements)?

EXHIBIT 1

National Waste & Recycling Association[SM]
Collect. Recycle. Innovate.

June 24, 2024

Via Electronic Mail and Hand Delivery

The Honorable Michael S. Regan
Administrator
U.S. Environmental Protection Agency
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Gautam Srinivasan
Associate General Counsel
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Re: **Petition for Reconsideration: Greenhouse Gas Reporting Program Subpart HH, Municipal Solid Waste Landfills**

Dear Administrator Regan and Associate General Counsel Srinivasan:

Enclosed please find attached a Petition for Reconsideration submitted by the National Waste & Recycling Association (NWRA) with respect to the rule entitled *Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule*, 89 Fed. Reg. 31802 (April 25, 2024), docket No. EPA-HQ-OAR-2019-0424. NWRA's Petition for Reconsideration is limited to Subpart HH of the Greenhouse Gas Reporting Rule, which is applicable to Municipal Solid Waste Landfills, and EPA's determination therein to reduce default landfill gas collection efficiency values for reporters under the rule.

NWRA appreciates EPA's consideration of this Petition and hopes to work cooperatively with EPA toward improvements in the accuracy of landfill sector emissions reporting. Please feel free to contact the undersigned at agermain@wasterecycling.org, or outside counsel for NWRA, Carol McCabe at cmccabe@mankogold.com or Matt Morrison at matthew.morrison@pillsburylaw.com, with any questions you may have.

Respectfully submitted,

Anne Germain
Chief Operating Officer and Senior Vice President of Technical and Regulatory Affairs
National Waste & Recycling Association

Enclosure

cc: Jennifer Bohman, EPA Office of Atmospheric Programs (via electronic mail)
Julius Banks, EPA Greenhouse Gas Reporting Branch (via hand delivery)
Carol F. McCabe, Manko, Gold, Katcher & Fox (via electronic mail)
Kelly A. Hanna, Manko, Gold, Katcher & Fox (via electronic mail)
Matthew W. Morrison, Pillsbury, Winthrop, Shaw, Pittman (via electronic mail)
Steve R. Brenner, Pillsbury, Winthrop, Shaw, Pittman (via electronic mail)

The National Waste & Recycling Association's
Petition for Reconsideration of The Final Rule:
Revisions and Confidentiality Determinations for Data Elements
Under the Greenhouse Gas Reporting Rule**,**
89 Fed. Reg. 31802 (April 25, 2024)
Docket No. EPA-HQ-OAR-2019-0424

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PETITION FOR RECONSIDERATION TO THE U.S. ENVIRONMENTAL PROTECTION AGENCY

I. <u>Introduction</u>

On April 25, 2024, the United States Environmental Protection Agency ("EPA") finalized updates to the Greenhouse Gas Reporting Program rules ("GHGRP"), codified under Title 40, part 98 of the Code of Federal Regulations and effective January 1, 2025 ("Final Rule").[1] The Final Rule is a culmination of two Notices of Proposed Rulemakings: the Data Quality Improvement Proposal and the 2023 Supplemental Proposal.[2] In finalizing the respective changes across part 98, EPA articulated its two overarching goals: (1) improving the quality of data collected from municipal solid waste ("MSW") landfills; and (2) strengthening applicable reporting requirements. The Final Rule includes updates to subpart HH of the GHGRP, applicable to MSW landfills, including unanticipated changes to methane emissions calculation methodologies that form the subject of this Petition for Reconsideration.

Specifically, in the Final Rule, EPA unexpectedly reduced the collection efficiency values contained in Table HH-3 and applied in equations HH-7 and HH-8 to calculate methane emissions from MSW landfills subject to the GHGRP ("Reporters").[3] As proposed in the 2023 Supplement, the lowered collection efficiencies would have applied only to "non-regulated" Reporters who are not required to and opt not to conduct surface methane emissions monitoring ("SEM") under applicable federal rules. EPA proposed to retain the same, higher collection efficiencies applicable to "regulated" landfills that are required to, or opt to, conduct SEM.

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[1] *Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule*, 89 Fed. Reg. 31802 (April 25, 2024) ("Final Rule").
[2] *Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule*, 87 Fed. Reg. 36920 (June 21, 2022) ("Data Quality Improvements Proposal"); *Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule*, 88 Fed. Reg. 32852 (May 22, 2023) ("2023 Supplemental Proposal").
[3] 2023 Supplemental Proposal, 88 Fed. Reg. 32861.

Relatedly, EPA proposed to impose a new “correction term” within equations HH-6, HH-7, and HH-8 for landfills conducting SEM to adjust emissions values based on the number of locations with concentration above 500 parts per million above background identified during surface measurement periods. Taken together, EPA’s proposal expressly coupled collection efficiency adjustments with SEM practices. In its Final Rule, however, EPA took an impermissible and unanticipated U-turn, decoupling collection efficiency from SEM and site-specific performance measures and imposing significantly reduced collection efficiencies across all Reporters, without adequate prelude or justification. Moreover, by requiring Reporters to apply a reduced collection efficiency irrespective of whether they are conducting SEM, EPA is effectively requiring the majority of Reporters to overstate their greenhouse gas emissions. These changes do nothing to achieve EPA’s two stated goals of improving data quality and strengthening reporting requirements.

The Petitioner is the National Waste & Recycling Association (“NWRA” or “the Petitioner”). NWRA is the leading voice of the North American waste and recycling industry on advocacy, education, and safety. The industry provides essential services that benefit our local communities and businesses by assisting our customers in achieving their environmental and sustainability aspirations. NWRA supports and promotes regulatory advancements and policies that benefit the solid waste industry and improve the quality of life for all Americans. Association members operate in all 50 states and the District of Columbia and can be found in most, if not all, U.S. congressional districts. Waste and recycling facilities number nearly 18,000 scattered throughout the U.S., mirroring population centers. Our nearly 700 members are a mix of publicly traded and privately owned local, regional and Fortune 500 national and international companies. NWRA represents approximately 70 percent of the private sector waste and recycling market.

Members of NWRA are directly and adversely affected by EPA's promulgation of the Final Rule, which cannot plausibly be considered the logical outgrowth of the 2023 Supplemental Proposal. NWRA and other interested parties were not afforded adequate notice of EPA's ultimate decision to reduce existing collection efficiencies identified in subpart HH of the GHGRP for all landfills, irrespective of whether a landfill was conducting SEM. While NWRA shares EPA's stated objective of ensuring accurate quantification and reporting of greenhouse gas emissions, the Agency's finalized approach undermines that shared objective by adopting a methodology that will overestimate methane emissions, despite an abundance of scientific evidence that more closely aligns with EPA's proposed approach to base emission estimates on site-specific factors like SEM. The Final Rule will also cause reporting under the GHGRP to be at odds with other federal reporting and permitting programs, as well as the landfill sector's established practices regarding sustainability and GHG reporting.

Since EPA's decision to lower collection efficiencies in subpart HH of the Final Rule is procedurally flawed and substantively unwarranted, NWRA respectfully requests that EPA reconsider this important aspect of subpart HH of the Final Rule.[4]

II. Background to the Final Rule

In its Fiscal Year 2008 Consolidated Appropriations Act,[5] Congress directed EPA to promulgate regulations requiring "mandatory reporting of greenhouse gas emissions above appropriate thresholds in all sectors of the economy of the United States."[6] Congress articulated,

[4] NWRA has also filed a petition for judicial review of the Final Rule in the United States Court of Appeals for the District of Columbia Circuit.
[5] 121 Stat. 1844, Pub. Law 110-116 (Dec. 26, 2007).
[6] *Id.* at 2128.

in light of the "growing scientific consensus" that humans were contributing to the accumulation of greenhouse gases in the atmosphere, leading to increased global temperatures, that a "comprehensive and effective national program of mandatory market-based limits and incentives on emissions of greenhouse gases" should be implemented to "slow, stop, and reverse" emissions in such a way which does not "significantly harm the United States economy."[7] Congress issued an accompanying joint statement directing EPA to use its existing authority under the federal Clean Air Act, 42 U.S.C. § 7401 *et seq.*, to develop the mandatory greenhouse gas reporting rule.

In accordance with this Congressional directive, EPA finalized its first version of the GHGRP on October 30, 2009, utilizing its information-gathering authority under Section 114 of the Clean Air Act.[8] The original GHGRP Rule included MSW landfills that generated over 25,000 metric tons of carbon dioxide equivalent or more per year as a source category and was promulgated under Title 40 of the Code of Federal Regulations, part 98, subpart HH.[9]

Since 2009, the GHGRP has been updated numerous times.[10] On June 21, 2022, EPA published a Notice of Proposed Rulemaking ("NPRM") in the Federal Register proposing certain updates to the GHGRP, referred to as the Data Quality Improvements Proposal.[11] Thereafter, EPA issued another NPRM to supplement the Data Quality Improvements Proposal—the 2023 Supplement[12] (collectively, the "Proposed Rules")—once again seeking comment from interested parties regarding proposed changes geared toward improving the quality of data

[7] *Id.* at 2152.
[8] *Mandatory Reporting of Greenhouse Gases*, 74 Fed. Reg. 56260, 56264.
[9] *See id.* at 56267.
[10] *Rulemaking Notices for GHG Reporting*, EPA (last updated May 31, 2024), https://www.epa.gov/ghgreporting/rulemaking-notices-ghg-reporting.
[11] Data Quality Improvements Proposal, 87 Fed. Reg. 36920 (June 21, 2022).
[12] 2023 Supplemental Proposal, 88 Fed. Reg. 32852 (May 22, 2023).

collected from MSW landfills and strengthening reporting requirements. The 2023 Supplement included proposed changes to several methodologies within subpart HH used to calculate methane emissions from MSW landfills subject to the rule.

On April 25, 2024, EPA finalized its updates to the GHGRP, including changes to collection efficiency values in table HH-3. However, the finalized collection efficiencies differed starkly from those in the Proposed Rules, specifically the 2023 Supplement. Interested parties, including the Petitioner, were completely surprised by and unprepared for this change.

A. The Proposed Rules

In the 2023 Supplemental Proposal, EPA proposed several changes to the GHGRP that it said would lead to more accurate emissions calculations, based on its conclusion that high emission events may be occurring where there is "a leaking cover system due to cracks, fissures, or gaps around protruding wells."[13] In order to address this concern, EPA proposed two ways in which collection efficiency or emission estimates would be adjusted, both related to SEM. First, EPA proposed to amend Equations HH-6, HH-7, and HH-8 for regulated reporters (those that are subject to SEM requirements), by adding a "correction term." Equation HH-6 is used to calculate methane emissions using modeled methane generation and measured methane recovery, while equations HH-7 and HH-8 are used in tandem to calculate methane generation and emissions using methane recovery and estimated gas collection efficiency.[14] EPA noted that the three equations did not "directly account for periods where surface issues reduce the gas collection efficiency and/or reduce the fraction of methane oxidized."[15] To address that concern, EPA

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[13] *Id.* at 32877–78. EPA also proposed other measures in the 2023 Supplemental Proposal to address a "poorly operating or non-operating gas collection system" and a "poorly operating or non-operating destruction device." NWRA commented on these proposed measures, which are not addressed in this petition.
[14] *See* 40 CFR 98.343(c)(3)(i).
[15] 2023 Supplemental Proposal, 88 Fed. Reg. 32878.

proposed a way to correct the estimated methane emissions based on monitored exceedances at the surface of the landfill. This proposed correction was based on conclusions from a study cited by EPA, *Heroux*, et al., and its internal citations, which suggested that methane "flux" (*i.e.*, the exchange of methane emissions and naturally occurring substances between Earth's surface and its atmosphere) is proportional to the measured methane concentration at six centimeters above the ground.[16] The proposed correction term would require Reporters subject to SEM to input the "leak duration days" (the number of days since the last monitoring event at the specified location) and the "surface methane concentration for the mth measurement that exceeds 500 parts per million above background."[17] The proposed correction term accounted for the fact that regulated landfills must record as a monitored exceedance, and take corrective action to address, any location with a reading of 500 ppm or more above background. EPA proposed to allow non-regulated landfills to elect to conduct SEM as well, so as to avail themselves of the use of the correction term when calculating their methane emissions using equations HH-6, HH-7, and HH-8.[18]

The second method by which EPA considered an adjustment of collection efficiency based on SEM was a proposed adjustment to the gas collection efficiency values in Table HH-3, as utilized in equations HH-7 and HH-8, applicable *only* to landfills that are not required to conduct SEM under other federal provisions or decline to elect to conduct SEM pursuant to proposed 40 CFR § 98.346(g)(7).[19] Specifically, EPA proposed to include a new set of gas

[16] *Id.*
[17] *Id.* at 32931. "Regulated" landfills are subject to such SEM requirements under the NSPS program, 40 CFR part 60, WWW or XXX; the EG program, subparts Cc or Cf; or Federal plans, 40 CFR part 62, subparts GGG or OOO. *Id.* at 32877–78.
[18] *See id.* at 32932 (proposing to implement elective surface-emissions monitoring for landfills with landfill gas collection systems that are not required to conduct such under an existing federal program under a new subsection, 40 CFR § 98.346(g)(7)).
[19] *Id.* at 32879.

collection efficiency values in Table HH-3, applicable to landfills that do not conduct SEM, that are "10 percent lower than the current set of collection efficiencies."[20] EPA proposed that the current set of collection efficiencies would be retained, and would "only be applicable for landfills that are conducting [SEM] according to the landfills rule requirements." [21] Since the vast majority of landfills conduct surface emission monitoring,[22] EPA's proposal would have lowered the collection efficiencies for *only* a relatively small subset of Reporters.

EPA's proposal rested on the conclusions of a study by the Environmental Integrity Project ("EIP Study")[23] that collection efficiencies of non-regulated landfills were 20% lower, on average, than regulated landfills. In discussing the EIP study conclusion relating to SEM, EPA stated: "These results make sense because the objective of the surface methane concentration measurements are to ensure proper gas collection and non-regulated landfills that do not conduct these measurements would not necessarily have such checks in place and may be expected to have higher emissions."[24] The EIP study results focused on a limited number of landfills in the state of Maryland that, when compared to the values reported under subpart HH, showed collection efficiencies that were 10% lower than regulated landfills under the GHGRP.

EPA specifically requested comment on: its proposal to lower collection efficiencies for landfills with gas collection systems that do not conduct SEM; the selection of a 10 percent collection efficiency reduction rather than the 20 percent reduction for those non-regulated landfills; and whether EPA should select an alternative value for non-regulated landfills based on

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[20] *Id.*
[21] *Id.*
[22] EPA-HQ-OAR-2019-0424-0256, Attachment A.
[23] EIP, *Greenhouse Gas Emissions from Maryland's Landfills* (2021), https://environmentalintegrity.org/wp-content/uploads/2021/06/MD-Landfill-Methane-Report-6.9.2021-unembargoed_with-Attachments.pdf).
[24] 2023 Supplemental Proposal, 88 Fed. Reg. at 32878.

the supporting data.[25] NWRA provided comment with respect to these proposed changes.[26] In addition to comments noting the technical and substantive inadequacy of the EIP Study, NWRA also noted that EPA's proposal and reliance on the EIP Study failed to account for other major factors that are more influential with respect to collection efficiencies at regulated and non-regulated landfills, including federal requirements to provide comprehensive controls, meet prescriptive timelines, and limit system downtime. NWRA also incorporated by reference the comments of Morton Barlaz, who likewise noted that EPA failed to identify all the factors that can affect collection efficiency, such as the type of cover and well density.[27] NWRA further noted that the equation HH-8 methodology accounts for these differences already, obviating the need for reduced collection efficiencies as proposed.

NWRA also provided comment on the proposed correction term, asking EPA to consider other studies that show significant variability in the correlation between surface emissions exceedances and methane flux. Specifically, we noted that the *Heroux*, et al. study EPA used to support the purported correlation was conducted over 20 years ago based on data from a single landfill in Canada.

Importantly, NWRA asked that EPA delay the finalization of any of the proposed revisions to subpart HH until the Solid Waste Industry for Climate Solutions ("SWICS") finalized its revisions to the third version of its white paper entitled *Current MSW Industry Position and State-of-the-Practice on LFG Collection Efficiency, Methane Oxidation, and Carbon Sequestration in Landfills*. The SWICS White Paper is a compilation of peer-reviewed data and studies relating to a broad range of MSW landfills, and it was undertaken for the

[25] *Id.* at 32879.
[26] *See* EPA-HQ-OAR-2019-0424-0255.
[27] NWRA incorporated by reference the comments of Morton Barlaz. *See* EPA-HQ-OAR-2019-0424-0286.

express purpose of creating a methodology that would result in more accurate inventories of methane from landfills. In relevant part, NWRA noted that the SWICS paper will "move toward a more quantified basis for GCCS collection efficiency assessment….and a revisit on the current state-of-the-practice on collection efficiencies, oxidation, carbon storage, methane generation in landfills and destruction efficiencies."[28]

B. Final Rule

In the Final Rule, EPA stated that, "[f]ollowing the consideration of comments received, we are not taking final action on the surface-emissions monitoring correction term that was proposed. *Instead*, we are finalizing the proposed lower collection efficiencies in table HH-3 to subpart HH but applying the reduced collection efficiencies for *all* reporters under subpart HH."[29] In making this decision, EPA conceded, consistent with NWRA's comments, that the *Heroux*, et al. study was insufficient, alone, to support the implementation of the correction term, because it was over two decades old and focused on one landfill in Canada.[30] Upon review of the additional studies identified by commenters, including those identified by NWRA, EPA agreed that there was indeed significant variability in measured surface concentrations and methane emissions flux across different landfills.[31] Due to "high uncertainty," EPA indicated that it is reassessing the appropriateness of a correction term and "evaluating other direct measurement technologies for assessing more accurate, landfill-specific gas collection efficiencies."[32]

With respect to the proposed collection efficiencies, EPA concluded that it "expected that the surface emissions correction factor would result in lower emissions than those calculated

[28] *See* EPA-HQ-OAR-2019-0424-0255.
[29] Final Rule, 89 Fed. Reg. at 31853 (emphasis added).
[30] *Id.* at 31855.
[31] Final Rule, 89 Fed. Reg. at 31855.
[32] *Id.*

using the 10-percentage point decrease in collection efficiency[.]"[33] Based on EPA's review of other studies correlating surface methane concentrations with methane flux," EPA stated its belief that a "more central tendency correlation factor is projected to yield emissions similar to a 10-percentage point decrease in collection efficiency."[34] EPA went on to state that "all the measurement study data" reviewed suggests that current collection efficiencies are overstated on average by 10-percentage points or more.[35] In making this point, EPA cited two studies that were not included in either the preamble or the docket for the Proposed Rules: *Duan et al.*, 2022 and *Nesser et al.*, 2023.[36] EPA asserted that the *Nesser* study, which observed 38 landfills subject to SEM requirements, provides evidence that most observed landfills had lower or similar measured collection efficiencies to those reported under subpart HH.[37] EPA further concluded that "[s]imilar low average collection efficiencies were noted by *Duan* et al.," and that those efficiencies justified its decision to finalize the lower default collection efficiencies for all landfills.[38]

III. Requested Reconsideration of the Collection Efficiency Values

Pursuant to Section 307(d)(7)(B) of the Clean Air Act, EPA "shall convene a proceeding for reconsideration of [a] rule and provide the same procedural rights as would have been afforded had this information been available at the time the rule was proposed" so long as the party seeking reconsideration can demonstrate: (1) "that it was impracticable to raise such

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[33] *Id.* at 31856.
[34] *Id.*
[35] *Id.*
[36] *Id.* (citing Duan, Z., et al., *Efficiency of gas collection systems at Danish landfills and implications for regulations*, 139 WASTE MANAGEMENT 269–78 (2022), https://doi.org/10.1016/j.wasman.2021.12.023.; Nesser, H., et al., *High-resolution U.S. methane emissions inferred from an inversion of 2019 TROPOMI satellite data: contributions from individual states, urban areas, and landfills*, EGUSPHERE [preprint] (2023), https://doi.org/10.5194/egusphere-2023-946; and supplement https://egusphere.copernicus.org/preprints/2023/egusphere-2023-946/egusphere-2023-946-supplement.pdf.
[37] Final Rule, 89 Fed. Reg. at 31856.
[38] *Id.* at 31856.

objection" during the public comment period or that "the grounds for such objection arose after the period for public comment (but within the time specified for judicial review)"; and (2) "such objection is of central relevance to the outcome of the rule." 42 U.S.C. § 7607(d)(7)(B).

The Petitioner could not practicably raise procedural and substantive objections to EPA's finalization of Table HH-3's reduced collection efficiencies by 10 percentage points, applicable to *all* Reporters under subpart HH, because EPA did not afford adequate notice of this change to interested parties prior to the public comment period. As such, the change to collection efficiency in HH-3 applicable to all Reporters under the Final Rule is not the "logical outgrowth" of the Proposed Rules. EPA is required to convene proceedings for reconsideration, so that interested parties may raise relevant substantive objections that are of central relevance to the outcome of the rule.

A. EPA did not afford interested parties with adequate notice of the lowered collection efficiencies applicable to all Reporters; therefore, the Final Rule is not the "logical outgrowth" of the Proposed Rules.

The practicability of raising an objection during the public comment period is dependent on EPA providing adequate notice of the changes it purports to finalize. The Clean Air Act incorporates the notice requirements set forth in the Administrative Procedure Act, by stipulating "[i]n the case of any federal rule to which this subsection applies, notice of a proposed rulemaking shall be published in the Federal Register, as provided under Section 553(b) of Title 5[.]" § 7607(b)(3). The APA's notice requirements are designed (1) to ensure that agency regulations are tested via exposure to diverse public comment, (2) to ensure fairness to affected parties, and (3) to give affected parties an opportunity to develop evidence in the record to support their objections to the rule and thereby enhance the quality of judicial review." *Int'l Union, United Mine Workers of America v. Mine Safety & Health Admin.*, 407 F.3d 1250, 1259

(D.C.Cir.2005). Notice, courts have recognized, must come from the agency's Notice of Proposed Rulemaking. *Chesapeake Climate Action Network v. EPA*, 952 F.3d 310, 320 (D.C. Cir. 2020). Because agencies "do not quite have the prerogative of obscurantism reserved to the legislatures," they must adhere to a "high standard of articulation" in expressing the "data [of] critical degree" in their Notices of Proposed Rulemakings. *United States v. Nova Scotia Food Prod. Corp.*, 568 F.2d 240, 252 (2d Cir. 1977). Notice, therefore, cannot be "bootstrap[ped]" from a comment received during the comment period after a Notice of Proposed Rulemaking has been published. *Fertilizer Inst. v. EPA*, 935 F.2d 1303, 1312 (D.C.Cir.1991). In this respect, if agencies "fail[] to disclose to interested persons the factual material upon which the agency was relying," the elements of fairness which are "essential to any kind of administrative action" are vitiated by preventing agencies from submitting comments of "cogent materiality." *Nova Scotia*, 568 F.2d at 249, 252.

Moreover, without adequate notice, it is widely recognized that a final rule does not equate to the "logical outgrowth" of the proposal. *See, e.g.*, *Envtl. Integrity Project v. EPA*, 425 F.3d 992, 996 (D.C. Cir. 2005); *Northeast Md. Waste Disposal Auth. v. EPA*, 358 F.3d 936, 951-52 (D.C. Cir. 2004); *Alon Ref. Krotz Springs, Inc. v. EPA*, 936 F.3d 628, 648 (D.C. Cir. 2019) (stating that the "impracticability prong" of Section 307(d)(7)(B) covers "instances when the final rule was not a logical outgrowth of the proposed rule"). A final rule is the "logical outgrowth" of a proposed rule only if interested parties "should have anticipated that the change was possible, and thus reasonably should have filed their comments on the subject during the notice-and-comment period." *Env't Integrity Project v. EPA*, 425 F.3d 992, 996 (D.C. Cir. 2005).

In contrast, agencies cannot justify changes implemented in a final rule by placing an "unreasonable burden on commentors not only to identify errors in a proposed rule but also to contemplate why every theoretical course of correction the agency might pursue would be inappropriate or incorrect." *Chesapeake Climate Action Network*, 952 F.3d at 320 (holding that a party's ability to comment on an *issue* generally does not in and of itself demonstrate sufficient notice from EPA). While an agency "need not subject every incremental change in its conclusions after each round of notice and comment to further public scrutiny before final action," *Sierra Club v. Costle*, 657 F.2d 298, 352 (D.C. Cir. 2981), interested parties must be able to anticipate that the change was possible, and could have submitted comments relating to such. *Northeast Md. Waste Disposal Auth.*, 358 F.3d at 952 (finding that a final rule which collapses the proposed rule's three categories into two is the logical outgrowth of the proposed rule); *Envt'l Integrity Project*, 425 F.3d at 996 ("The Court will refuse to all agencies to use the rulemaking process to pull a surprise switcheroo on the regulated entities.").

Here, the Petitioner did not have adequate notice of EPA's decision to impose lower collection efficiencies upon *all* Reporters. Rather, the Petitioner had notice that EPA was considering an adjustment to collection efficiencies and emission calculations tied to SEM practices; EPA indicated that it may lower collection efficiencies by 10% for those MSW landfills not conducting SEM and by a correction term for those that do conduct SEM and for which surface emissions were detected above defined thresholds. EPA did not indicate anywhere in the Proposed Rules that it was considering an across the board lowering of collection efficiencies regardless of SEM practices and results. Indeed, the very basis for EPA's proposal in the first instance was a concern about accurately accounting for "methane emissions from large release events that are currently not quantified under the GHGRP" including those that may result from "emissions from leaking cover systems due to cracks, fissures, or gaps around protruding wells"[39]—issues that would be detectable by SEM. EPA's decision in the Final Rule had nothing to do with SEM at all—in fact, as discussed above, EPA pivoted away from SEM and in its place adopted an across-the-board reduction in collection efficiencies based in large part on newly identified data.

While it is true that EPA is not obligated, and cannot be reasonably expected, to subject "every incremental change in its conclusions" to additional rounds of notice and comment before final action, this change is not incremental. *See Sierra Club*, 657 F.2d at 352. The Petitioner could not and did not anticipate EPA's final action, especially given that EPA requested comment regarding: (1) the "new set of proposed collection efficiencies for landfills with gas collection systems that do not conduct surface methane concentration measurements"; (2) EPAs "selection of 10 percent lower collection efficiencies for landfills that are not monitored for surface methane rather than selecting a 20 percent lower value as suggested by the commenters that referenced the [EIP Study] data"[40]; and (3) supporting data on whether EPA should select an "alternative collection efficiency value than the proposed 10 percent difference or the 20 percent difference[.]"[41] Based on these requests for comment, the Petitioner reasonably expected EPA to: finalize the collection efficiencies as proposed for non-regulated Reporters; lower the values applicable to non-regulated Reporters in accordance with the percentages identified in the EIP Study; retain the status quo; or, if commenters pointed to scientific data that supported some "alternative" value for non-regulated landfills, subject interested parties to another round and notice and comment on a different proposed value based on the new scientific data. *See United*

[39] 2023 Supplemental Proposal, 88 Fed. Reg. at 32877–78.
[40] *Id.* at 32878; EIP, *Greenhouse Gas Emissions from Maryland's Landfills* (2021), https://environmentalintegrity.org/wp-content/uploads/2021/06/MD-Landfill-Methane-Report-6.9.2021-unembargoed_with-Attachments.pdf).
[41] 2023 Supplemental Proposal, 88 Fed. Reg. at 32879.

States v. Nova Scotia Food Prod. Corp., 568 F.2d 240, 252 (2d Cir. 1977). In no event did EPA suggest that it was evaluating a collection efficiency reduction for all Reporters as a standalone measure, uncoupled from SEM as a factor on which that value should be based.

NWRA submitted comments in accordance with EPA's requests, in part because we disagree that SEM is a strong indicator of overall collection efficiency, especially as extrapolated to a quantification of annualized emissions. Further, NWRA disagreed with the technical information proffered by EPA to support its proposal. Specifically, the Petitioner's comments questioned the adequacy of the EIP Study on the basis that it was not properly peer-reviewed in accordance with EPA's General Assessment Factors[42] and Peer Review Policy.[43] NWRA also commented that the EIP Study, which focused on 14 landfills in Maryland only, was not representative of MSW landfills subject to subpart HH across the entire United States. In addition, NWRA pointed out that the equation HH-8 methodology, as-is, adequately accounts for the factors which legitimately and substantially influence the difference in collection efficiencies between landfills conducting SEM and landfills not conducting SEM. Accordingly, NWRA asked that EPA either maintain the status quo or await publication of comprehensive, representative data in the updated version of the SWICS White Paper, a document that EPA has relied upon in the past. NWRA's comments were also substantially influenced by the proposed "correction term," which EPA proposed in tandem with the lowered collection efficiencies. Though we objected to lowering collection efficiencies at all, we at least recognized that, coupled with the correction term, there existed an incentive for non-regulated landfills to conduct

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[42] Summary of General Assessment Factors for Evaluating the Quality of Scientific and Technical Information (June 2003) (available at https://www.epa.gov/sites/default/files/2015-01/documents/assess2.pdf).

[43] Peer Review Handbook (4th Edition 2015) (available at https://www.epa.gov/sites/default/files/2020-08/documents/epa_peer_review_handbook_4th_edition.pdf).

SEM, consistent with the original goals articulated by Congress in directing EPA to establish the GHGRP.[44]

If the Petitioner had been on notice of the remote possibility that EPA would finalize lower collection efficiencies applicable to *all* Reporters, without regard to SEM, the Petitioner certainly would have submitted corresponding comments, outlining the broad range of scientific reasons why EPA should not do so. But since EPA failed to provide such notice, EPA's finalized collection efficiencies cannot permissibly be considered the "logical outgrowth" of its original proposal.

The situation here is unlike other cases in which the D.C. Circuit has found that the final rule was a "logical outgrowth" of a proposed rule. For example, in *Northeast Maryland Waste Disposal Authority v. EPA*, the Circuit Court held that a final rule which collapses the proposed rule's three categories into two *is* the logical outgrowth of the proposed rule. 358 F.3d 936, 953 (D.C. Cir. 2004). Rather, EPA's action here is akin to situations where the Circuit has found a lack of logical outgrowth. In *International Union*, for example, the agency's proposed rule provided that "[a] minimum air velocity of 300 feet per minute must be maintained" to ventilate underground coal mines.[45] The final rule, however, provided that "[t]he maximum air velocity in the belt entry must be no greater than 500 feet per minute, unless otherwise approved in the mine ventilation plan."[46] The D.C. Circuit vacated the final rule because, although "[t]here were some comments during the hearings urging the Secretary to set a maximum velocity cap," the Agency "did not afford a ... public notice of its intent to adopt, much less an opportunity to comment on, such a cap." *International Union*, 407 F.3d at 1261. Like the concept of air velocity in

[44] 121 Stat. 1844, Pub. L. 110-116 (Dec. 26, 2007).
[45] 68 Fed. Reg. 3936, 3965 (Jan. 27, 2003).
[46] 69 Fed. Reg. 17,480, 17,526 (Apr. 2, 2004).

International Union, the general concept of collection efficiency may have been raised in the 2023 Supplement, but the Final Rule's across the board decrease in collection efficiencies for all landfills is not consistent with the Proposed Rules, nor was it foreseeable from the Proposed Rules. EPA's final action here "finds no roots in the agency's proposal," *Kooritzky v. Reich*, 17 F.3d 1509, 1513 (D.C. Cir. 1994), equating to an impermissible "surprise switcheroo." *Envt'l Integrity Project v. EPA*, 425 F.3d 992, 996 (D.C. Cir. 2005).

EPA has attempted to support its collection efficiency "switcheroo" by citing two new scientific studies that allegedly support the lowering of collection efficiencies as applicable to *all* Reporters, without regard to SEM. Specifically, EPA states that "[a]ll the measurement study data [] reviewed suggests that current GHGRP collection efficiencies are overstated on average by 10-percentage points or more," citing to *Duan et al.*, 2022[47] and *Nesser et al.*, 2023.[48] As explained below, neither these studies nor the EIP Study support EPA's final decision.

Further, from a notice standpoint, EPA did not cite to either the *Duan* or *Nesser* studies in the Proposed Rules. The *Nesser* study was advanced by the paper's co-author, Hannah Nesser, in her comment in response to EPA's 2023 Supplement. [49] The paper itself was published online on June 13, 2023, only a few weeks before the close of the public comment period on July 22, 2023. The information contained therein was not even publicly available so as to inform EPA's proposals advanced on May 22, 2023, in the 2023 Supplement. In relying on entirely new data within the *Nesser* paper, EPA attempts to impermissibly "bootstrap" notice from a comment. *See*

[47] Duan, Z., et al., *Efficiency of gas collection systems at Danish landfills and implications for regulations*. 139 WASTE MANAGEMENT 269–78 (2022), https://doi.org/10.1016/j.wasman.2021.12.023.
[48] Nesser, H., et al., *High-resolution U.S. methane emissions inferred from an inversion of 2019 TROPOMI satellite data: contributions from individual states, urban areas, and landfills*. EGUSPHERE [preprint] (2023), https://doi.org/10.5194/egusphere-2023-946.
[49] EPA-HQ-OAR-2019-0424-0306. The paper was published online on June 13, 2023, only a few weeks before the close of the public comment period on July 22, 2023.

Fertilizer Inst. V. EPA, 935 F.2d 1303, 1312 (D.C.Cir.1991). EPA cannot reasonably assert that the final collection efficiencies are the "logical outgrowth" of the 2023 Supplement by relying on a study introduced via comment, without providing other interested parties the opportunity to review and comment on the study as well, for the purpose for which it is offered. *See, e.g.*, *United States v. Nova Scotia Food Prod. Corp.*, 568 F.2d 240, 251 (2d Cir. 1977).

Even more unacceptable is EPA's reliance on the *Duan* study. EPA did not cite or refer to *Duan* in either proposed rule; nor was it cited by an interested party during the public comment process. EPA's sudden reliance on *Duan* appears to be a post-hoc rationalization for its Final Rule, rather than appropriately identified support for a proposal that was properly noticed. Indeed, in this rulemaking, EPA has expressly acknowledged that newly cited studies introduced during the comment period warrant the agency's further consideration. As described *supra*, EPA proposed to implement a "correction term" to equations HH-7 and HH-8 that it hoped would more accurately quantify emissions by "account[ing] for periods where surface issues reduce the gas collection efficiency and/or reduce the fraction of methane oxidized."[50] In NWRA's comments on the proposal, we objected to the addition of the correction term on the basis that EPA's cited sources, namely *Heroux, et al.* and its internal sources, do not "adequately capture the complexity of the attempted correlation between surface emission exceedances and methane flux."[51] We asked that EPA consider other studies which show significant variability in the alleged correlation. In response, EPA stated that it would "continue to review additional information on existing and advanced methodologies and new literature studies and consider ways to effectively incorporate these methods and data in future revisions under subpart HH[.]"[52]

[50] 2023 Supplemental Proposal, 88 Fed. Reg. at 32878.
[51] EPA-HQ-OAR-2019-0424-0319.
[52] Final Rule, 89 Fed. Reg. at 31855.

EPA also indicated that it would take time to further consider the implementation of a correction term in light of newly advanced data, without taking any action in the Final Rule.[53] Consistent with its response to comments on the correction term, EPA should have acknowledged that more study of collection efficiency values is needed and should have subjected the 10-percent across-the board reduction collection efficiencies to an additional round of notice-and comment. *See, e.g.*, *Mexichem Specialty Resins, Inc. v. EPA*, 787 F.3d 544, 554 (D.C. Cir. 2015) (EPA may determine that affording a party seeking reconsideration the "same procedural rights" requires the initiation of rulemaking to gather additional data" to inform its decision).

B. <u>The finalized collection efficiencies should be reconsidered because the Petitioner's objections are of "central relevance to the outcome of the rule."</u>

An objection is of central relevance if it "provides substantial support for the argument that the regulation should be revised." *Coal. For Responsible Regulation v. EPA*, 684 F.3d 102, 125 (D.C. Cir. 2012); *Kennecott Corp. v. EPA*, 684 F.2d 1007, 1019 (D.C. Cir. 1982) ("Because the reasonableness and accuracy of the forecast data is critical to whether a smelter can qualify for [a nonferrous smelter order], Asarco and Magma's objections to that data, if well-founded, would clearly have been "'of central relevance.'").

The finalized collection efficiencies should be reevaluated and revised because they were central to the proposed and Final Rules. Indeed, emissions calculations are the crux of the GHGRP. EPA has articulated its over-arching goal to increase the accuracy of emissions calculations, so that Reporters, and more broadly the public at large, can understand whether and to what extent an entity is contributing to greenhouse gas emissions.[54] Universal required

[53] *Id.*
[54] Final Rule, 89 Fed. Reg. at 31884 ("[T]ransparent, standardized public data on emissions allows for accountability of polluters to the public who bear the cost of the pollution. The GHGRP serves as a powerful data resource and provides a critical tool for communities to identify nearby sources of GHGs and provide information to state and local governments.").

changes in calculation methodologies, therefore, should be considered carefully by EPA, especially where it has added a new methodology that overestimates emissions across the reporting sector. At a minimum, the "central relevance" requirement for reconsideration is satisfied in circumstances such as this, where there are well-founded objections pertaining to "critical" portions of the rule. *See Kennecott*, 684 F.2d at 1019.

Indeed, EPA's finalization of understated collection efficiencies, and the lack of support thereof, undermine the very purpose and objective of the GHGRP—to promote the accurate and comprehensive collection and reporting of greenhouse gas emission data. These failures will, in turn, harm the Petitioner's members. The finalized collection efficiencies will result in discrepancies among state and federal programs that require methane emissions reporting. With respect to federal programs, EPA has used GHGRP data on MSW landfills to "inform the development of the 2016 NSPS and EG for landfills." [55] Similarly, the "benefits of improved reporting also include enhancing existing voluntary programs, such as the Landfill Methane Outreach Program (LMOP)."[56] Moreover, EPA recognizes that "[s]everal states use GHGRP data to inform their own policymaking."[57] GHGRP emission estimates will also be at odds with EPA's own emissions factors in AP-42, as well as state permitting programs, which allow for a range of collection efficiencies and the recognition that higher collection efficiencies may be achieved at some sites that are designed and engineered to collect and control landfill gas.[58]

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[55] *Id.*
[56] *Id.*
[57] *Id.*
[58] *See* AP-42, at 2.4-6, https://www3.epa.gov/ttnchie1/ap42/ch02/final/c02s04.pdf

> "To estimate controlled emissions of CH4, NMOC, and other constituents in landfill gas, the collection efficiency of the system must first be estimated. Reported collection efficiencies typically range from 60 to 85 percent, with an average of 75 percent most commonly assumed. Higher collection efficiencies may be achieved at some sites (i.e., those engineered to control gas emissions). If site-specific collection efficiencies are available (i.e., through a comprehensive surface sampling program), then they should be used instead of the 75 percent average."

Without accuracy and consistency across these programs, Reporters and agencies will not be able to appropriately identify and address emissions-related issues at affected facilities.

To the extent that GHGRP reported emissions are overestimated compared to reported emissions under other programs, such discrepancies will also add complexity to sustainability reporting and permitting, negatively impacting and complicating information provided to shareholders and third parties, and subjecting Reporters to risk. As a practical matter, the lowered collection efficiencies will have a compounding effect across multi-facility companies and may act as a disincentive to increase gas collection given that EPA's final rule now assumes inefficiencies among Reporters using HH-8. This is because HH-8, in general, assumes that emissions are directly proportional to the amount of landfill gas that is recovered and destroyed. Thus, the lowered collection efficiencies in the new rule could disincentivize higher actual collection.

Moreover, absent reconsideration, the final rule may have broad unintended consequences on policies designed to reduce greenhouse gas emissions. EPA's Renewable Fuel Standard ("RFS") program, for example, requires gasoline and diesel producers to incorporate renewable fuels into the Nation's transportation fuel supply.[59] Congress sought to accomplish this mandate in large part by encouraging the increased production and use of cellulosic biofuels—including renewable natural gas derived from landfill biogas—with the goal of achieving lower costs for consumers, reduced GHG emissions, better air quality, and greater energy independence.[60] Other policies have built upon the success of the RFS program, offering

[59] *See* 40 C.F.R. § 80, subpart M.
[60] *Renewable Fuel Standard (RFS) Program: Standards for 2023–2025 and Other Changes*, 88 Fed. Reg. 44468, 44471 (July 12, 2023).

additional incentives for landfill methane capture, which waste sector stakeholders rely on in making business decisions around the installation of bio gas processing equipment.

States such as California, Oregon, Washington, and New Mexico have also developed Clean Fuel Standard programs[61] to encourage the use of low-carbon transportation fuels by providing credit to renewable fuel producers on a sliding scale based on the carbon intensity of each fuel. Unfortunately, the finalized collection efficiencies will have a negative impact on the carbon intensity scores of fuels sourced from landfill-derived biogas, resulting in reduced financial incentives for the production of renewable natural gas and potentially disincentivizing projects aimed at capturing methane emissions from waste sector operations. Congress has similarly incentivized the implementation of clean energy projects under the Inflation Reduction Act of 2022 ("IRA")[62], making tax credits available to taxpayers using a "technology-neutral" approach. The IRA specifically included a suite of tax credits designed to reward renewable fuel producers for lowering the carbon intensity scores of their fuels.[63] Similar to the negative impacts of the final rule associated with the aforementioned Clean Fuel Standard programs, EPA's finalized collection efficiencies will reduce the value of various tax credits for the production or generation of renewable natural gas, clean hydrogen, renewable electricity, and sustainable aviation fuel—potentially resulting in lost opportunities to capture landfill methane for beneficial use. Finally, to the extent that future legislative actions would contemplate a "carbon tax" or similar financially based implications for greenhouse gas emissions, it is

[61] Cal. Code Regs. tit. 17, § 95480; Or. Admin. R. 340-253-0000; Wash. Rev. Code Ann. § 70A.535.005; New Mexico House Bill 41 (requiring the Environmental Improvement Board to promulgate regulations to initiate the program no later than July 1, 2026).
[62] 136 Stat. 1818, Pub. L. 117–169 (Aug. 16, 2022).
[63] *See* 26 U.S.C. § 6426.

imperative that the quantification of such emissions is reliable and accurate. EPA should set a high standard under the GHGRP for such accuracy.

C. **EPA lacks adequate technical justification for the finalized reduction in collection efficiencies.**

As finalized, the lowered collection efficiencies are technically unjustified, and the proffered bases do not support EPA's change in position.

An agency action is arbitrary and capricious if there does not exist a "rational connection between the facts found and the choices made." *Motor Vehicle Mfrs. Ass'n of U.S., Inc. v. State Farm Mut. Auto. Ins. Co.*, 463 U.S. 29, 43 (1983). A rational connection between the facts found and the choices made does not exist if, among other reasons, the agency failed to consider an important aspect of the problem or the agency offers an explanation for its decision that runs counter to the evidence. *Id.* Both shortcomings are present here. In the 2023 Supplement, EPA purported to address "methane emissions from large release events" and focused on whether landfills were using SEM to address "leaking cover systems due to cracks, fissures or gaps around protruding wells" as a basis on which to adjust collection efficiency.[64] But in the Final Rule, EPA dismissed SEM as a consideration and relied only on study papers, including two that were newly cited, to support an across the board reduction in collection efficiencies, rather than focusing on methane emissions from large release events as it did in the 2023 Supplemental Proposal. In so doing, EPA prevented comment that would have addressed overall collection efficiencies across the MSW landfill sector rather than emissions associated with large release events, including those that occur via cover problems that are addressed by SEM. Such material comments would have advanced arguments falling within the "relevant factors" that EPA is

[64] 2023 Supplemental Proposal, 88 Fed. Reg. at 32877–78.

required to consider before finalizing a regulation. Without consideration of such important input, EPA ignored "important aspects of the problem" relating to landfill collection efficiency and greenhouse gas emissions. *Motor Vehicle Mfrs. Ass'n of U.S., Inc. v. State Farm Mut. Auto. Ins. Co.*, 463 U.S. 29, 43 (1983). While reviewing courts are generally deferential with respect to decisions involving agency expertise, *Logic Tech. Dev. LLC v. FDA*, 84 F.4th 537, 549 (3d Cir. 2023); *GenOn REMA, LLC v. EPA*, 722 F.3d 513, 526 (3d Cir. 2013), agencies are forbidden from reaching "whatever conclusions [they] like" and defending such positions "with vague allusions to [their] own expertise." *Sierra Club v. EPA*, 972 F.3d 290 (3d Cir. 2020) ("Although EPA has offered vague allusions to the inability of unspecified plants to meet a lower standard, the agency has deprived us of the ability to review its decision by showing its work."). Put simply, an agency action must be "reasonable and reasonably explained." *FCC v. Prometheus Radio Project*, 592 U.S. 414 (2021). This was not.

In the Final Rule, EPA acted arbitrarily by relying on scientific data that was not presented in either of the Proposed Rules. Just as importantly, EPA also failed to adequately explain how the scientific conclusions of the studies on which it relied—which involved the use of remote sensing data to quantify landfill emissions—support the final collection efficiencies without regard to SEM. In fact, in the Final Rule EPA underscored the dangers of relying on such technologies at this juncture. There, EPA stated that it was "not taking final action at this time regarding the incorporation of other direct measurement technologies" such as satellite imaging, aerial measurements, vehicle mounted measurement or continuous sensor networks because "most top-down facility measurements are taken over limited durations (a few minutes to a few hours) typically during the daylight hours when specific meteorological conditions exist (*e.g.*, no cloud cover for satellites; specific atmospheric and wind speed ranges for aerial measurements).”[65] EPA further recognized that these methods of measurement “may not be representative of the annual CH_4 emissions from a facility, given that many emissions are episodic.”[66] Consequently, EPA concluded, “[e]xtrapolating from limited measurements to an entire year therefore creates risk of either over or under counting actual emissions.”[67] In this respect, EPA’s decision to heavily rely upon *Nesser* and similar studies, whose findings are the result of satellite imaging, in supporting a broad-based and unqualified reduction in collection efficiency values, is puzzling. EPA makes no effort to explain this discrepancy in logic, which has resulted in a Final Rule that runs counter to the agency’s own findings.[68]

1. <u>The Nesser Study does not support EPA’s collection efficiency determination.</u>

EPA cites the *Nesser* study for the general proposition that “recent aerial studies indicate methane emissions from landfills may be considerably higher than bottom-up emissions reported under subpart HH for *some* landfills” and further notes that such higher emissions may be attributable to “poorly operating gas collection systems or destruction devices and leaking cover systems.”[69] But EPA fails entirely to explain how the *Nesser* study, which was based on its review of only 38 landfills, supports a broad-based collection efficiency reduction applicable to

[65] Final Rule, 89 Fed. Reg. at 31856.
[66] *Id.*
[67] *Id.*
[68] This petition focuses on the introduction of scientific data from Nesser, et al., 2023 and Duan et al., 2022. EPA also referenced two additional studies: Oonk, H., *Efficiency of landfill gas collection for methane emissions reduction*, 2 GREENHOUSE GAS MEASUREMENT AND MANAGEMENT, 129–145 (2012) https://doi.org/10.1080/20430779.2012.730798; and Arcadis, *Quantifying Methane Abatement Efficiency at Three Municipal Solid Waste Landfills; Final Report*. Prepared for U.S. EPA, Office of Research and Development, Research Triangle Park, NC. EPA Report No. EPA/600/R–12/ 003. (Jan. 2012). https://nepis.epa.gov/Exe/ZyPDF.cgi/P100DGTB.PDF?Dockey=P100DGTB.PDF.
It is unclear whether EPA relies on these studies to support its assertion that historical collection efficiencies are overstated, because EPA fails to adequately explain the relevance of these studies and how they support the finalization of the lowered collection efficiencies. Final Rule, 89 Fed. Reg. at 31856.
[69] Final Rule, 89 Fed. Reg. at 31854 (emphasis added).

the more than 1,000 landfills[70] that are subject to reporting under the GHGRP.[71] Just as critically, EPA does not explain the basis on which such collection efficiencies can be appropriately or accurately measured with satellite imagery—a key concern for the Petitioner.

The *Nesser* study uses 2019 satellite (TROPOMI) data at approximately 25 x 25 km resolution to estimate methane emissions for grid cells in the contiguous United States with 2012 reported methane emissions larger than 0.1 Mg /(km year).[72] *Nesser* alleges that landfill emissions are 51% higher than the Greenhouse Gas Inventory ("GHGI") indicates.[73] The study compared optimized emissions for 73 individual landfills to those reported under the GHGRP and alleges to have found a median 77% increase in emissions relative to reported values.[74] Of the 73 studied landfills, 38 of the facilities recovered gas and reported an average efficiency of 0.5 (0.33 – 0.54) compared to the reported average of 0.61.[75] However, the collection efficiency reported in the 2019 GHGI was either within or higher than the author's reported uncertainty range for 15 of the 38 landfills.[76] Moreover, the study found no correlation (R2 = 0.00) between GHGRP emissions and the landfill estimates. The correlation did not improve when considering only facilities that do or do not capture landfill gas.[77] In summary, NWRA believes that the *Nesser* study introduces several uncertainties, which, taken separately or collectively, undermine its use as a basis for EPA's action:

- The range reported is not a credible (confidence) interval for the estimated emissions but is the range of the eight members of the ensemble. This range only accounts for

[70] EPA-HQ-OAR-2019-0424-0256, Attachment A.
[71] Final Rule, 89 Fed. Reg. at 31856.
[72] *Nesser*, *et al.*, at 2, 4.
[73] *Id.* at 26.
[74] *Id.*
[75] *Id.* at 19.
[76] *Id.*
[77] *Id.*

the uncertainty introduced by the optimized boundary conditions, bias correction, and regularization factor, and does not account for the uncertainty in the measurements, transport model or and source attribution methods.

- Emission sources not included in the 2012 GHGI are not accounted for. The source aggregation approach assumes that the 2012 reported fractional sectoral contributions are correct in each 25 x 25 km grid cell.
- The study only quantified 70 of the 1297 landfills that reported to the GHGRP in 2019.
- Satellite data can only be collected during clear daytime conditions, so landfills in areas with snow or high cloud cover were less likely to be quantified. With a low (3%) success rate, TROPOMI data may be as few as 12 measurements over the course of a year for a given site, biased toward clear summertime conditions.
- The study does not discuss whether readings occurred during landfill operating hours.
- It is our understanding that TROPOMI is an open-source satellite in geosynchronous orbit, meaning that measurements are taken at the same time each day, thus failing to account for key differences in nighttime values. EPA's own work discusses that 99% of landfills have more negative temporal pressure during days compared to the rest of the time leading to overestimating methane emission. While not published, EPA should be aware of work done within its own agency regarding this topic.

Indeed, even the authors acknowledge the risks inherent in relying on such data: "[o]ur landfill attribution approach, which relies on a prior estimate from 2012, may therefore misallocate emissions to the Puente Hills Landfill instead of to co-located oil and gas operations".[78] Further, the study goes on to say, "[c]ompared to TROPOMI, both the prior and posterior GEOS- Chem simulations produce similar coefficients of determination (R2) and root-mean-square errors (RMSEs)," indicating that using the authors' estimated emission rates fail to explain any additional variability in the satellite measurement compared with the 2012 reported values.[79]

By not accounting for all the sources of uncertainty in the model and measurements in the reported uncertainty range, the authors have failed to demonstrate that the difference between the observed and reported collection efficiencies is statistically significant. The variation in observed collection efficiencies and significant sources of uncertainty in the observations do not provide sufficient justification for a 10% reduction in collection efficiency across the board.

2. The Duan Study does not support EPA's collection efficiency determination.

EPA similarly fails to explain how the conclusions of the *Duan, et al.*, 2022 study support its decision to lower collection efficiencies and uncouple collection efficiency from SEM. In fact, the conclusions set forth in the *Duan* study more closely *support* EPA's 2023 Supplement proposal to tie collection efficiency to SEM.

The *Duan* study observed 23 Danish landfills using a tracer gas dispersion method.[80] Gas collection efficiencies were calculated by taking the collected methane gas and dividing it by the sum of collected methane, methane emitted into the atmosphere, methane oxidized in cover soil, methane migrated laterally, and methane stored in the landfill body.[81] As a result, the study concluded that Danish landfills, on average, have lower collection efficiencies than other

[78] *Id.*
[79] *Id.* at 13.
[80] Duan, Z., et al., *Efficiency of gas collection systems at Danish landfills and implications for regulations*, 139 WASTE MANAGEMENT 270 (2022), https://doi.org/10.1016/j.wasman.2021.12.023.
[81] *Id.*

countries, and suggested that such was the result of shallow wells, lack of gas collection in some areas, and low recovery due to minimal production.[82] The study based its conclusions on "whole-site methane," even when collection systems did not cover the site. Sites that had discontinuous GCCS operations had high collection efficiencies (94-95%) when the system ran, but lower collection efficiencies when the GCCS was turned off, leading to lower average collection efficiencies.[83]

Notably, the *Duan* study acknowledged the complexity associated with quantifying gas production, emissions, and collection efficiency.[84] The study stated, "[a]t landfills with well-designed liner and cover systems and aggressive gas collection approaches, efficiency can be as high as above 90%, as observed in previous studies (e.g. UK-J and Redwood landfills) based on whole-site emissions measurements."[85] Further, the study noted "[i]f gas collection has not been established in every cell at a landfill—for example, if no gas collection occurs at active cells—using average efficiency will underestimate the actual gas collection efficiency in closed cells."[86] Based upon the complexity of calculation and landfill-dependent factors, the study actually suggests coupling collection efficiency with SEM.[87] This acknowledgment better comports with EPA's proposal in the 2023 Supplement, rather than what was finalized in the Final Rule. In sum, the *Duan* study agrees that a one-size-fits-all approach is inappropriate when it comes to landfill collection efficiency—an implication that is directly at odds with EPA's decision to

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[82] *Id.* at 277.
[83] *Id.* at 274.
[84] *Id.* at 275 ("Landfill gas production and emissions are determined by many factors, such as waste composition, waste age, disposed waste amount, landfill design and operation, lack meteorological conditions, etc."); *see also id.* at 276 ("Gas collection efficiency depends on the phase of the landfills, design, and management of the LFG collection system, the presence or type of top cover, etc.").
[85] *Id.* at 270.
[86] *Id.* at 276.
[87] *Id.* Specifically, it states that "surface methane concentration screening could be conducted to identify significant release points or areas, following which any identified major leaks should be repaired."

lower default collection efficiencies across the board. With little more than a few sentences supporting EPA's use of this study in the Final Rule, EPA has failed to establish a rational connection between *Duan* and lowered default collection efficiency values irrespective of SEM.

Further diminishing any justification for reliance on the *Duan* study is the fact that it pertains to Danish landfills that are not representative of landfills across the United States. EPA has agreed with NWRA's contention that the data the agency used to support the proposed correction term—which rested on an analysis conducted using a dynamic flux chamber covering a surface area of 0.2 m^2 over 20 years ago at one landfill in Canada—could not adequately support the proposal.[88] Similarly, here, EPA should not rely on a study evaluating Danish landfills, especially where the authors state that there are stark differences between U.S. and Danish landfills. Specifically, the study states that the "measured emissions normalized to the disposed waste mass and areas of the landfills in Denmark are *significantly* lower than" normalized emissions of U.S. landfills, which may be the result of Denmark's 1997 ban on landfilling organic waste.[89] Consequently, relying on the *Duan* study is unacceptable, especially in light of EPA's outward refusal to rely on studies not found to be "nationally representative" of MSW landfills.[90]

3. The EIP and Duren Studies do not support EPA's collection efficiency determination.

Although EPA cites to both the EIP Study and the *Duren et al.*, 2019[91] study in the 2023 Supplement, EPA fails to adequately explain how either of these studies support its decision to

[88] Final Rule, 89 Fed. Reg. at 31855.
[89] *Duan et al.*, at 276.
[90] Data Quality Improvements Proposal, 87 Fed. Reg. at 37009.
[91] Duren et al., *California's Super Emitters*. 575 NATURE 180¬84. 7 (2019), https://doi.org/10.1038/s41586-019-1720-3.

lower collection efficiencies by 10% across all categories of affected landfills. As such, EPA's decision, which relies on these papers, is not supported.

EIP's findings rest on their discovery of a math error in the State of Maryland's methane emissions calculation for landfills. The study pointed out that the Maryland Department of the Environment calculated emissions as 10% of uncollected gases and 90% oxidized instead of 90% uncollected and 10% oxidized. From there, the study discussed how few landfills have gas collection and control systems—21 out of 40—with only four subject to federal requirements under the New Source Performance Standards program. EIP ultimately suggests two solutions: (1) more widespread implementation of gas collection systems, and (2) organics diversion. It compares collection efficiencies of facilities with gas collection and control systems that are subject to NSPS (76% collection efficiency) and those that voluntarily install such systems (55% collection efficiency): "EPA estimates that the average collection system harnesses 75% of the gas generated in the waste heap." However, EIP then notes that Maryland landfills have system collection efficiencies that range from 5-95%, with an average of 59%.

As stated in NWRA's comments to the 2023 Supplement, Maryland landfills are not representative of landfills across the United States and represent a low number of federally regulated landfills. Therefore, the data from this study should not be extrapolated to other landfills in the U.S. for comparing subpart HH collection efficiencies and LandGEM modeling-based collection efficiency. EPA exacerbated this misplaced reliance by failing to consider key variables in its analysis, including differences in waste disposal streams (and associated differences in potential methane generation capacity), calculation methodologies for collection efficiencies based on reported collection volumes, and the significance of federal expansion timelines and downtime limitations over the performance of SEM.

In addition, EPA failed to articulate a rational explanation with respect to how the study's conclusions support the across-the-board reductions in collection efficiencies seen in the Final Rule, and failed to address the concerns raised by NWRA in its comments. Ultimately, EPA went from using the EIP Study to support reduced collection efficiencies for facilities not conducting SEM, to reducing collection efficiencies for all Reporters regardless of SEM. Interestingly, EPA could not cite this study, or any other for that matter, to "support further reductions in gas collection efficiencies for voluntary gas collection systems."[92] Even in light of EPA's scientific and technical expertise, the use of the EIP Study to support the finalized changes is not "reasonable [or] reasonably explained." *FCC v. Prometheus Radio Project*, 592 U.S. 414 (2021).

To the extent that EPA's finalized collection efficiencies were promulgated using conclusions from *Duren et al.*, 2019, such reliance is likewise misguided. The *Duren* study conducted five campaigns between 2016 through 2018 to survey more than 272,000 "infrastructure elements" in California using an airborne imaging spectrometer that the authors alleged "can rapidly map methane plumes."[93] However, the *Duren* study conceded "[t]he fact that we did not detect a larger population of smaller methane point sources across the landfill sector suggests that most of those facilities emit methane as area sources that cannot be detected with this method."[94] EPA similarly acknowledged this shortcoming in its Technical Support Memo:

> *It is important to note that only landfills with anomalous emissions could be quantified by the aerial methods used by Duren, et. al., (2019) and that these emissions only occurred at 7 percent of the surveyed landfills. However, when these anomalous emissions occur, the CH4 emissions reported to the EPA under Subpart HH are consistently lower than the measured emission rates extrapolated to annual*

[92] Final Rule, 89 Fed. Reg. at 31856.
[93] *Duren, et al.*, at 180.
[94] *Id.* at 182.

> *estimates……… Because the California aerial study of Duren, et. al., (2019) could not quantify the emissions from 93% of the landfills that did not have anomalous emissions, this study does not provide evidence that the Subpart HH methodologies are inaccurate or unbiased under typical conditions that exist for most landfills.*[95]

The *Duren* study also failed to discuss diurnal issues or times of flights (*e.g.*, whether flights were conducted during the daylight hours), and it relied on a "persistence" factor that is inappropriate for multiple reasons. In this original publication, *Duren* gave landfills a blanket "100%" persistence factor, meaning that it extrapolated estimated emissions results to the entire year, which EPA has recognized as inappropriate.[96] Moreover, use of this persistence factor is inappropriate because the authors filtered their runs to weed out flights where they didn't get a detection, or the detection was unreliable for various QA/QC reasons.

Further, the *Duren* study never addresses whether the same plume may have been detected on multiple flyovers. This information is important, because it could either exaggerate or undermine the 100% persistence concept that is fundamental to emission quantification based on such remote observations. For example, different plumes would have different calculated emissions, with no one plume being appropriate for extrapolation. Further, the reality of variable emissions points reflect the variable nature of emissions over time. Assuming continuous emissions could easily overlook low- or even no-emissions days, in direct conflict with the notion of "100% persistence."

As another example, *Duren*'s methodology for calibrating wind data also relies on the work done by others in the Four Corners region, which is a very flat, desert type area that is inappropriate for other types of topography, including the canyon-topography landfills located in

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[95] EPA-HQ-OAR-2019-0424-0256 Technical Support for Supplemental Revisions to subpart HH; Municipal Solid Waste Landfills, at 3.
[96] *See discussion supra* in Section III.C.1.

California. These calculations are highly sensitive to accurate wind modeling, making *Duren*'s use of a wide geographic NOAA data area questionable. In particular, *Duren's* approach was to use NOAA data, and subdivide the area around the landfill into 3 km squares, averaging the 9 closest squares into the "average site windspeed and direction" and applying that to the detected concentrations.[97] But plumes are not formed in that manner in challenging topographical areas. As with the point above, more recent publications from *Duren* and others, as well as other industry presentations, recognize that canyon landfills are notoriously difficult from which to quantify emissions.

Like *Nesser*, which utilized satellite data to support its findings, the integrity of the aerial measurements collected in *Duren* cannot provide adequate support for the lowered collection efficiencies across the entire MSW landfill sector for the same reasons.[98]

4. <u>Other papers and emerging studies do not support EPA's reduction in collection efficiency determination.</u>

EPA, industry participants, and third parties continue to actively assess the value of remote sensing techniques for landfill emission quantification. While there is great interest and optimism around this topic, specific conclusions around collection efficiency values are premature. For example, in its comments to the 2023 Supplemental Proposal, Carbon Mapper has pointed out that there is "no existing system to validate or revise GHGRP reporting" based on "observed emissions rates using remote sensing."[99] Instead, Carbon Mapper suggested an multi-tiered monitoring approach to validate reported annual emissions by using a system to quantify "total site-wide emission sources" using "high-frequency to continuous monitoring."[100]

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[97] *Duren* et al., at 181.
[98] *See supra*, Section III.C.1.
[99] EPA-HQ-OAR-2019-0424-0324, at 5.
[100] *Id.* at 5.

In addition, in responding to EPA's stated concern in the 2023 Supplemental Proposal about large release events, Carbon Mapper recommended the use of site-specific data to aid in assessing these events to avoid double counting, including "construction periods and locations, type of GCCS and combustion devices, any use of automated well tuning, monitoring methods used (including non-regulatory, voluntary monitoring), and cover types used."[101]

To the extent that EPA intended to rely on top-down, direct measurement technologies to support the reduction in collection efficiencies, EPA improperly extrapolated data that, if collected on a continual basis, would tend to prove the opposite conclusion. For example, a study by *Cusworth*, et al. found that "[o]n average, aerial emission rates were a factor of 2.7 higher than GHGRP for all landfills and a factor 1.4 higher for landfills with 10+ unique overpasses. Consistent with this study, independent assessments of US emission inventories have indicated a needed 1.25 to 1.5 scaling of waste emissions to reconcile inventories with in situ ground-based measurements and coarse resolution satellite observations."[102] These findings emphasize even the Nesser authors' direct acknowledgement that the average of more point-in-time observations for a single site tends to agree more closely with annual inventory estimates; providing evidence that there is not enough data to support the extrapolated claim that observations are more representative than annual inventory estimates. The recency of the *Cusworth* publication reinforces the imperative raised by the Petitioners in their comments: that EPA should wait to promulgate changes to subpart HH in anticipation of forthcoming data that will provide more appropriate support for comprehensive changes.

[101] *Id.* at 5.
[102] Cusworth, et al., *Quantifying methane emissions from United States landfills*. 383 SCIENCE 1499 (2024).

As discussed *supra* in Sections III.C.1 and III.C.2, remote sensing measurements using satellite and aircraft systems like TROPOMI and AVIRIS-NG, described in *Nesser*, et al., 2024 and *Duren*, et al., 2019, can only be made during daylight hours, causing landfill emission rates derived from these approaches to be biased high because the measurements are made during active landfilling operations and do not capture the period when the landfill is not receiving waste. Another study, *Delkash*, et al., 2022, used eddy covariance ("EC") measurements to assess diurnal variations in methane emissions and "showed that short-term tracer correlation method ("TCM") measurements conducted between 12:00 and 18:00 overestimate diurnal emissions estimated by the EC tower up to 73% at this site."[103] The EC methodology is able to operate continuously to capture concentration measurements to support emissions estimates over longer durations in a wide range of meteorological conditions and atmospheric stability classes. The study reported significant diurnal variation in methane flux at one landfill where EC and TCM were deployed over three seasons, and found that daytime methane flux rates were up to 23 times higher than nighttime fluxes.[104] Moreover, the daily average of EC observations presented a lower estimated emission rate when compared to tracer correlation method observations, a methodology similar to that used in the *Duan*, et al., 2019 study. While the *Delkash* study included only one landfill, its findings point to the potential bias of relying on daytime only measurements to determine landfill emissions rates, particularly when those rates will then be compared to annual rates like the GHGRP. The study, therefore, stands for the same conclusion articulated above: assessing the accuracy of the GHGRP modeled rates requires measurement methods that continuously monitor both point-source and diffuse emissions so as to better

[103] Delkash, et al., *Diurnal landfill methane flux patterns across different seasons at a landfill in Southeastern US*, 144 WASTE MANAGEMENT 76, 85 (2022).
[104] *Id.* at 76.

understand diurnal and seasonal variations to compare point-in-time observations to annual emissions inventory estimates.[105]

IV. Basis for Relief and Proposed Next Steps

Overall, EPA does not articulate a rational connection between the scientific and technical evidence relating to landfill collection efficiency and the decision to stray from its proposal and apply a uniform approach to collection efficiency values uncoupled from SEM. While NWRA did not support the SEM-based approach advanced by the 2023 Supplemental Proposal for the reasons expressed in our comments, we acknowledge the importance of site-specific design and performance factors in assessing collection efficiency. EPA's Final Rule is the opposite of a site-specific approach, based on SEM or otherwise. We expected the Final Rule to be the logical outgrowth of the proposal to tie collection efficiency adjustments to SEM. We also recognized that the proposed coupling of collection efficiencies and SEM served as an incentive for "non-regulated" landfills to implement SEM to avail themselves of the higher collection efficiencies. Lowering collection efficiency regardless of SEM now may have an unintended effect—if Reporters know that they can never achieve greater than 85% efficiency in estimating emissions under the GHGRP, there is little incentive to increase efficiency. EPA's simple explanation that lowered collection efficiencies are warranted in light of the agency's review of "direct measurement data for landfills" leaves an unfillable gap in reasoning and logic, warranting reconsideration.

NWRA and its members recognize the importance of developing technologies and ongoing studies and analyses of direct measurements and remote sensing data. The MSW landfill sector is deeply engaged in this work, in partnership with EPA's Office of Air and Radiation as

[105] *Id.* at 85; *see also* Stark, et al., *Investigation of U.S. landfill GHG reporting program methane emission models*, 186 WASTE MANAGEMENT, 86, 86, 91 (2024).

well as its Office of Research and Development, Carbon Mapper, GHG Sat, RMI and others. Through SWICS and company-specific data analyses, NWRA anticipates that it will have a substantial set of data to share with EPA in the very near term, after appropriate quality control and assessment is complete. The data will consist of direct measurements, correlated with site-specific SEM and operational conditions, and evaluations of resulting emission impacts. NWRA will share this data with EPA in the proposed reconsideration period to help inform EPA's perspective on collection efficiencies. Most importantly, to the extent that these advancements assist in the strengthening of emission quantification and information, and thereby provide avenues for improvements in methane capture, the GHGRP should be structured to acknowledge and account for such improvements. The Final Rule unfortunately has the opposite effect, by imposing reduced collection efficiencies across the board, based on overgeneralized and qualitative theories that do not support the determination that was made.

As set forth at length above, NWRA requests that EPA grant reconsideration of the reduced collection efficiencies set forth in Table HH-3 of the Final Rule. Interested parties were not afforded the opportunity to comment on EPA's finalized collection efficiencies because they were not a "logical outgrowth" of the Proposed Rules.

To the extent that EPA declines to grant reconsideration on the bases set forth in Section 307(d)(7)(B) of the Clean Air Act, the Petitioner asks that EPA treat this submittal as a petition for rulemaking under the Administrative Procedure Act, 5 U.S.C. § 553(e), which is a "procedural right." *Massachusetts v. EPA*, 415 F.3d 50, 53 (D.C. Cir. 2005) *rev'd and remanded on other grounds by* 549 U.S. 497, 527 (2007); *Friends of the Earth v. EPA*, 934 F. Supp.2d 40, 54 (D.D.C. 2013) ("EPA is required to respond to a citizen petition for rulemaking.").

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EXHIBIT 2

A Controlled Release Experiment for Investigating Methane Measurement Performance at Landfills

Final report

Revised on July 9, 2024

Fluxlab

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This report was prepared for the Environmental Research and Education Foundation (EREF) by

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Executive Summary

A large-scale controlled release study was performed at a closed landfill in Petrolia, Ontario Canada between November 6, 2023, and November 14, 2023. During this time, 16 combinations of vendors and methodologies were assessed for their performance of quantification and detection of methane during 71 experiments.

For quantification performance, ground and aerial methodologies were used. Fenceline truck-based measurement systems using the Mobile Gaussian Plume Assessment (MGPA) method underestimated emission measurements, on average by 47% and with an uncertainty of ± 43%. Uncertainty around MGPA measurements reduces with better atmospheric factors, but timing constraints led to lack of replicates. Mobile Tracer Correlation Emission Assessment (MTCEA) on average underestimated emissions by 11% and had an uncertainty of ±20%. The drone-based UAV Point Sensor Emission Measurement (UPSEA) vendors displayed tendencies to both over- and underestimate. The UPSEA method provided good quantification estimates – vendor C reported very few outliers, with vendor D having a greater spread. Vendor C on average overestimated emissions by 14 % and had an uncertainty of ±34%, while vendor D on average underestimated emissions by 11% and had an uncertainty of ±62% but demonstrated sensitivity to atmospheric stability and reported fewer than other vendors (n<10). Aerial-based Light Detection and Ranging (LiDAR) systems improved when they were revised using onsite weather data, resulting estimates on average overestimated by 45% with an uncertainty of ± 45%. Remote Point Sensor Emission Assessment (RPSEA)offers a low maintenance option for measuring emissions with uncertainty of ± 39% in the best-case scenario. RPSEA is currently in the early development stages, with variability across vendors.

MTCEA, LiDAR, and UPSEA delivered minimal bias and generally delivered low variability. However, all are relatively specialized tools requiring specialized equipment and knowledge and may not be useful or available to all sites. Although trucks tended to under-estimate and were more volatile, they delivered estimates that were on average within a reasonable margin of the actual values and would therefore be reasonable alternatives for some applications like rapid screening, in suitable conditions. LiDAR had the best detection performance; it was able to detect 100% of the emitting sources, without false positives.

For detection performance, UAV Column Sensor Emission Assessment (UCSEA) systems detected dispersed source releases above 10 kg/hr on even ground. However, the detection performance deteriorated when scanning on slopes, with either very limited or no detections reported. The two UCSEA systems reported false positives fractions of 0.79 and 0.83, which is the ratio of false positives to total reported detections. LiDAR-based detection systems are very sensitive to emissions and detect emissions as low as 1 kg/hr. UCSEA can improve with changes in work practice and more testing and may eventually be capable of replacing walking surface emissions measurement.

This study highlights the need for further research in several areas related to methane emission quantification in a landfill setting. Validation of the Satellite Imaging Sensor Emission Assessment (SISEA) method is of high priority and will require future controlled release configurations of over 300

kg/hr during low cloud cover months. Studying methane emission rates during day and night cycles and variability among methodologies are important factors to advance landfill methane measurements. A permanent or long-term, buried underground release setup would facilitate frequent research and validation opportunities.

Contents

AGL	Above Ground Level
CGU	Canadian Geophysical Union
CMOS	Canadian Meteorological and Oceanographic Society
CNG	Compressed Natural Gas
CSA	Canadian Standards Association
ECA	Environment Compliance Approval
ECCC	Environment Climate Change Canada
ELARS	Eastern Landfill Atmospheric Research Station
ERA5	5^{th} gen. European Centre for Medium-Range Weather Forecasts Reanalysis
HRDEM	High Resolution Digital Elevation Model
ICI	Infrared Cameras Incorporated
LEA	Lagrangian Emission Assessment
LFG	Landfill Gas
LiDAR	Light Detection and Ranging
MDL	Minimum detection limit
MECP	Ministry of the Environment, Conservation and Parks
METEC	Methane Emissions Technology Evaluation Center
MGPA	Mobile Gaussian Plume Assessment
Mid-IR	Mid-infrared
MOS	Metal Oxide Sensor
MTCEA	Mobile Tracer Correlation Emission Assessment
NETL	National Energy Technology Laboratory
OTM51	Other Test Methods-51
PD	Probability of Detection
PRS	Pressure reduction system
RPSEA	Remote Point Sensor Emission Assessment
SISEA	Satellite Imaging Sensor Emission Assessment
TDLAS	Tunable diode laser absorpotion spectroscopy
TSSA	Technical Standards and Safety Authority
UAS	Unmanned Aircraft Systems
UAV	Unmanned Aerial Vehicle
UCSEA	UAV Column Sensor Emission Assessment
UPSEA	UAV Point Sensor Emission Assessment
WM	Waste Management

1. Introduction

Landfills contribute approximately 16% of the anthropogenic methane emission in the United States (Delkash et al., 2022). There are several methane measurement methodologies available; however, few are validated, and none are recognized as an international reference method. Main challenges in measuring methane emissions from landfills is the temporal and spatial variability. Emission rates can vary by up to 7 orders of magnitude within few meters, which is primarily caused due to cracks or holes in the soil cover, this causes emission hotspots or elevated levels of methane concentration (Mønster et al., 2019). However, landfill operators lack reliable information on measurement tools that will provide data to meet Environmental, Social, and Governance (ESG) criteria, requirements imposed on publicly traded companies to disclose verified emissions, or measurement requirements that may be part of future governmental regulations. As the urgency of the climate crisis has grown, so too has the array of measurement technologies and methodologies used to evaluate emissions. These methodologies can help operators better understand their emissions and meet emission reduction targets, if their accuracy is validated.

This controlled methane release study was conducted at a closed landfill in Petrolia, Ontario between November 6 and 14, 2023. The selected site was, in many ways, an ideal controlled release test site insofar as both FluxLab and ECCC (Environment Climate Change Canada) conducted past measurements there, providing a solid baseline understanding of the characteristics of the landfill. Additionally, this site has the appropriate morphology, low emissions, and no interfering neighboring methane sources.

All the methodologies tested in this study can survey landfills for emissions, but each has different dependencies, costs, speeds, and uncertainties. We assembled a varied group of methodologies to assess their performance under controlled conditions to help educate landfill operators and regulatory bodies about the benefits and drawbacks of different measurement methodologies. Results are also meaningful to the renewable natural gas sector.

Unlike oil and gas sources, landfill emissions are highly variable. Methodologies used to measure landfill emissions are, therefore, likewise varied and offer different capabilities. For this reason, we divided the participating methodologies into three groups. One group specializes in localization capabilities, meaning they can identify where emissions are coming from. The second group consisted of methodologies that specialized in quantification, meaning they can identify how much is being emitted. The third methodology group had both localization and quantification capabilities.

The study sought answer three main questions:

1. How do different methodologies perform in various meteorological conditions?
2. What are the quantification accuracies of different methodologies?
3. What are the localization accuracies of different methodologies?

2. Methods

2.1. Facility Selection

The Petrolia landfill located at 4052 Oil Heritage Road, Petrolia, Ontario (42°52'19"N 82°7'14"W; Figure 1), near Sarnia, is a closed landfill once owned and operated by the Town of Petrolia and by Waste Management (WM) Canada since 1990. The site closed its gates to new garbage in June 2016 after decades of operation (approval signed in 1982) but still operates as a transfer station for a nearby WM waste collection facility. The site is approximately 41.23 ha, and 26.02 ha was used for the disposal of municipal, industrial, and commercial solid wastes. It was approved for a total capacity of 4,749,000 m^3 and its reported fill rate was 365,000 t/y (65,000 t/y of Municipal waste from the Municipalities within the County of Lambton and 300,000 t/y of Institutional, Commercial, and Industrial waste from the Province of Ontario). Incoming waste was deposited into excavated cells below ground level in the local clayey soil. Figure 2 shows a drawing of the layout of the Petrolia landfill. The site has now been capped, top-soiled and seeded.

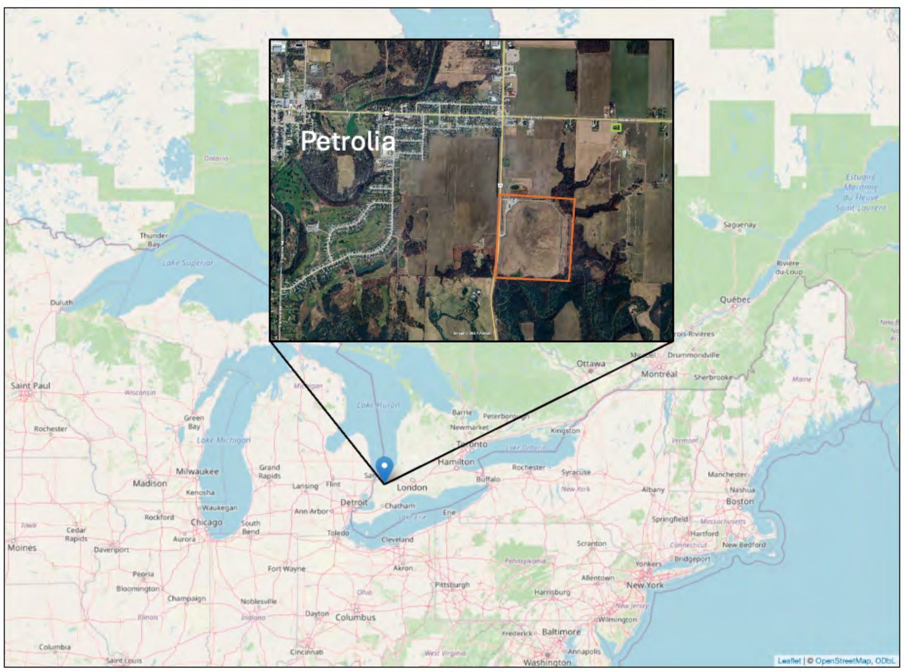

Figure 1: Petrolia landfill location. The blue marker positions the landfill in Ontario. In the inset, the landfill perimeter is outlined in orange. The location of a known cluster of oil & gas batteries is highlighted in green.

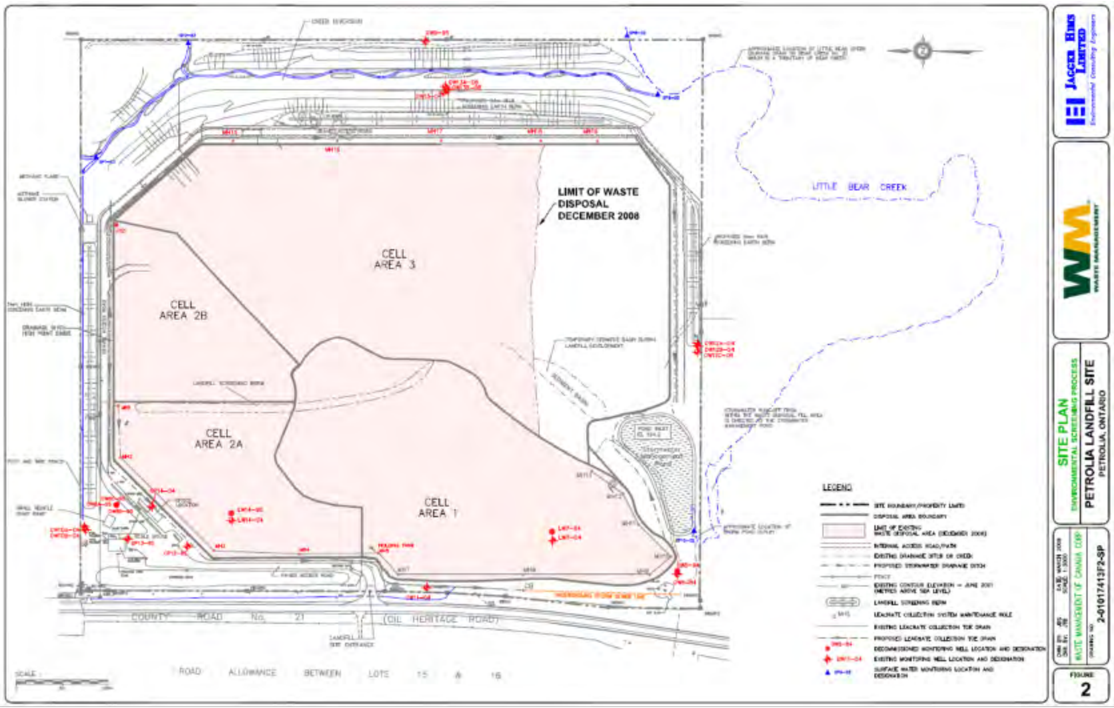

Figure 2: Petrolia Landfill Site Layout (Jagger Hims Ltd. 2009)

The landfill collects contaminated runoff from rain and moisture, known as leachate, and sends it to alternative municipal treatment facilities via sewer lines.

This site has a Landfill Gas (LFG) Collection and Flaring system. In 2010, the landfill commenced the operation of a landfill gas-to-energy project which converts methane gas into enough energy to power 2,500 homes (up to 3.2 megawatts of electricity, WM projected number, 2009). Bluewater Power Generation continues to generate electricity at the Petrolia landfill, even after the landfill stops accepting waste.

From the 2020-2021 Ministry of the Environment, Conservation and Parks (MECP) report, 2,710 tonnes CH_4/y of methane was recovered in 2021 and all of it was utilized (none was flared). This site is not reporting its emissions to the Canada Greenhouse Gas Reporting Program (GHGRP).

Environment and Climate Change Canada surveyed the site in September 2021 with a mobile laboratory and estimated emission of 19.7 kg/hr or 173 tonnes CH_4/y using a Gaussian dispersion model (Sebastien Ars (ECCC) presentation on June 7th, 2022, at CGU/CMOS joint-meeting). Using the same measurement technique and processing, FluxLab surveyed this site in July 2022 and obtained a similar emission rate: 20kg/h or 175 tonnes CH_4/y. The landfill methane emission rate was also estimated prior to the releases in November 2023 using a tracer-based method (labeled as technology E in this study) and determined to be 24.44 kg/hr or 214 tonnes CH_4/y.

The site's topography is moderately complex and typical of a landfill (Figure 3). The cells are like hills that slope away from the center. The highest point of the landfill is about 35m above the outer edges and the surrounding areas which are generally flat and used as croplands or covered with trees.

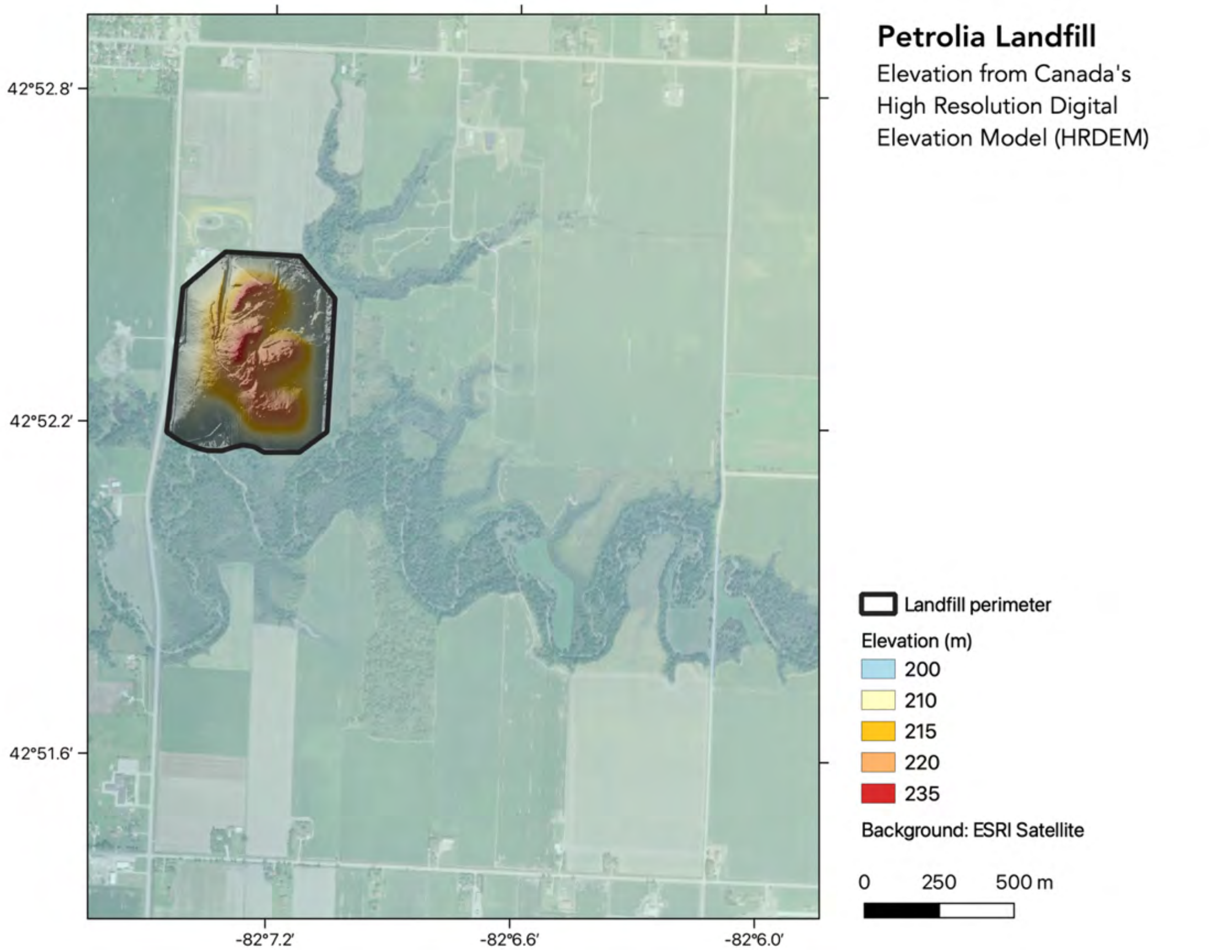

Figure 3: Petrolia landfill and surroundings elevations

A known source of methane emissions is located approximately 900m northeast of the landfill (see Figure 1). This source comprises several oil and gas tanks.

The climate of Petrolia, located in Lambton County, is tempered by the Great Lakes. Lakes contribute humidity to the atmosphere, increasing precipitation in fall and winter. Warm lake temperatures also lead to milder winters. In contrast, in summer, the cool waters of the lake temper the warm tropical air from the south. We used data from ERA5, ERA5-land (the latest climate reanalysis produced by ECMWF, the European Centre for Medium-Range Weather Forecasts) and Historical Climate data (ECCC). Our wind analysis (Figure 4) suggests that from September to November, the prevailing winds are West- Southwest and occur between 1:00 pm and 4:00 pm.

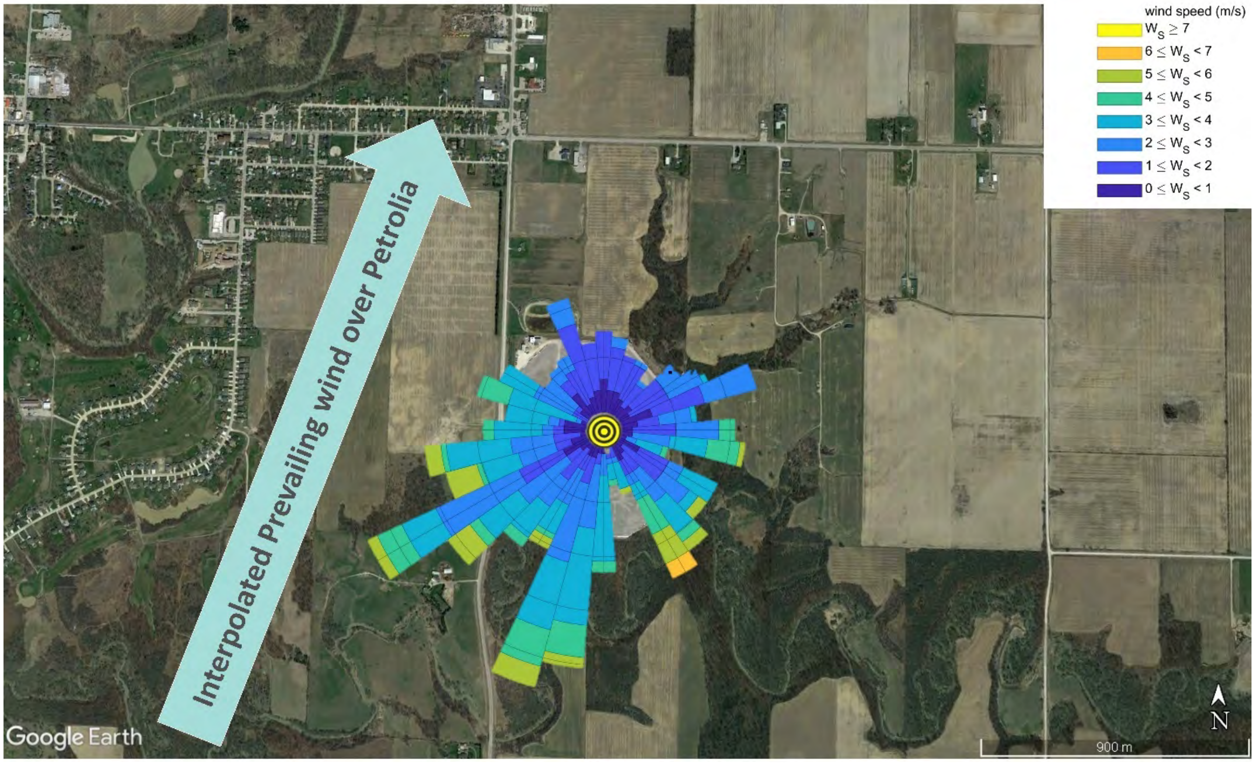

Figure 4: Wind rose patterns based on ERA5, ERA5-Land, and Sarnia historical climate data

Petrolia has several recreational facilities such as a recreation center, soccer fields, baseball diamonds, track and field, and a golf and curling club. However, all these facilities are located more than 800 meters away to the west of the Petrolia Landfill. Additionally, the site does not have public access, meaning that vendors and service providers were able to access/use the site without hindrance. Having a gas collection system, the relatively low background emission and the distance from public activities made the Petrolia site an ideal location for this study. Its central location in North America facilitated the participation of many vendors.

WM Canada generously offered the site to run this controlled release study and helped overcome various permitting and installation challenges. Two permits were required to execute the controlled release study at the site. The first was a technical permit to ensure gas transfer system safety and its compliance with guidelines set by the Canadian Standards Association (CSA). This permit was issued by the Technical Standards and Safety Authority (TSSA), which is Ontario's public safety regulator for various devices and equipment. This study was assessed by the Fuels division and a variance approval was secured, in relation to CSA code B149.1 which outlines the installation code for natural gas propane, that was used as a reference for the variance application. The TSSA approved the gas release system and inspected it on several occasions. The second permit covered the environmental and public impact of carrying out these activities at the landfill and releasing methane, and acetylene as a tracer gas (see section 2.3). This Environment Compliance Approval (ECA) was issued by the Ministry of Environment, Conservation and Parks (MECP). Since this study was using a temporary setup, a streamlined application stream was used. In addition to the application, immediate neighbors of the landfill property were contacted, and a fifteen-day consultation period was observed.

2.2. Methodology for Vendors

The experimental protocol for this study was based on METEC's survey protocol, which was built by the Methane Emissions Technology Evaluation Center (METEC) at Colorado State University. The base protocol was primarily written to validate oil and gas emission measurement technologies. The adaptation of the METEC method mostly relies on the fact that in oil and gas, the main components are point sources while landfill emissions come from multiple sources or even areas. The rate of emission from a landfill is also expected to be much higher than for oil and gas sites. Many publications used the application of the METEC method for controlled release studies (Day et al. 2024, Ilonze et al. 2024, Mbua et al. 2023, Bell et al. 2023) and among those Sonderfeld et al. 2017 were also focused on active face emission in landfills.

To reflect a landfill-based study, the main protocol changes were:

1. Classification of point and area source releases
2. Meteorology measurement details
3. Simplification of experiment cycles
4. Removal of oil and gas measurement-specific analysis (e.g. classification of detections on equipment unit)

Some vendors used the same technologies, and so where appropriate within this report we refer to testing methodologies, instead of using "technology" or "vendor". The primary experimental flow involved informing scheduled participants about the timings of the controlled releases using cellular application/ text message. Methodologies were used during their specified time. Short 5 to 15-minute breaks between releases were introduced to allow the test center to alter release configurations and vendors to prepare for the next set of releases.

The protocol emphasizes the need for transparent documentation without revealing proprietary information. The first step includes documenting the configuration of survey solutions, such as system components, software revisions, methodology, and personnel involved. In the next step, vendors conduct emission detection within defined facility boundaries, documenting controlled releases and survey data. The process involves establishing experimental design points, conducting surveys, and submitting data to the test center and the final step requires vendors to report experiment and detection data, including survey summaries and facility quantification data that includes essential details such as experiment and facility IDs, survey start/end times, and emission rates.

One of the key protocol features is having separate evaluations for emission quantification and localization. The primary metrics for each involve different sets of assessments. The emission rates and location for the controlled release points are the true values for the evaluation of the vendors' performance.

Classification of detection involves categorizing detections as true positive or false positive based on accuracy in identifying controlled releases. The metrics for detection are as follows:

1. Probability of Detection (PD): This metric evaluates the likelihood of correctly detecting emissions under different environmental conditions. It considers the number of true positive detections in relation to controlled releases.
2. False Positive Fraction: It assesses the ratio of false positive detections to total reported detections, providing insights into the rate of erroneous detections.
3. False Negative Fraction: This metric indicates the ratio of false negative detections to total controlled releases, highlighting instances where emissions were not detected.
4. Survey Time: This measures the duration of emission surveys, considering the time from the start to the end of the survey.

For localization techniques and models, primary metrics focus on the precision and accuracy of localization, particularly in pinpointing the exact emission points identified by the detections. The uncertainty in finding the sources was introduced mostly by the precision of the instruments or the error percentage of the method of analysis.

For further evaluation, secondary metrics were put in place: 1) Quantification Accuracy evaluates the accuracy of reported emission rates compared to metered rates, both in absolute and relative terms; 2) Quantification Precision assesses the precision of reported emission rates, providing insights into the consistency of measurements and, 3) Localization Accuracy and Precision delve into the accuracy and precision of reported coordinates or bounding boxes, offering detailed insights into the spatial accuracy of detections.

Survey efficiency, survey speeds, and annualized costs are evaluated based on actual survey reports submitted, offering practical insights into the efficiency of survey operations.

Overall, these metrics provide a comprehensive evaluation of detection systems' performance, considering factors such as accuracy, precision, efficiency, and environmental conditions.

Two weeks after the data collection phase, vendors were required to submit their estimates. Quantification methodology providers were instructed to provide their rate estimates in kg/hr and localization methodology providers were instructed to provide coordinates of leak estimates. After the first round of submissions, vendors were provided on-site weather data by the test center and allowed to resubmit estimates. Releases during the quantification phase of the study (1^{st} week) ranged from 30 to 50 min releases in most cases with a greater range of release rates being used. During the localization phase of the study (2^{nd} week) releases ranged from 60 to 90 min and the releases were usually below 100 kg/hr in most cases.

The rate estimates provided by vendors in kg/hr were compared against the sum of average flowmeter values that vendors participated in. The results are displayed using parity charts in Figures 3-5 with linear regression values listed in table 5. For the analysis of methodologies performing offsite measurements, vendor estimates were compared against the total site emission rate, which was calculated by adding the background emission rate and total gas release rate. The background emission rate was determined to be 24.44 kg/hr (Std. dev 8.88 kg/hr) using the Tracer correlation method. For analysis of methodologies performing onsite measurements (near the border of the release area), estimates were compared against only the total gas release rates.

Detection methodologies were assessed by classifying leak estimates provided by vendors into three categories, true positive, false positive and false negative. Leak coordinates provided by vendors were mapped using software (QGIS 3.34.2) along with release point/area coordinates. Active emitter locations were compared against vendor estimates to analyze localization performance.

A 15 m x 15 m bounding box was drawn with the release point at the center for active release points. Leak coordinates that fall within the bounding box are considered true positives. To account for GPS uncertainty, leak coordinates within 5 meters of the bounding box were also considered true positives. Leak coordinates outside of the bounding box are considered as false positives. Active leak points that were not detected were classified as false negatives. Figure 5 shows a detection map for one of the experiments where there were two active emission sources (shown with a bounding box) and the leak coordinates provided by the vendor (shown with a red dot). Release points are shown in a white circle with a black dot, inactive release points are shown without a bounding box. Using the categorized leak estimates, methodologies were assessed for the probability of detection, false positive and negative fractions. Equations 1-4 list the primary factors used to assess detection performance. Appendix C contains assessment summary maps for detection methodologies.

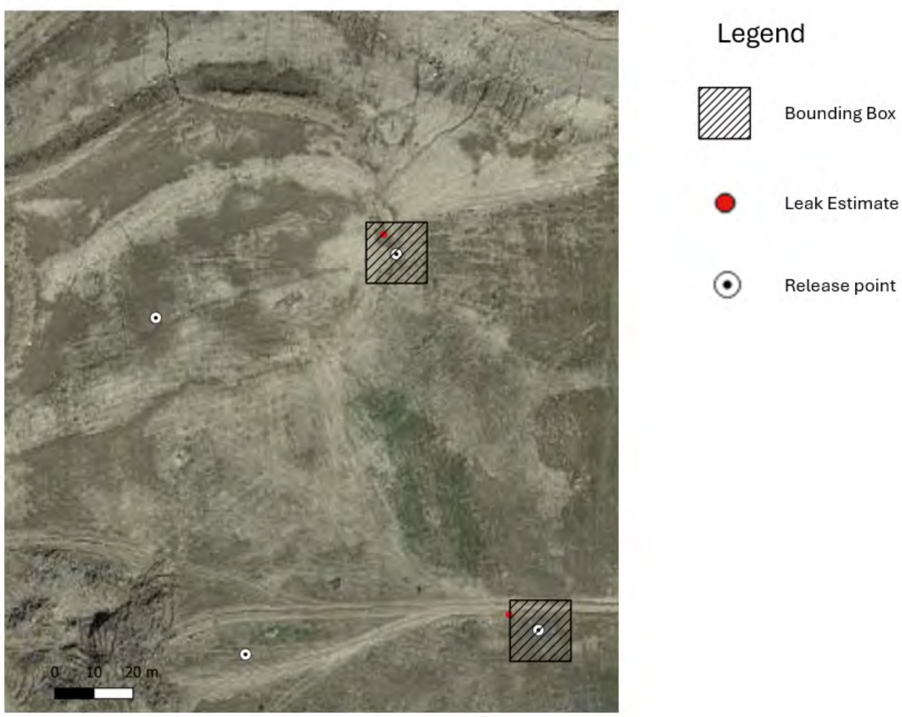

Figure 5: Sample detection map

$$PD = \frac{n_{TP}}{n_{TP} + n_{FN}} \quad ...(1)$$

Where PD is the probability of detection , n_{TP} is the number of true positives and n_{FN} is the number of false negatives.

$$FPF = \frac{N_{FP}}{N_{RD}} = \frac{N_{FP}}{N_{FP} + N_{TP}} \quad ...(2)$$

Where FPF is the false positive fraction, N_{FP} is the total number of false positives, N_{RD} is the total number of reported detections and N_{TP} is the total number of true positives.

$$FNF = \frac{N_{FN}}{N_{CR}} \quad ...(3)$$

Where FNF is the false negative fraction, N_{FN} is the total number of false negatives and N_{CR} is the total number of controlled releases.

$$LA = \frac{N_{TP}}{N_{RD}} = \frac{N_{TP}}{N_{TP} + N_{FP}} \quad ...(4)$$

Where LA is the localization accuracy, N_{TP} is the total number of true positives, N_{RD} is the total number of reported detections and N_{FP} is the total number of false positives.

$$\mathrm{TNR} = \frac{N_{TN}}{N_{FP} + N_{TN}} \quad ...(5)$$

Where TNR is the true negative rate, N_{TN} is the total number of true negatives, N_{FP} is the total number of false positives.

3. Setup

The controlled release system for the study was a non-permanent pipeline network of mostly polyethylene pipes placed above ground on approximately a 10-acre (4 hectares) section of the landfill. Release points were set up in various elevations of the landfill. A CNG trailer was used as the source of methane for the study. With combined release rates ranging from 1 kg/hr - 300 kg/hr, methane was released from point and diffused sources. Between November 6th and 14th, 3025.81 kg of methane were released.

The field team initially mowed sections of the landfill where pipelines would be placed. Using a combination of manual and mechanical approaches, sections of the landfill were dug. G1 technicians were responsible for sourcing materials and making connections between polyethylene and metal pipes. Alicat MCR series flow controllers were placed in black plastic containers and connected to the pipeline network. Flow controllers were calibrated by the manufacturer prior to using it for this study. With a standard accuracy of ± 0.6% of reading or ± 0.1% of full scale, flow rate data was collected every 1 second. Wiring work involved connecting flow controllers to a console which allowed gas to be released remotely. A laptop was connected and used to monitor the flow controller performance. Appendix B lists the equipment used to set up the pipeline network.

The controlled release setup was designed with 8 points and 2 dispersed sources. Point source releases simulate emissions from membrane tears and wells, whereas dispersed source releases simulate emissions from landfill's active face. Elevated metal nozzles with a release rate of up to 19.7 kg/hr were used for point sources. For dispersed sources, a perforated tube spread over 10-15 cm of soil covering an area of about 170 m^2 was used. Dispersed source points were able to release methane up to118.3 kg/hr Flow controllers recorded flow in standard litres per minute (SLPM). Each release source was regulated and monitored in real time by using ATEX-certified Alicat flow controllers which were installed at the end of each downstream branch of the pipeline. During releases, participants and test center personnel did not have access to the detection facility for safety and permitting requirements.

Methane gas was sourced from Enbridge and supplied by Certarus. Natural gas with composition of 94.5% methane, 4.5% ethane, 0.09% propane, 0.4 % nitrogen, and 0.4 % carbon dioxide, was used for the study. A bulk CNG trailer was connected to a small pressure reduction trailer which decreased the pipeline inlet pressure to approximately 55 psig. The pressure reduction trailer also had a relief valve with a set pressure of 80 psig to protect downstream piping. Sections near polyethylene fittings were covered with soil and grass was cut to stubble length on areas where the pipeline lay on the ground.

Flowrate data from flow controllers was compared with the end-of-day gas use report from Certarus which is generated by the onboard pressure reduction system (PRS) trailer software. When comparing the amount of gas released between the flow controllers and PRS software there was a difference of 5 percent. Gas flow performance was monitored from the PRS trailer and the remote-control center. Mass flow values from flow controllers were used for analysis in subsequent sections. Flowmeters have an uncertainty of 0.6% and the error propagation is calculated using the root sum of squares. Average flowmeter readings for each experiment are listed in Appendix A.

Three weather stations were set up to collect meteorological data as shown in Figure 6. Onsite weather data such as windspeed, barometric pressure, wind direction, etc. were collected and later sent to vendors. Campbell Scientific weather sensors (MetSens200 and MetSens500) were used for the study (see Appendix B for specifications). Weather sensors were factory calibrated prior to the study and weather stations were checked daily by FluxLab team members to ensure equipment was in proper operating condition.

The test center designed release configurations based on participating methodologies. Each experiment was matched with a corresponding release with distinct flow rates and active emission patterns. When possible, the test center ran duplicate scenarios to assess consistency in methodology performance. Measurements taken in between releases were used to determine the background emission rate which was utilized in the assessment of methodologies taking fence line measurements.

Figure 6: Map of Controlled Release Setup

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4. Participating Technologies

Table 1 lists sixteen methodologies, which were a combination of vendors and technologies, participated in the study. Appendix D summarizes methodology properties such as cost, minimum detection limit and limitations. Due to confidentiality agreements, results are arbitrarily identified by an anonymized identifier.

Table 1: Summary of methodologies that participated in the controlled release study

Technology Identifier	Technology Type	Platform Type	Sensor	Method	R&D ?
A	Quantification/ Detection	Truck	LGR	MGPA	No
B	Quantification	Truck	LICOR	MGPA	No
C	Quantification/ Detection	Drone	TDLAS	UPSEA	No
D	Quantification	Drone	Mid-IR LDS	UPSEA	No
E	Quantification	Truck	Picarro	MTCEA	No
F	Quantification	Aircraft	Picarro	APSEA	No
G	Quantification/ Detection	Helicopter	LiDAR	LiDAR	No
H	Quantification/ Detection	Satellite	Spectrometer	SISEA	No
I	Quantification	Fixed	EM27	RPSEA	Yes
J	Quantification	Fixed	Metal Oxide	RPSEA	Yes
K	Quantification	Fixed	Metal Oxide	RPSEA	Yes
L	Detection	Drone	TDLAS/ Laser Falcon	UCSEA	No
M	Detection	Drone	TDLAS/ Laser Falcon	UCSEA	No
N	Quantification/ Detection	Truck	LGR	LEA	Yes

Participants were asked to submit information about their respective solutions using a provided technology questionnaire. Most technologies in this study offer methane quantification and a few offers detection or the ability to do both quantification and detection. Quantification technology providers were instructed to submit their estimated emission rate in kg/hr, upper limit of emission rate in kg/hr, lower limit of emission rate in kg/hr and measurement time for each experiment that they participated in. Detection technology providers were instructed to submit estimated leak coordinates (longitude and latitude) and measurement time. Technologies were also allowed to participate in the research and development (R&D) stream which allowed more flexibility in reporting timelines. Technologies in the R&D stream are either up and coming or looking to enter the methane monitoring market.

The following technology overview is based on the questionnaire vendors submitted prior to participating in the controlled release study, and materials in the public domain. In this description, we include the time it takes for an average measurement, the number of replicates included, and high-level cost estimates based on vendor day rates and daily productivity in this study and/or for oil and gas methane measurement service companies in Canada's competitive and mature regulated marketplace.

4.1. Mobile Tracer Correlation Emission Assessment (MTCEA)

The Tracer correlation method is considered the gold standard for landfill quantification measurement and has been used for over two decades (e.g. Mosher et al., 1999) and its errors have been extensively probed in previous works like Fredenslund et al. (2019a). The method involves a controlled release of a non-reactive gas, such as sulfur hexafluoride or acetylene, that is easy to detect and distinguish from other gases emitted by the landfill. The data collected on tracer gas concentrations are analyzed statistically to establish correlations between the tracer gas and the target gases (e.g., methane). By understanding how the tracer gas disperses throughout and downwind of the landfill, emissions of the target gases can be estimated. No wind measurements are required. The vendor performing tracer release work at Petrolia used a Picarro dual gas analyzer, working from the public road system. This method generally takes two days at an estimated $5,000 USD/day commercial rate. One day would be used for reconnaissance and setup, and another for measurement and tear-down, and in that timeframe the vendor could deliver several replicate measurements. With an annual budget of $20,000 USD for site measurements, MTCEA measurement visits could occur every 6 months.

4.2. Gas Mapping LiDAR (LiDAR)

Methane detection by LiDAR (Light detection and ranging) is a mature technology in oil and gas and is in widespread commercial application. Numerous point-source controlled release tests have proven its ability to detect point source leaks to 1-3 kg/hr with 90% probability (Bell et al. 2002, Singh et al. 2021, Conrad et al. 2023, Rutherford et al. 2023). While the method is applicable for landfill measurement, it has seen relatively limited use. Gas mapping LiDAR uses a pulsed beam of radiation that reflects off the ground surface, and back to the aircraft where a specialized receiver detects and analyzes the spectral signature of light absorbed or scattered by methane in the atmosphere. The result is a column measurement that can be used for detection or quantification.

Unlike other column-measurement instruments, LiDAR will normally yield information on where the gases sit within the measurement column, which could be used to augment sensitivity for ground-emitted gases. For a surface leak detection scan, the helicopter flies a serpentine pattern while holding a fixed altitude. Surface leak scans can be used for quantification, by adding up quantifications for individual plumes. For a quantification scan, which is a more developmental technique, the helicopter flies transects downwind and perpendicular to the emission source of interest and solves for emission rate using mass balance. Area-based emissions are common in landfills and may prove more difficult for LiDAR to detect and quantify. The measurement generally takes one day at an estimated $14,000 USD/day commercial rate. During a flight of several hours, the vendor would deliver many replicate quantification AND leak detection scan measurements. Aircraft vendors may charge for bad weather days when the aircraft is grounded. With an annual budget of $20,000 USD for site measurements, one LiDAR measurement visit could occur.

4.3. UAV Column Sensor Emission Assessment (UCSEA)

This technology consists of a UAV-mounted Tunable Diode Laser that emits a narrow beam of light at a wavelength appropriate to detect methane by using its spectral signature. The laser is carried on the underside of the UAV and is directed towards the ground. The laser beam reflects off the ground and back to the UAV. During its travel, the beam interacts with the gas molecules and some of the light is absorbed at specific wavelengths corresponding to the molecular absorption lines of methane. The technology is often called TDLAS, Active TDLAS, or a "column-type" sensor. Measurements are retrieved in ppm*m. Relative to LiDAR, the disadvantage of a column-type sensor is that methane in each unit distance of laser beam travel is incorporated into the ppm*m measurement. Most of the laser beam's transit is of course through atmospheric air containing relatively little methane. Therefore, a strong methane enhancement at the surface is diluted by the air above and can be difficult to detect, unless the sensor has very high precision, or flight altitude is reduced. Two vendors in our study were using UCSEA technology both with flight altitudes of 20 m and 30 m spacing for serpentine paths for leak detection. UCSEA is a new technology and has not been validated in controlled release studies, or by scientists in the peer review literature, although it is in use already to replace surface emission assessments at landfills that are normally done by walking the site. The measurement would generally take 2 days at an estimated $5,000-8,000 USD/day commercial rate. In that timeframe, the vendor would deliver one leak detection scan. With an annual budget of $20,000 USD for site measurements, an UCSEA measurement visit could occur every 6-10 months.

4.4. UAV Point Sensor Emission Assessment (UPSEA)

This technology uses a drone with a mounted TDLAS, MOS, or other point measurement sensor for landfill gas quantification. Two vendors participating in the study used UPSEA. In the method, the UAV flies repeated horizontal transects perpendicular to the wind direction and repeats the measurements at different altitudes to paint in a screen or curtain. Sometimes called a "flux plane" measurement, the method sees wind speed, temperature and pressure values interpolated across the plane, after which the interpolated values are used in a mass balance equation to solve for emission rate. Both vendors using this technique carried out their work using preprogrammed flight patterns. UPSEA is a mature technology and has been validated in point-source controlled release studies at oil and gas sites (Singh et al. 2021, Ravikumar et al. 2019). In the point-source controlled release study by Ravikumar et al. 2019, the authors found reasonable correspondence between measured and known emission rates for UPSEA with R^2 of 0.42, and an upward (overestimation) bias of 27%. The measurement would generally take 2 days at an estimated $5,000-8,000 USD/day commercial rate. In that timeframe, the vendor would deliver one aggregate quantification measurement assembled from several screen measurements in different parts of the landfill, each of which might take 1-2 hours for setup and flight. With an annual budget of $20,000 USD for site measurements, an UPSEA measurement visit could occur every 6-10 months.

4.5. Mobile Gaussian Plume Assessment (MGPA)

For this quantification technology, a high-performance methane analyzer deployed in a vehicle is carried along transects driven along the downwind fenceline, or on transects even farther downwind using the road network. Measurements can be made as far away as several kilometers. Wind speed and direction are measured alongside methane concentrations, and all are geolocated. Rate quantification involves the use of a Gaussian Dispersion model inversion, with some key differences. Since individual plumes emanating from a landfill have typically not coalesced by the time they reach the fenceline, the transects must be broken into small segments each of which incorporates a distance and peak height. A human using an air quality modeling system like Polyphemus (Ars, S. et al., 2020) can fit these area-based segments. Alternatively, a computational inversion can be used to find the best fit between all measured segments, and the combination of one or more simulated site plumes of x emission rate. Source height is normally incorporated into either type of analysis from a Digital Elevation Model, and normally the method would provide some estimate of probable source location. Two vendors used the MAGPA approach in this study. Whether using area-based MGPA (near or far field applicability) or peak height-based methods (far field applicability for plumes that have coalesced), the MGPA is an old and accepted method. A comprehensive study by Fredenslund et al. (2019b) found a good correlation between MGPA and the gold standard MTCEA ($R^2 = 0.765$), although MGPA showed a predictable low-bias where emission rate values were normally just 72% of those measured using MTCEA. The measurement would generally take one day at an estimated $5,000 USD/day commercial rate. In that timeframe, the vendor would deliver two quantification estimates, each comprising numerous replicate transects. In this study, it should be noted that because of the very fast-changing experiments, the average number of replicate transects being used for estimates was only ~2, whereas ~12 would be more normal work practice. With an annual budget of $20,000 USD for site measurements, a MGPA measurement visit could occur every 3 months.

4.6. Airborne Point Sensor Emission Assessment (APSEA)

For this mature quantification technology, a high-performance gas analyzer is mounted in a small aircraft. The aircraft flies stacked orbits of some radius slightly larger than the site. The first orbit is at about 150 m above ground level, or the lowest permissible flight altitude in Canada, and orbits are repeated at progressively higher altitudes until the aircraft reaches the top of the surface-mixed layer. Wind values may be measured in the air, or wind estimates are procured from databases. The wind and methane concentration are interpolated onto a flux screen around the site, and the flux rate is solved using a mass balance equation. Abbadi et al. 2023 found that this technology was highly correlated to known release rates (R^2 of 0.93), but consistently under-estimated emission rates with a low bias where predicted emission rates were only 52% of actual values. The low bias could result from the downward extrapolation approach used by this vendor (Erland et al., 2022), or potentially from measurements during highly stable atmospheric conditions where the center of mass for landfill plumes sites below the initiating flight altitude (~150m). The measurement would generally take one day at an estimated $14,000 USD/day commercial rate. In that timeframe, the vendor would deliver numerous quantification measurement estimates during a flight time of several hours. Aircraft vendors may charge for bad weather days when the aircraft is grounded. With an annual budget of $20,000 USD for site measurements, an APSEA measurement visit could occur once annually.

4.7. Remote Point Sensor Emission Assessment (RPSEA)

These quantification technologies consist of freestanding stations around the landfill perimeter in which various environmental sensors are used to measure wind speed, wind direction, temperature, pressure, and humidity. Methane detection is done using a metal oxide (MOS) sensor. Another type uses an open path Fourier Transform infrared (FT-IR) spectrometer. Algorithms are used to continually assess facility emissions using an inverse source dispersion model, or similar. RPSEA technologies have been scrutinized lately in oil and gas controlled-release studies (Bell et al. 2023, Day et al. 2024), with varying results. It is difficult to understand the transferability of these results to the landfill context, where sites are large, topographically variable, and where emissions are larger. While there are many RPSEA vendors on the oil and gas market, there are none yet purporting to measure landfill emissions with accuracy, and no validation studies for RPSEA in landfill applications. Several vendors in our study used RPSEA method. These measurements are continuous (~hourly) and unfortunately costs are poorly constrained since some business models will differ widely; some focus entirely on service whereas others combine hardware and service costs. We estimate annual costs of $7,000-30,000 USD depending on the vendor and size of the landfill. With an annual budget of $20,000 USD for site measurements, a site could possibly be measured several thousand times, or RPSEA may be too expensive to do on an annual basis.

4.8. Satellite Imaging Sensor Emission Assessment (SISEA)

A satellite-mounted sensor takes a series of images and collects methane column measurements for individual pixels. The images are merged, and an interference pattern is created which allows the quantification and detection of methane emissions at facility scale. Generally, SISEA will be expected to most easily detect large point source emissions within a facility, and area-based sources could be missed. Several studies have validated SISEA for point source emissions quantification, with good results at high emission rates. Sherwin et al. (2023) found that the most sensitive present-day satellite can detect a point source emission of as little as 170 kg/hr, although expected detection success would vary for area sources. Like UCSEA, the column enhancements of near-ground methane enhancements will be diluted by the overlying column of atmospheric methane. To detect methane from a satellite, very large ground-level concentrations are needed, and landfill-type area methane sources may be difficult to detect at this magnitude. These measurements could theoretically be delivered daily under clear sky conditions, but generally, a package of images and quantification estimates at some delivery frequency would be purchased for $3,000-6,500 USD each, depending on volume. With an annual budget of $20,000 USD for site measurements, a SISEA measurement could probably be made every 2-4 months.

4.9. Lagrangian Emission Assessment (LEA)

This method combines the type of truck-based sampling used in MGPA but pairs the measurements with a different post-processing algorithm. Lagrangian models are commonly used to predict source location probabilities and can be used to calculate emission rates for either point or area-based sources. Normally, Lagrangian models are applied to tower-based measurements, but can be adapted to a mobile setting, as if the tower were moving through the domain. For landfill measurements, Lagrangian approaches can be used to infer source locations where a ground team would detect emissions when on site, and the approach can also provide whole-site quantification estimates. Although most Lagrangian models are computationally intensive, some models that use pre-calculated footprint tables are appreciably more efficient and could complete estimates faster than Gaussian inversions. Costs and timelines would be as for MGPA. For an annual budget of $20,000 USD, a measurement visit could occur every 3 months.

Costs for some of the vendors and measurement methods could drop with different business models, for example, drones stationed onsite, or sensors mounted on landfill trucks. We expect these business models to emerge over the coming years.

5. Limitations of the Study

Due to permitting requirements and other factors, experimental limitations affected participation in the study and outcomes.

- Methane releases ranged from 10 to 50 minutes in most cases. This makes replication difficult for certain methodologies that might generally survey a site for 1-3 hours (e.g. MGPA). Due to favorable weather conditions, plume development was good, and vendors were able to submit estimates with high confidence in most cases.
- Depending on the methodology used, some vendors had an advantage due to the release points being visible.
- The safety permit obtained from TSSA did not allow personnel to access the release area when gas was being released. This affected methodologies that validate potential leak sources with a ground scan which in turn resulted in a high number of false positives being reported for the detection method.
- Satellite SISEA methodology could not be validated as the distributed and area-based releases were not large enough to detect despite several attempts with high rates (up near 300 kg/hr) under clear conditions.
- Weather conditions were mostly good during the 9-day period however a couple of days had rainfall and high winds which prevented vendors from taking good measurements.
- Intermittent leaks from the south side of the landfill were identified when vendor data were being analyzed. This increased the number of false positive counts in certain cases. To account for this issue, leak estimates made by methodologies in that area were not considered as part of the performance assessment. This improved methodologies' localization accuracies in certain cases.

6. Results and Discussion

The releases were conducted in early November, with an initial focus on quantification methodologies, followed by detection methodologies. While weather conditions for the study were generally good with consistent winds, various aerial vendors were unable to deploy on certain days due to strong winds or other conditions. Schedules were modified as needed, and Table 2 shows methodology, participation by day.

Table 2:Participating methodology schedule

Date of Release	Type of emission measurement	Participating Vendors
Nov 6, 2023	Quantification	A, B
Nov 7, 2023	Quantification	A, B, C, D, E, F, H
Nov 8, 2023	Quantification	A, B, C, D, E
Nov 9, 2023	Quantification	A, B, C, D, E, F, G, H
Nov 10, 2023	Quantification	A, B, E, F, G, H
Nov 11, 2023	Detection	A, G, L
Nov 12, 2023	Detection	A, C, H, L
Nov 13, 2023	Detection	L, M
Nov 14, 2023	Detection	H, M

Once measurements were complete, vendors were provided with a specified timeline to submit measurement estimates. Most measurement reports were received within the expected timeframes. Table 3 shows report submission dates for each participating vendor. Vendor A primarily participated during the quantification phase of the study; however, they were also taking measurements during the detection phase of the study mainly for R&D purposes.

Vendors were instructed to provide their initial estimates by December 12, 2023 and a resubmission of estimates by January 12, 2024. After vendors provided their initial estimates, onsite weather station data were shared and vendors had the opportunity to resubmit their estimates if they chose to do so.

Table 3: Vendor estimates submission schedule

Vendor	Methodology	Date of 1st submission	Date of 2nd submission
A	MGPA	Jan 18, 2024	Mar 13, 2024
B	MGPA	Dec 12, 2023	Mar 15, 2024
C	UPSEA	Dec 12, 2023	-
D	UPSEA	Dec 14, 2023	-
E	MTCEA	Dec 11, 2023	-
F	APSEA	Apr 04, 2024	-
G	LiDAR	Dec 11, 2023	Jan 10, 2024
H	SISEA	Nov 29, 2023	-
I	RPSEA	Dec 12, 2023	-
J	RPSEA	Dec 12, 2023	-
K	RPSEA	Dec 12, 2023	-
L	UCSEA	Nov 22, 2023	-
M	UCSEA	Dec 08, 2023	-
N	LEA	Apr 01, 2023	-

6.1. Release Conditions

Three Atmospheric Research Stations were set up based on their location relative to the emission sources to collect meteorological data as shown in Figure 7. The stations recorded weather data including Wind Speed (m/s), Wind Direction (degrees), Barometric Pressure (mbar), Relative Humidity (%RH), Air Temperature (Celsius), and Dew Point (Celsius), which was then sent to vendors. The FluxLab team checked the weather stations daily to ensure the equipment was working correctly.

This section summarizes atmospheric measurements and controlled release conditions at the Eastern Landfill Atmospheric Research Station (ELARS). The total height above ground for weather data measurements was calculated by summing elevation relative to sea level and the height of the tripod which equaled to 1.82 meters for ELARS. ELARS was on the eastern side of the landfill to use the easterly winds for downwind testing and was the closest station to the release buffer zone. The measurement period considered here runs from November 5, 2023, at 15:20 to November 14, 2023, at 17:29, with recordings every 2 seconds. Initial data preprocessing included formatting and synchronizing timestamps, checking time continuity, correcting wind direction, interpolating missing measurements, filtering wind data, and exporting and cleaning up the data.

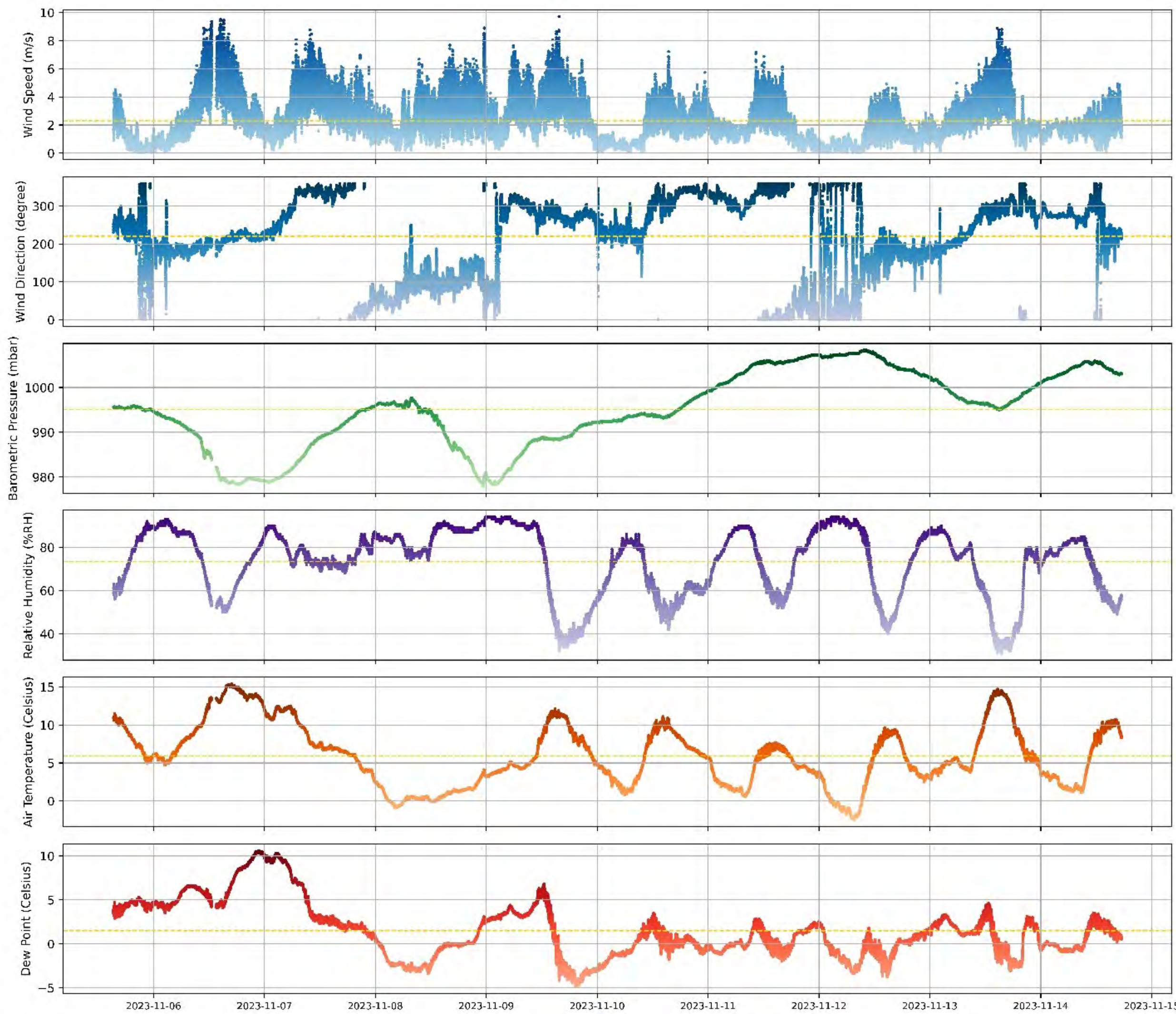

Figure 7:Time series data from the Eastern Landfill Atmospheric Research Station (ELARS) during the experimental period. From top to bottom: wind speed (m/s), wind direction (degrees), barometric pressure (mbar), relative humidity (%), air temperature (°C), and dew point (°C). The yellow line represents the mean of each series.

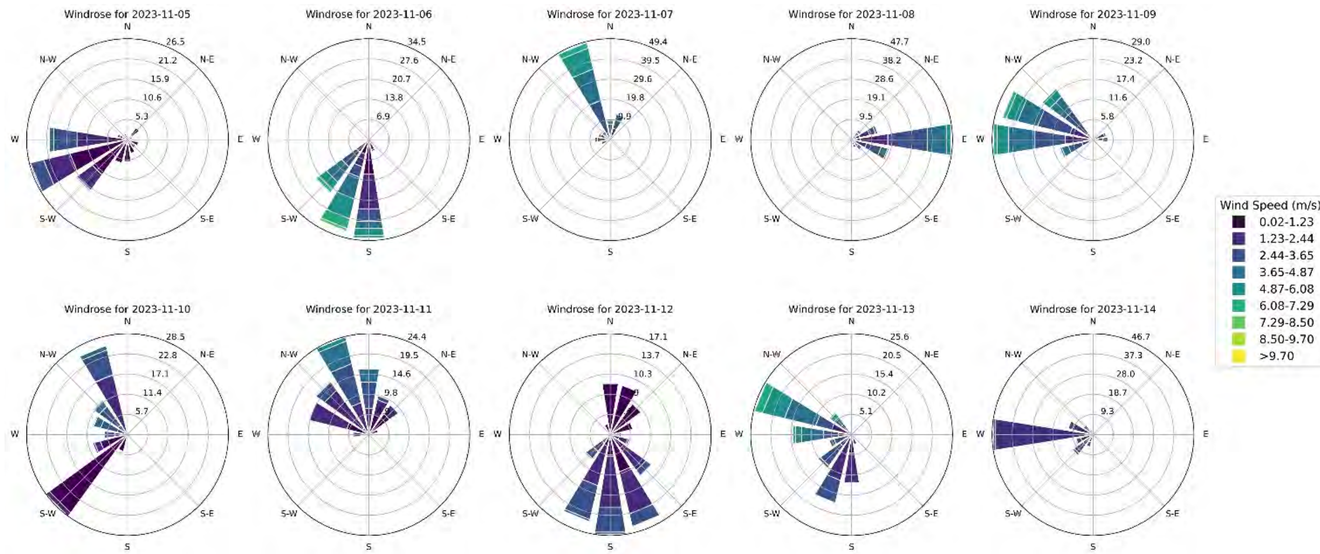

Figure 8:Daily wind roses from the Eastern Landfill Atmospheric Research Station (ELARS) during the experimental period.

The first days of the quantification experiments were mostly cloudy, but the detection test days had clearer, slightly windier conditions. Table 4 provides daily meteorological data, highlighting the most significant Pasquill Stability Classes for each day, with most days categorized as neutral (Class D) and some as slightly unstable (Class C) during the detection experiments. The cloudiness percentage time series (Figure 9) indicates that most days were partly cloudy and clear during the second round of detection experiments, increasing the likelihood of satellite measurement.

Table 4:Daily stability classes and sky conditions based on cloud cover observed during the experimental period.

Day	Statistically Significant Stability Class	Stability Level	Description
2023-11-06	D	Neutral	Calm and Partly Cloudy
2023-11-07	D	Neutral	Mostly Cloudy
2023-11-08	D	Neutral	Cloudy
2023-11-09	D	Neutral	Windy and Mostly Cloudy
2023-11-10	D	Neutral	Calm and Partly Cloudy
2023-11-11	C	Slightly Unstable	Windy and Partly Cloudy
2023-11-12	C	Slightly Unstable	Windy and Partly Cloudy
2023-11-13	C	Slightly Unstable	Windy and Clear
2023-11-14	D	Neutral	Calm and Partly Cloudy

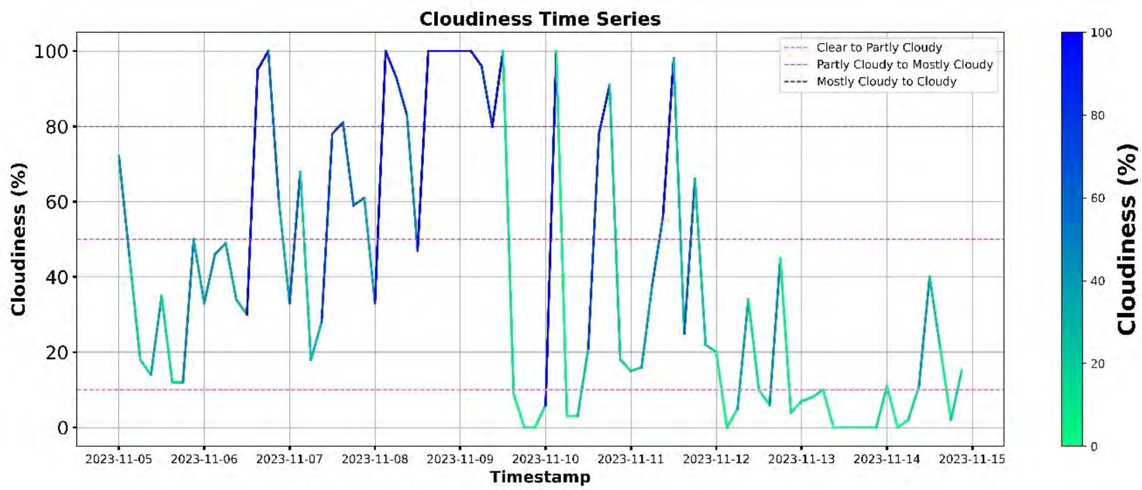

Figure 9: Daily cloudiness percentage of the study area during the experimental period, with thresholds indicating sky conditions.

6.2. Quantification Performance Assessments

6.2.1. Mobile and Drone Methodologies

Figure 10 shows performance results for MGPA, MTCEA, and UPSEA methodologies (vendors A, B, C, D & E). Vendors A and B use the same MGPA method and display a similar trend where both underestimate relative to the known release rates. As listed in Table 5, both vendors were measuring about 60% of known release rates (see Table 5), which is like a previous study in which MGPA measurements measured about 70% of known rates (Fredenslund et al., 2019). The gold-standard MTCEA measurements were very comparable to known release rates, with only minor downward bias. Vendor C uses the UAV UPSEA flux plane method, and the measurements were closer to the parity line than either of the three truck-based measurement vendors but with more spread in the measurements.

Compared to the UAV measurements, the mobile truck-based offsite methodologies (MTCEA and MGPA) offered flexibility and extended duty cycle across weather conditions and were able to report measurements on each day of the experiment, including when UAV and aerial and satellite vendors were unable to measure. Standard operating practices for these methodologies typically involve measuring emissions for several hours at a specific site. However, in this study release rates were changing on a 10 to 50-minute cycle, with very little time in between releases. Reports from vendors indicated that these conditions limited the performance of truck-based methodologies and that greater variance in measurements would be expected under the fast-changing conditions. Reported variance differed between vendors. Variance estimates from vendors A and B (MGPA) seemed unrealistically low, and few overlapped the line of best fit. Variance estimates from Vendor E, the MTCEA, were realistic and almost all overlapped the line of best fit. Vendor C using the UPSEA method also reported reasonable estimates of variance.

The performance of two UAV-based measuring systems, both using the UPSEA method, is shown in Figure 10, with varying results. Vendor C produced excellent estimates while deploying this method whereas estimates from vendor D were much less predictable. Although the regression line of best fit was statistically significant ($p<0.05$), we observed a substantial departure from the parity line. The levels of uncertainty for this methodology are being developed with data from this study, however, the vendor reported that an uncertainty of 5% was expected, which did not fully capture the observed uncertainty of their method in the field setting. The reason for the difference between vendors using the same method is not clear. Measurement conditions may have played a role given that the vendors performed their work at different times, but in both cases conditions were comparable. Both vendors carried high-resolution laser-based point sensors. We anticipate that differences arose primarily due to post-processing method differences and/or expertise. The UPSEA estimates from both vendors were less biased here than in previous controlled release studies where a 37% over-estimate bias was reported (Ravikumar et al., 2019) although, that study tested an earlier variant of the same methodology. Measurement estimates have improved in recent years, or else landfill controlled-release measurements are better suited to this methodology than smaller oil and gas point source releases.

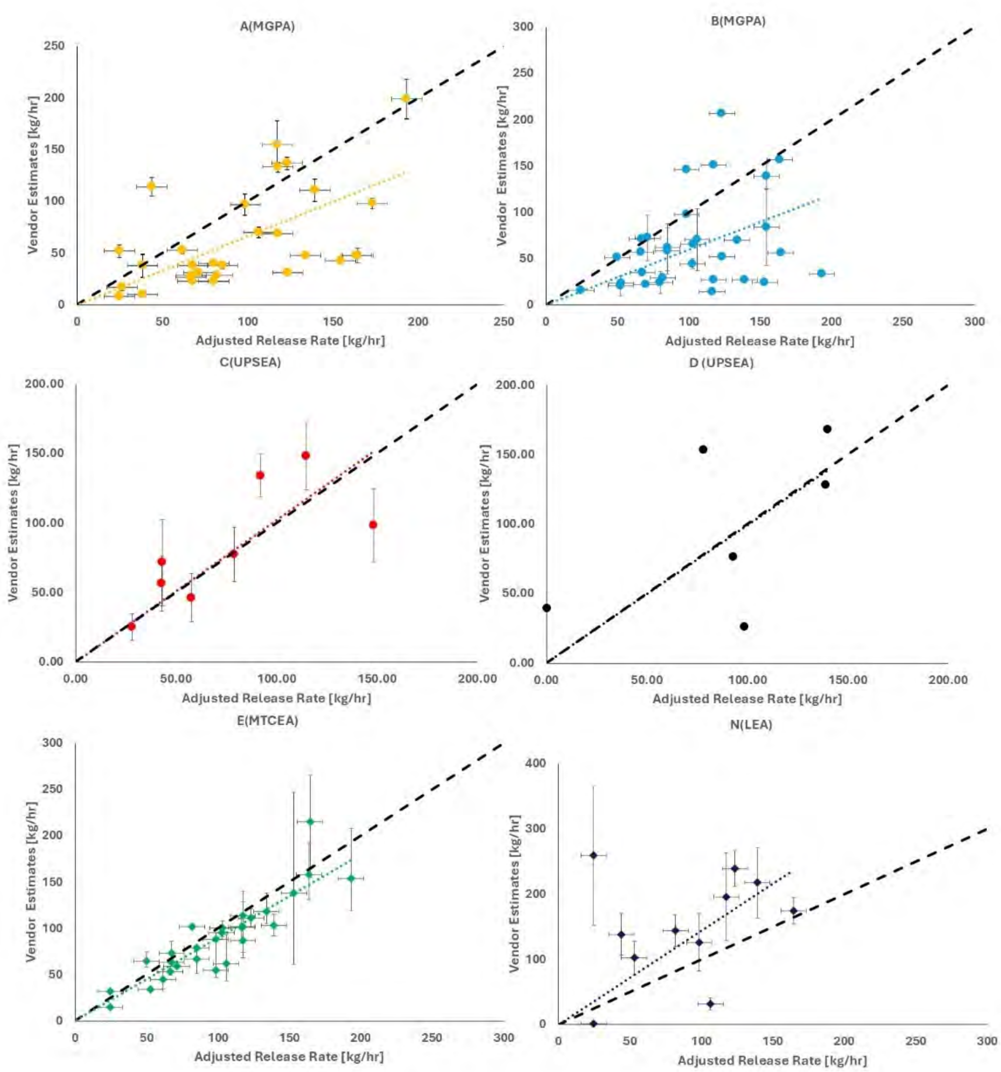

Figure 10: Parity charts of controlled release tests for truck and drone-based measurements. The dashed reference line shows the 1:1 parity relationship.

6.2.2. Aerial and Satellite Methodologies

Figure 11 shows parity charts for aerial and satellite-based systems. UPSEA methods had fewer submissions due to a combination of weather factors preventing measurements and some measurements not meeting internal quality standards. Vendor D for example had eight successful attempts to scan and submitted six estimates. Weather factors such as wind speed, time of day, and cloud coverage become strong contributing factors for technologies in this group. No detections were reported from the satellite-based vendor during the study. Contributing factors include release rates not meeting the minimum detection threshold, greater cloud coverage in November, and lower elevation of the sun which resulted in reduced signals for northern sites. Discussions with the vendor confirmed that the distributed nature of emissions, where emission rates were high >300 kg/hr but distributed from 10 release points, including 2 area-based release points) over 10 hectares, would have been challenging for the SISEA method to detect. For this release configuration, the Minimum Detection Limit (MDL) cannot be predicted but is at least 300 kg/hr. With the possibility of larger future releases at the same site, we can hopefully define MDLs and other performance metrics.

Vendor F, using the APSEA method, generally underestimated compared to the actual release rates. The measurements were not classified by the vendor as high quality since their internal meteorological conditions for measurements were not met. For this approach, meteorological conditions must allow for an emission plume to rise and disperse. Conditions under Pasquill stability class B are preferred, which consist of windspeed ranging from 2-6 m/s, good solar insolation, and limited cloud cover. During scheduled measurement times for vendor F, windspeeds of 7-11 m/s and near overcast conditions were observed. This resulted in the plume flowing beneath the minimum flying altitude and not rising quickly enough for measurement purposes. Despite the poor conditions, the measurements were linearly related to the actual release rates with a strong R^2 of 0.89. The slope of the line of best fit was 0.64 (Table 5), meaning that the vendor was typically reporting only 64% of the actual emission rate. This underestimation bias is comparable to recent estimates for point source releases reported by Abbadi et al. 2023, where the measurements were strongly correlated with actual rates with an R^2 of 0.92 (see Table 5), but where they were only reporting 52% of actual emission rates. Like MPGA, this method may be prone to under-estimation and may need bias correction. The variance estimates provided by the vendor were moderately successful in overlapping the line of best fit.

Vendor G used two forms of LiDAR quantification including aggregate emissions during detection scans (G-1 in Figure 11) and aerial mass balance screens (G-2 in Figure 11) to quantify methane releases. Both techniques were successful but tended to overestimate. As shown in Table 5, the mass balance estimates were overestimated to a greater degree. After considering onsite meteorological data, the estimates were improved and closer to actual emissions values in both cases with an overestimation of 43% and 17% in the case of detection scans and screens, respectively. LiDAR quantification did not quite match the performance accuracy that can be achieved in oil and gas settings as described by Conrad et al. (2023), but the same study also points to differing performance with dark skies and shadows that can create overestimated biases – and this was potentially a factor in our study where cloud-free days were rare and clouds were rolling quickly across the site in steady winds.

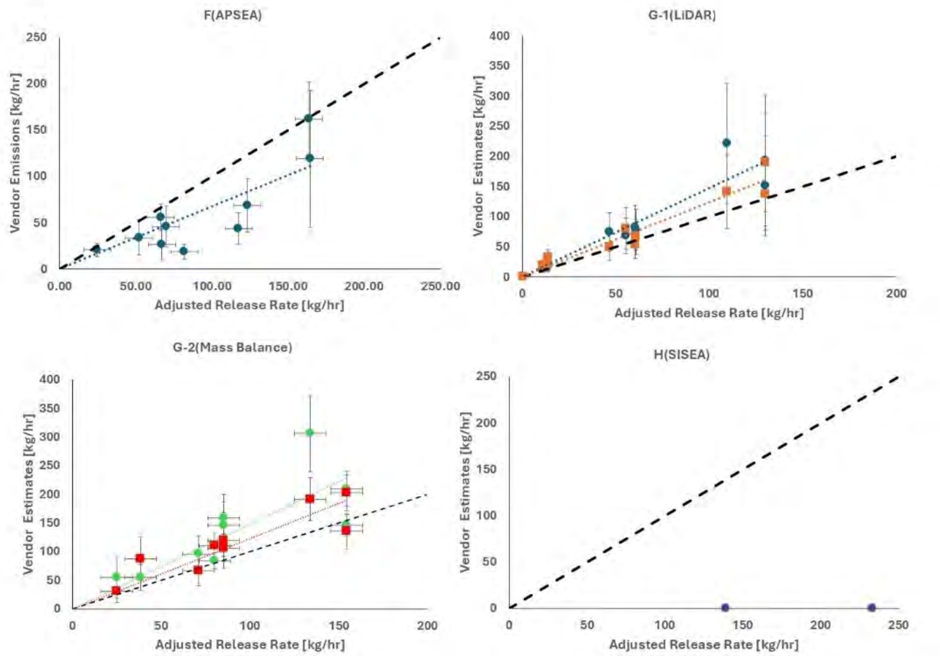

Figure 11: Parity charts of controlled release tests for aerial measurements. Plots G-1 (LiDAR) and G-2 (aerial mass balance) show two separate measurements by the vendor. Blue and green data points represent their 1st submission, and orange and red represent their revised submission after taking onsite weather data into account.

Figure 12 shows parity charts for continuous emission measurement systems (CEM) in the research and development group. Results from this study aim to further develop CEM sensors and algorithms specifically for landfill emission measurements. Estimates from vendor J provided the closest measurements to actual emission values compared to the other continuous sensors. Continuous sensors offer a low-maintenance method of measuring emissions compared to other vendors. Due to the low number of sensors available for the study, only a limited set of wind conditions were covered.

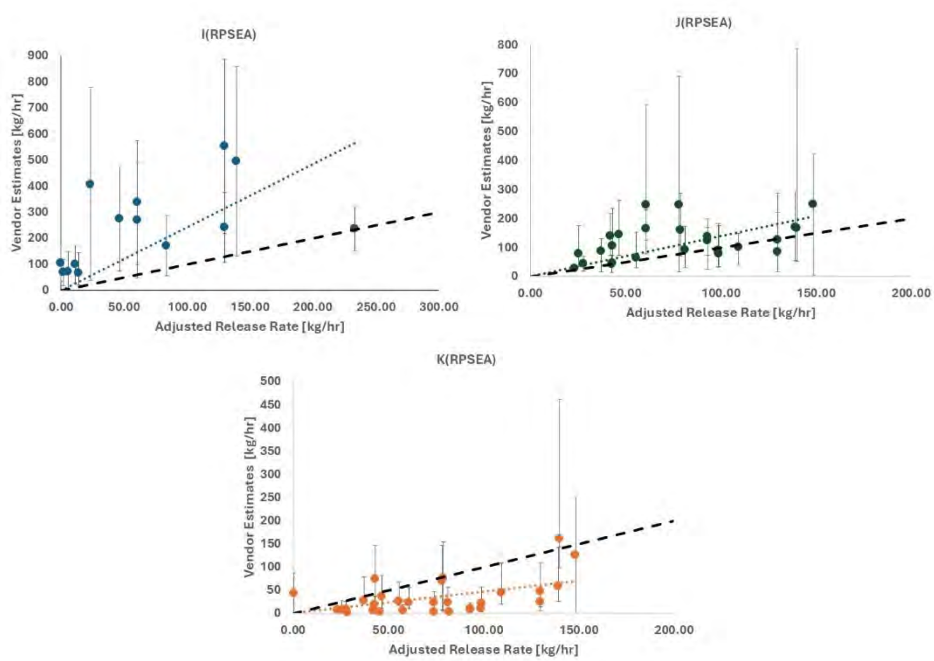

Figure 12:Parity charts of controlled release tests for CEM.

6.2.3. Statistical Properties for Mobile, UAV, Aerial and Satellite Methodologies

Table 5 lists linear regression values and average percent recovered for quantification methodologies. The bias factor along with the value of the slope provides information whether a methodology is under or over estimating emission rates. Value of slope less than one means a technology is underestimating whereas value of slope greater than one means that a technology is overestimating. Standard deviation percentage of residuals indicates the spread of emission rate values from the trendline. Deviation from true value percentage range provides the range of deviation for quantification estimates since standard deviation represents two-thirds of a normal distribution therefore outliers lie outside of the standard deviation range. A lower standard deviation percentage is desirable as it represents a lower uncertainty in emission estimates. and methodologies with higher number of estimates submitted indicates greater statistical power. When calculating residual and deviation from true values , scenarios with 0 kg/hr were omitted since values relative to the true value is undefined when the true release value is approximately 0 kg/hr.

Table 5: Linear regression values from Figures 10,11 and 12. *Calculated using values from the second submission.

Technology Identifier	Slope (1st sub)	R^2 (1st sub)	Slope (2nd sub)	R^2 (2nd sub)	Bias Factor 1/slope	StDev residuals %	Dev. from true value %	Number of estimates (n)
A	0.6644	0.7701	-	-	1.5051	47.61	1-160	30
B	0.5670	0.6739	-	-	1.7637	39.63	1-88	31
C	1.0211	0.9021	-	-	0.9793	34.71	2-66	8
D	0.9915	0.8211	-	-	1.0086	61.98	8-96	6
E	0.8972	0.9623	-	-	1.1146	20.49	3-44	28
F	0.6781	0.8915	-	-	1.4747	23.89	1-77	10
G-1	1.4735	0.9578	1.2423	0.9725	0.8050*	44.64*	6-128*	12
G-2	1.4847	0.9043	1.2265	0.9570	0.8153*	40.67*	7-130*	9
H	0.0000	-	-	-	-	-	-	0
I	2.4248	0.6354	-	-	0.4124	975.19	1-3597	14
J	1.3959	0.7885	-	-	0.7164	96.36	2-306	25
K	0.4615	0.5959	-	-	2.1668	39.10	5-96	30
N	1.4368	0.7333	-	-	0.6960	88.34	6-215	11

Quantification error percentage was calculated for each quantification estimate using equation 5. Error percentage was plotted against pressure and windspeed values from the eastern landfill atmospheric research station weather station. The resulting R^2 and p-values are listed in Table 6.

$$Quantification\ Error = \frac{|Measured\ Emission\ Rate - Controlled\ Release\ Rate|}{Controlled\ Release\ Rate} \times 100 \quad ...(5)$$

Table 6: Pressure and wind dependencies on quantification error

Vendor Identifier	Pressure Adj R^2	Pressure p-value	Windspeed Adj R^2	Windspeed p-value
A	-0.0268	0.6087	0.0794	0.0756
B	0.1419	0.0210	0.2583	0.0021
C	-0.1497	0.7758	0.3929	0.0569
D	-0.2414	0.8758	-0.0734	0.4628
E	-0.0114	0.4121	-0.0285	0.6205
F	0.0679	0.2342	0.0362	0.2807
G-1	0.3562	0.0234	0.1027	0.1637
G-2	0.6814	0.0038	-0.1236	0.7394
H	-	-	-	-
I	-0.0042	0.3501	-0.0484	0.5392
J	0.2031	0.0137	0.0338	0.1880
K	-0.0312	0.7280	-0.0226	0.5545
N	-0.1207	0.8646	-0.0.0836	0.5953

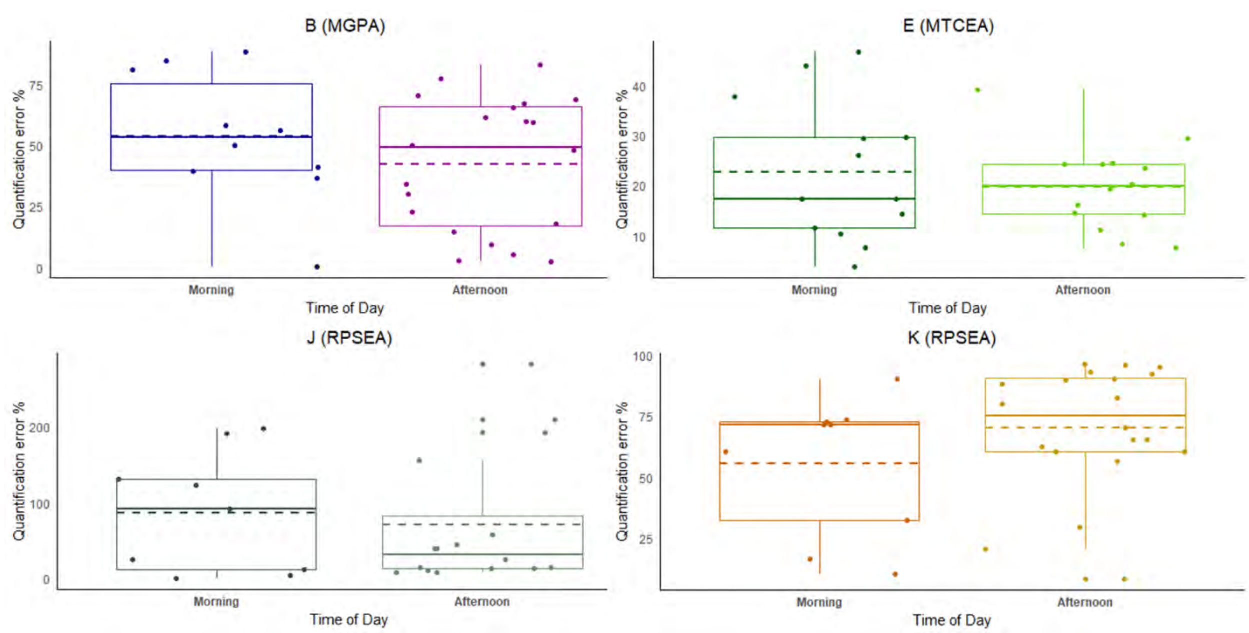

Figure 13: Boxplots of quantification accuracy of individual estimates based on time of day

Most methodologies did not show a significant dependence between error percentage and pressure and windspeed values. B (MGPA method) showed a correlation between quantification error percentage and pressure and wind speed. Vendor C's measurements (UPSEA method) showed an inverse correlation between windspeed and error percentage, with percent error decreasing as windspeed approaches 4-6 m/s. G-1 (LiDAR) displayed a significant positive correlation with barometric pressure and error %, and J (UCSEA) displayed an inverse correlation with barometric pressure.

Box plots showing quantification error during morning and afternoon measurements are shown in Figure 13 for methodologies that reported over 10 measurements during both periods of the day. The solid line indicates median quantification error percentage and dashed line indicates mean quantification error percentage for respective times of the day. Vendors B and E (MGPA and MTCEA respectively) displayed similar quantification error levels during both periods of the day, however greater variations in afternoon measurements can be observed for B (MGPA) whereas vendor E (MTCEA) displays greater variation for morning measurements. Continuous sensor vendor J(RPSEA) reported higher quantification error percentages in the morning compared to afternoon measurements and K(RPSEA) reported similar error percentages for both morning and afternoon measurements.

6.3. Discussion on Performance

Both MGPA methods (A and B) use the same methodology. The point-source Gaussian inversion method relies on various model parameters, including stability class and wind speed and direction. In a sensitivity analysis of the same technique conducted by Ars et al. (2017), it was found that the stability class contributes the most uncertainty followed by wind direction, wind speed, and source location. The overall uncertainty was estimated to be around 75%. With better constraints on atmospheric conditions, the uncertainty was reduced to 55%. In a landfill study that used the same methodology, Kumar et al. (2024) reported a level of uncertainty of approximately 30% on emission estimates from distant roads. Truck-based emission rate uncertainty was also determined to be 63% in a controlled release study described in O'Connell et al. (2019; SI). However, this last study used the Gaussian plume model differently. The measurements are likely leading to underestimated rates because the whole landfill emission might not have been fully sampled from ground-level transects on public roads. Moreover, the model does not account for plume lofting that arises from the elevated landfill surface temperature. The bias of 1.58 and 1.76 for technology A and B respectively, fit into the uncertainty range from Ars et al. (2017).

During the study, MGPA methodologies were limited by the compressed timeline. Normally MGPA requires more replication. During the study, experimental conditions and release rates were changing as often as every 30 minutes, leaving only 20 minutes for measurement. This left time for only 2 full transect passes on average per submitted measurement estimate. Numerous submitted estimates were based on a single transect pass because the plume was still increasing or subsiding during one of the passes. Normal practice for the vendor is to incorporate 6-15 full transect passes into a single measurement estimate, which might represent 2 hours of transect driving. Although various researchers over time have recommended the number of replicates required for robust Gaussian measurements, the normal recommendation is 3 at the very minimum, and ideally 10 or more. By including more replicates, the variance and volatility of individual transect estimates should reduce. Using the data submitted by vendor A, we averaged successive groups of 6 measurements from low rates to high, to simulate the effect of including 12 transects (6 measurements with 2 transects each) in a single measurement estimate (Figure 14:). As expected, the groupings decreased measurement variance substantially and more than halved average residuals (departures from the best-fit line) to 13 kg/hr across a range of 25-200 kg/hr. This indicates that under normal work practice, we might expect less variance from MGPA. Replication will help decrease variance / increase precision. Bias corrections can improve accuracy, when we multiply measurement estimates by a repeating under-estimation factor.

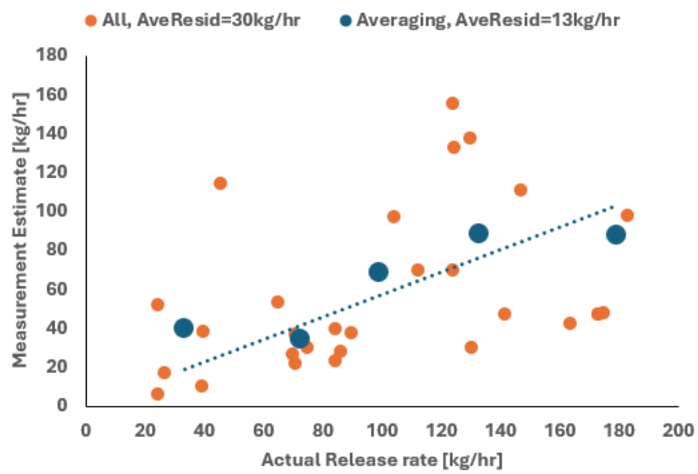

Figure 14: Simulated replicate parity chart for MGPA

Vendor E using the MTCEA method stands out with measurements closer to the parity line than other truck-based solutions, and other methodologies. We found no significant correlation between error percentage and pressure and windspeed values. Previous studies, like Foster-Witting et al. (2015) also note insensitivity of the MTCEA approach to atmospheric changes.

Consistent with a review of advanced UAS leak detection and quantification methods by Hollenbeck et al. (2021), the UPSEA method offered accurate and precise emission rate estimates but proved sensitive to atmospheric stability. In controlled release testing of flux screens derived from miniature Mid-Wave Infrared TDLAS data collected aboard a quadcopter (Corbett and Smith, 2022), the linear fit between the metered and calculated rates had an R^2 value of 0.8236, which is comparable to those of vendors C and D herein (Adj. R^2=0.9201 and Adj. R^2=0.8211, respectively). Furthermore, Corbett and Smith (2022) reported a TDLAS flux plane error range of 1.19-88.36% and a negative correlation between wind speed and absolute error. In independent single-blind controlled release testing of mobile leak detection and quantification technologies by Ravikumar et al. (2019), UAS-based TDLAS flux screens yielded exclusively true positives and true negatives, demonstrating a lower detection limit comparable to OGI and an order-of-magnitude quantification accuracy comparable to Picarro. There are fewer published controlled release studies describing Mid-IR LDS UAS flux planes, though a preprint study by Dooley et al. (2024) found a strong correlation (R^2=0.99997) between actual and estimated emissions across a wide range of release rates (0.04-1500 kg/hr) as well as systematic underestimation by their approach.

A few studies have measured methane emission fluxes from landfills using the APSEA mass balance technique (e.g., Obiminda et al. 2017; Allen et al. 2019; Gasbarra et al. 2019; Yong et al. 2024), but to our knowledge, this technology was never validated and compared in a blinded controlled methane release test in a landfill context. One controlled release test over a managed agricultural field showed that, under favorable measurement conditions, emissions from the point release source could be quantified by aerial mass balance (UAVs) with an uncertainty of 30 % (Morales et al.

2022; https://amt.copernicus.org/articles/15/2177/2022/). The authors also stated that emission rate estimates were on average slightly overestimated under optimal conditions, but lower average accuracy was observed when measurements were performed under less favorable wind conditions. In another controlled released study, also with a methane point source, Abbadi et al. (2023) showed, despite a low number of measurements, that the aerial mass balance technology was able to quantify release above 10 kg (CH_4) hr^{-1}.

Similarly, recent technologies such as satellite-based SISEA measurements using emission image capture have never been tested for detection and quantification during single-blind controlled methane release tests in a landfill context. The method has shown the ability to detect methane at landfills but with unknown accuracy. A recent study (Sherwin et al. 2023) tested several satellite methodologies with a trailer of liquefied natural gas acting as a methane point source. The authors reported that for all detected emissions from this point source, mean estimates for all satellite-team combinations were between – 68 and 110% of the release rate. It is difficult to understand how these results would translate to a landfill context where more non-point source emissions are present.

Continuous sensors show substantial promise from a cost and variability standpoint. But they are in early stages of development. A controlled release study for oil and gas detection by Chen et al. (2023) focused on detecting and quantifying methane emissions using Continuous Methane Monitoring Technologies, and while some methodologies showed good accuracy, others showed high rates of false positives. Unfortunately, the context for these oil and gas sites is very different from that of a landfill where topographic change is significant, numerous emission points are active at once, and the scale is over 100x larger. Landfill-specific controlled release testing and development must be carried out to bring these systems toward maturity for the waste sector. Given these limitations, one RPSEA methodology did perform well. Perhaps more impressively, the technology producer did not know they were participating, since a third party brought their sensor to the experiment. The technology producer may have preferred a different placement, but the results are promising. Error bars may have been overestimated.

Lagrangian footprint model has been widely used for natural sources, but using the model for emissions from anthropogenic sources is quite limited. Various studies have shown the Lagrangian footprint model's effectiveness in assessing methane emissions. Gerbig et al. (2006) used the COMET model to simulate greenhouse gas concentrations in the Netherlands and Ireland. Pisso et al. (2021) assessed methane emissions from offshore oil platforms in the Norwegian Sea, while Brunner et al. (2014) focused on methane emissions in Europe. Among these studies, none of them were focused on emissions from landfills. In this study, LEA participated as an R&D methodology, but its performance was promising given that this was a first-use trial, and the optimal work practice strongly diverged from the preference of having several hours, rather than several tens of minutes, to collect data.

Overall, the quantification results from most methodologies were promising. Table 7 lists key findings for quantification methodologies. They could all be useful, especially with replication. We observed high variability between vendors applying the RPSEA and UPSEA methods, which may indicate that standardization of operating procedures is needed. We observed very similar results between vendors applying MGPA. For MGPA, questions remain about variance under normal work practice, and these should be tested during subsequent rounds of controlled-release testing. Ultimately, there is no best vendor or methodology for quantification measurements, because the costs of these measurements may limit use to once per year. Frequent measurements can appreciably lift the value of inherently lower precision methods, and help capture temporal variation across daily, seasonal, and annual cycles. Bias corrections should potentially be applied to methodologies where we see a repeating trend of under- or over-estimation, as in this study and others.

Table 7: Summary of key findings for quantification methodologies

Technology Identifier	Method	R&D ?	Key Findings
A	MGPA	No	Reported approximately 66% of known release rates with a tendency to underestimate emission rates. Method is usually deployed over several hours and short release windows affected quantification performance. Method offered flexibility and extended duty cycle across weather conditions and was able to report measurements on each day of the experiment.
B	MGPA	No	Reported approximately 56% of known release rates with a tendency to underestimate emission rates. Method is usually deployed over several hours and short release windows affected quantification performance. Method offered flexibility and extended duty cycle across weather conditions and was able to report measurements on each day of the experiment.
C	UPSEA	No	Quantification estimates were very good with few outliers. Methodology is affected by weather conditions where measurements are not possible during rain and windspeed above 12 m/s.
D	UPSEA	No	Estimates varied greatly from true release rates with bias being less predictable. Methodology is affected by weather conditions where measurements are not possible during precipitation and windspeed above 17 m/s.
E	MTCEA	No	Quantification estimates were consistently close to true release rates with a slight downward bias. Method requires setup of tracer gas and frequent monitoring of its consumption levels. Method offered flexibility and extended duty cycle across weather conditions and was able to report measurements on each day of the experiment.
F	APSEA	No	Underestimated measurements consistently and vendor reported that estimates were not classified as high quality due to internal meteorological for measurements were not met. Requires 2-6 m/s windspeed, solar insolation and not a lot of cloud cover for good measurements.
G	LiDAR	No	Both LiDAR and mass balance methods were accurate and had a tendency to overestimate emission rates. Increase in quantification estimates were observed after onsite weather data were considered.

			Requires good visual flight rules conditions for flying aircraft. Ideal wind speed ranges from 3- 6 m/s.
H	SISEA	No	Emissions were not detected for quantification or localization purposes. Minimum detection limit expected to be at least 300 kg/hr. Cloud cover over the site and/or wind speed exceeding 10 m/s prevents emission measurement.
I	RPSEA	Yes	Overestimated emissions in most cases. Low maintenance method of quantifying estimates, due to low number of sensors only a limited set of wind conditions were covered.
J	RPSEA	Yes	Provided the closest measurements to actual emission values compared to other fixed sensors. Due to low number of sensors only a limited set of wind conditions were covered.
K	RPSEA	Yes	Underestimated emission in most cases. Due to low number of sensors only a limited set of wind conditions were covered.
N	LEA	Yes	Overestimated emissions in most cases. Lagrangian models are usually applied to tower-based systems however in this instance it was adapted to a mobile setting.

6.3.1. Detection Performance Assessments

Table 8 lists values for detection performance analysis. False positives are detections reported by methodologies that cannot be attributed to a controlled release and false positive fractions is the number of false positive detections relative to total number of detections. A false positive fraction of 0 desirable. True negative readings are instances when a methodology was able to correctly predict an inactive release point as a non- emitting source. True negative rate is the total number of true negative readings relative to the summation of true negative readings and false positive readings. A true negative value of 1 is desirable. Localization accuracy is the number of true positive detections relative so the summation of false positive readings and true positive readings. Localization accuracy of 1 is desirable.

Table 8: List of primary detection metrics

Method Identifier	False Positive Fraction	False Negative Fraction	True Negative Rate	Localization Accuracy	Survey Time (mins)
C	1	1	0.70	0	40
G	0	0	1	1	20
H	-	-	-	-	0.3
L	0.83	0.63	0.28	0.17	50
M	0.79	0.50	0.52	0.21	60
N	0.79	0.85	0.54	0.1-0.5	15

6.3.2. Analysis of Primary Detection Metrics

Table 7 lists the values obtained from equations 2 – 5 along with survey times for detection methodologies except for vendor N, which is not a leak detection technology per se but a screening that can be applied offsite. Lagrangian emission assessment is applied in a mobile setting for detection purposes in this study therefore the expectation for its assessment is different compared to other vendors. For all vendors, except N, a false positive and negative fraction closer to zero is desirable since it indicates the methodology's ability to correctly detect emissions. A true negative rate of one is desirable since it indicates the methodology's ability to classify inactive release points as a non-releasing source and it also indicates a lower false positive count. The Lagrangian model is usually not used for localization purposes, errors introduced from measurement and using the model affects resulting leak estimates. Vendor G (LiDAR) performed very well detecting active emissions 100 percent of the time without false positive readings. Vendor C provided accurate quantification estimates; however, was unable detect leaks correctly in all measurement attempts. Vendors L and M used the same drone-mounted TDLAS column sensor, and the results were similar, with a high fraction of false positives reported. Although both vendors were using identical sensors, vendor M was slightly more sensitive to leaks and we suspect that differences can be attributed to subtle differences in the work practice. It should be noted that both were unable to fully deploy their methodology, since a ground scan is usually performed to validate potential leak sources identified by the drone-mounted sensor. Vendor N was deployed from 1 km to 1.9 km from the landfill center point and was able to discern sources within ~100 m, indicating an uncertainty rate of about 15%. Since the study area could only be accessed when gas was not being released, vendors could not validate potential leak spots, which likely contributed to a much higher percentage of reported false positives. In their normal work practice vendors would manually verify using EPA21. Figure 15 illustrates the total number of true positives, false positives, and false negatives for vendors G, L, and M.

Figure 15: Classification of detection categories

6.3.3. Analysis of Probability of Detection Plots

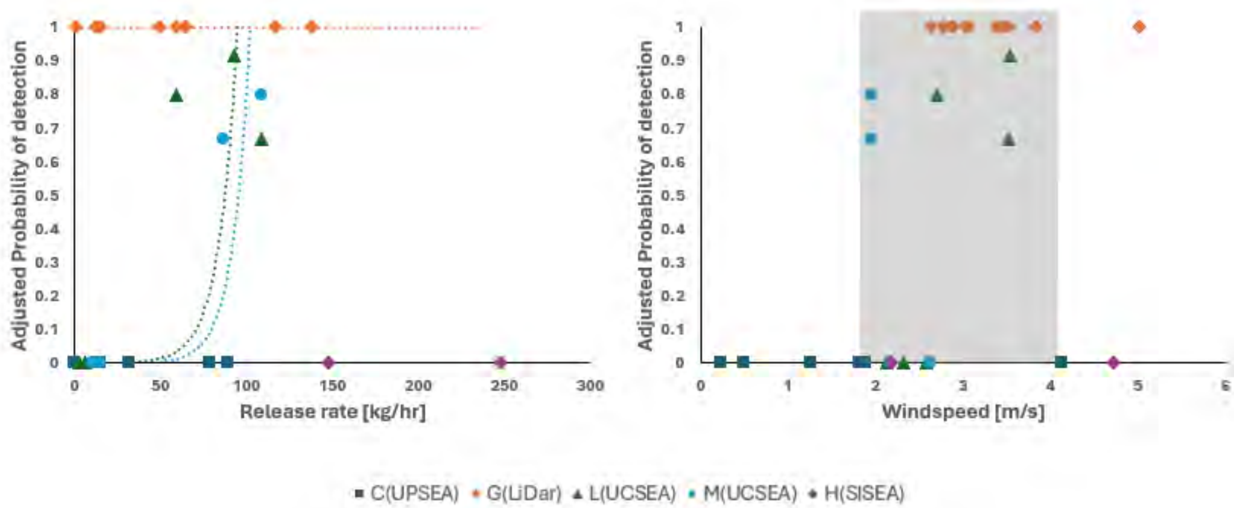

Figure 16: Adjusted Probability of Detection Curves against release rate (left) and wind speed (right)

The probability of detection curve was plotted against release rates and windspeed in Figure 16. LiDAR was very sensitive to emissions as low as 1 kg/hr. The LiDAR methodology's sensitivity is consistent with the detection analysis conducted by Bell et al. (2022) where a minimum detection limit of 0.25 (kg/hr)/(m/s) was observed at an altitude of 500 ft AGL, with 90% probability of detection. For UCSEA, the minimum detection limit was 95.34 kg/hr (vendor L) and 101.88 (vendor M), at an altitude of 20 m AGL, with 90% probability of detection. The locations of releases were a significant factor for UCSEA systems. True positive measurements were made more frequently on flat surfaces compared to slopes. When comparing the probability of detection with wind speed, most true positive detections were made between 2 and 4 m/s (shown in the shaded region in the right-hand side plot in Figure 16).

6.3.4. Detection Technology Performance Analysis

Comparison of UCSEA against previously published works is not possible since there are very few peer-reviewed papers published on the topic, and none using the sensor employed by vendors L and M. One paper by Natalie Pekney's group at NETL that describes the use of an ICI TDLAS column sensor mounted on a UAV flying the length of pipelines. A similar study by Li et al. discovered a minimum detectable release rate of 4 kg/hr in pipeline surveys with the ICI TDLAS-equipped UAV (Li, 2020). This compares favorably to the release rate-dependent probability of detection of technologies L and M, which was more than 10 times as high. There are some differences between the resolution and range specification sheets of the sensors, 1 ppm*m in Li et al. vs 5 ppm*m for vendors L and M, and respectively, 50 m vs 25 m. The sensors used in our study appear to have lower resolution by a factor of 5 and are being piloted nearer the edge of the measurement range, which may explain the differences between the results we observed, and the greater sensitivity observed by Li et al. (2020).

The only other similar controlled release experiment to UCSEA was conducted by Arain et al. (2020) using a mobile ground robot with a Sewerin TDLAS sensor to measure path-integrated methane concentrations, much like USCEA. The Sewerin sensor has a resolution and range that is virtually identical to the sensor used by vendors L and M. Arain and co-authors found a probability of detection of 56% and a 40% false positive rate. Although release rates were not disclosed, the test was conducted indoors, without wind which would have maximized the likelihood of detection. The probability of detection for vendors L and M was even lower in an outdoor environment where wind would quickly dilute concentrations. Vendors L and M returned appreciably larger false positive rates, but comparable false negative rates.

Overall, methodologies' performance in the detection component of the study was highly variable. Table 9 lists key findings for detection methodologies. One vendor (G-LiDAR) scored perfect marks in leak detection trials with no false positives and even made us aware of a malfunctioning flow controller bleeding at under 1 kg/hr. Other methodologies, at rates exceeding 90 kg/hr, could detect fewer than 20% of the releases. The difference in sensitivities between methodologies was roughly 100x in leak detection.

There is pressure to replace walking surveys with more repeatable methods that will reduce injuries incurred by walking on rough terrain. UAV surveys, and especially UCSEA, seem to fit the bill. However, there is substantial variation in the resolution of available TDLAS column sensors on the market, with some advertising as low as 1 ppm*m resolution to 100 ppm*m resolution. Even though it might not be intentional, the evolution of UCSEA, OTM51, and other UAV-based technologies mimic the sensitivity and attributes of EPA21 surface emissions monitoring walking surveys. However, EPA21 sensitivity is not well established, and until it is, it will be unclear whether these UCSEA methodologies deliver equivalent results. If industry and regulators agreed on the minimum leak rate that should be detectable in surveys sensors, work practice could be adjusted to meet rate-based outcomes, which are easy to test experimentally.

The LiDAR methodology performance was impressive, and potentially more sensitive than any landfill operator needs. While UCSEA methodologies had lower performance, they are less expensive to deploy. Based on previously published research, windspeed-specific thresholds, and work practice UCSEA has potential to improve its sensitivity. Lower-precision technology is not necessarily a poor choice for landfills, it just may need to be applied more frequently. The new US EPA OOOO/NSPS standards for oil and gas sites put forward a resolution-based frequency, where less sensitive methods must be deployed more often so they can catch larger emitters earlier – to reduce an equivalent amount of methane as an infrequently deployed higher resolution method. A similar approach could be developed for rate-based landfill leak detection sensitivity, with a move away from concentration thresholds.

Table 9:Summary of key findings for localization methodologies

Technology Identifier	Method	R&D ?	Key Findings
C	UPSEA	Yes	Methodology did not register any true positive emission estimates during the localization phase of the study.
G	LiDAR	No	Performed very well detecting active emissions 100 percent of the time without false positive readings.
H	SISEA	No	Emissions were not detected for quantification or localization purposes. Minimum detection limit expected to be at least 300 kg/hr. Cloud cover over the site and/or wind speed exceeding 10 m/s prevents emission measurement.
L	UCSEA	No	Reported high number of false positive estimates with limited visibility when measuring active emission points on slopes. Minimum detection limit at 90 % probability of detection was determined to be 95.34 kg/hr.
M	UCSEA	No	Performed slightly better than compared to other methods using TDLAS sensors. Also had high number of false positives and a minimum detection limit at 90% probability of detection of 101.88 kg/hr.
N	LEA	Yes	Reported mostly false positive estimates. Model is usually used for quantification purposes therefore is not suited for providing localization estimates.

7. Future Work

This study contributes to understandings of how different technologies operate and perform in a landfill setting, and several topics warrant further exploration. One aspect that must be further explored is the validation of satellite-based methane measurements. Satellite-based methodologies are gaining increased attention due to their expanding abilities. In future studies, a setup with the ability to release over 300 kg/hr during months with low cloud coverage will aid in validating satellite-based measurements.

Continuous fixed methane sensors offer a low-maintenance option for monitoring landfill methane emissions. During this study, fixed sensor coverage was inadequate and analysis of measurement quality over a variety of wind profiles could not be assessed. Longer release times, along with full site coverage, will allow a more accurate assessment for fixed sensors.

Certain vendors in this study were not able to fully deploy their methodologies due to permitting restrictions. In future studies vendors will be able to provide better measurement estimates if they can access the active release area, and if drone-based methodologies have a better line of sight. Having access to the release area will also allow detailed surface emission reports (SEM) to be developed for the study. Prioritizing methodologies such as OTM 51 and UCSEA will help develop standard work practices and a shift away from walking-based surveys.

Studying the rate of methane emissions during day and night cycles is another topic of interest. The ratio of maximum to minimum flux during a day-night cycle can vary between 1.81 to 23.20 as mentioned in Delkash et al. (2022). Studying the variability between day and nighttime measurements among methodologies will further advance measurement practices.

Our 2023 study utilized a temporary, above-ground pipeline setup which was later dismantled. To prevent waste and allow vendors to test new technologies, a permanent or long-term, controlled release setup buried underground can be assembled. This will allow frequent validation and research and development opportunities.

8. Summary Conclusions

A temporary controlled release setup was assembled and used to test 16 combinations of vendors and methodologies for quantification and detection performance during 71 experiments. Quantification methods performed well during the study. Truck-based systems using the Gaussian model tend to underestimate and the tracer correlation method was the most accurate among the truck-based methodologies. Using onsite weather data improved accuracy of LiDAR and should be an important consideration for vendors.

Detection methods and vendor performance varied greatly. LiDAR was very effective in localizing leaks and detecting emissions as low as 1 kg/hr. TDLAS systems, at a rate of around 80%, provided a high number of false positive leak estimates. This occurred with both vendors, who used the same technology.

Key takeaways from the study are listed below:

- MTCEA provided good quantification estimates while being flexible to operate in various weather conditions. UPSEA provided accurate quantification estimates as well , however the methodology requires good weather conditions to operate (no precipitation, windspeed below 12 m/s).
- Collecting onsite weather data is recommended as it has shown to improve quantification estimates
- LiDAR was able to detect all active emitting points including flowrates as low as 1 kg/hr.
- UCSEA reported high number of false positives (False positive fraction > 0.79) with limited visibility when measuring active emission points on slopes.
- RPSEA showed promising results; however, require further validation in a landfill setting to ensure its accuracy.

Table 10 summarizes key metrics for participating methodologies.

Table 10: Key performance metrics for all vendors

Technology Identifier	Method	Dev. from true value %	St Dev of Residuals %	Localization accuracy
A	MGPA	1-160	47.61	-
B	MGPA	1-88	39.63	-
C	UPSEA	2-66	34.71	-
D	UPSEA	8-96	61.98	-
E	MTCEA	3-44	20.49	-
F	APSEA	1-77	23.89	-
G-1	LiDAR	6-128	44.64	1
G-2	Mass Balance	7-130	40.67	-
H	SISEA	-	-	-
I	RPSEA	1-3597	975.19	-
J	RPSEA	2-306	96.36	-
K	RPSEA	5-96	39.10	-
L	UCSEA	-	-	0.17
M	UCSEA	-	-	0.21
N	LEA	6-215	88.34	0.1-0.5

This study will allow operators and regulators to make more informed decisions about landfill emission measurement techniques. Furthermore, vendors will be able to use data created during this study to further develop their methodologies and improve their services for the waste management sector, to reduce methane.

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A: Summary Data Table

Table A-1: Flowmeter data and uncertainty for all experiments. Flow rates are in kg/hr and experiment times are in Eastern time format.

Exp#	Q_A	Q_B	Q_C	Q_D1	Q_D2	Q_D3	Q_E	Q_F	Q_K4	Q_K5	Flowmeter Total	Site Total	Time Start	Time End	U_A	U_B	U_C	Q_D1	Q_D2	Q_D3	Q_E	Q_F	Q_K4	Q_K5	RSS	%U
1	2.78	4.64	2.78	0.00	0.00	6.50	0.93	1.86	0.00	0.00	19.49	43.93	2023-11-06T10:00:12.840	2023-11-06T10:40:14.723	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0	0	0.000108	0.0108
2	3.71	4.64	5.57	4.64	0.00	0.00	3.70	1.86	0.00	4.38	28.50	52.94	2023-11-06T11:40:28.179	2023-11-06T12:20:57.916	0.006	0.006	0.006	0.006	0	0	0.006	0.006	0	0.006	0.000126	0.0126
3	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.30	24.74	2023-11-06T12:40:15.593	2023-11-06T13:30:35.568	0	0	0.006	0.006	0	0	0.006	0.006	0.006	0	0.00009	0.009
4	5.57	14.85	17.45	0.00	0.93	0.00	2.78	22.27	18.19	0.00	82.03	106.47	2023-11-06T13:53:12.998	2023-11-06T14:43:28.377	0.006	0.006	0.006	0	0.006	0	0.006	0.006	0.006	0	0.000126	0.0126
5	14.85	0.00	12.99	0.00	16.71	0.00	17.63	10.21	0.00	1.65	74.04	98.48	2023-11-06T15:41:01.218	2023-11-06T16:30:51.252	0.006	0	0.006	0	0.006	0	0.006	0.006	0	0.006	0.000108	0.0108
6	2.77	1.85	0.00	0.00	0.00	2.78	9.26	10.21	1.57	0.00	28.44	52.88	2023-11-07T08:16:09.775	2023-11-07T09:06:23.783	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0.006	0	0.000126	0.0126
7	0.00	0.00	0.00	0.00	0.00	0.00	2.80	22.28	0.45	0.00	25.53	49.97	2023-11-07T09:40:24.157	2023-11-07T10:30:36.410	0	0	0	0	0	0	0.006	0.006	0.006	0	0.000054	0.0054
8	-0.01	-0.01	0.00	0.00	0.00	0.00	-0.01	0.25	0.02	0.00	0.25	24.68	2023-11-07T11:11:52.591	2023-11-07T12:10:46.914	0	0	0.006	0	0	0	0	0.006	0.006	0	0.000054	0.0054
9	5.55	13.87	2.78	3.70	0.00	0.00	21.33	50.11	0.00	1.54	98.87	123.31	2023-11-07T12:30:27.287	2023-11-07T13:20:41.804	0.006	0.006	0.006	0.006	0	0	0.006	0.006	0	0.006	0.000126	0.0126
10	5.54	8.32	11.11	10.19	0.00	0.00	41.71	58.47	0.00	4.64	139.98	164.42	2023-11-07T13:40:15.331	2023-11-07T14:30:28.162	0.006	0.006	0.006	0.006	0	0	0.006	0.006	0	0.006	0.000126	0.0126
11	0.10	1.08	2.06	0.00	2.95	0.00	19.92	17.74	1.66	0.00	45.50	69.94	2023-11-07T14:45:05.445	2023-11-07T15:18:11.408	0.006	0.006	0.006	0	0.006	0	0.006	0.006	0.006	0	0.000126	0.0126
12	3.71	4.64	4.64	0.00	5.57	0.00	13.91	21.35	3.71	0.00	57.53	81.97	2023-11-07T15:26:14.286	2023-11-07T15:56:16.816	0.006	0.006	0.006	0	0.006	0	0.006	0.006	0.006	0	0.000126	0.0126
13	0.00	-0.01	0.00	0.00	0.00	0.00	45.78	46.16	0.04	0.00	91.96	116.40	2023-11-08T08:13:40.905	2023-11-08T09:04:52.638	0.006	0	0	0	0	0	0.006	0.006	0.006	0	0.000072	0.0072
14	11.14	3.71	0.93	5.61	0.00	0.00	46.94	44.55	0.00	1.87	114.74	139.18	2023-11-08T09:17:03.823	2023-11-08T10:07:27.289	0.006	0.006	0.006	0.006	0	0	0.006	0.006	0	0.006	0.000126	0.0126
15	6.50	11.14	0.93	0.00	0.00	9.28	47.13	51.04	2.78	0.00	128.80	153.24	2023-11-08T10:17:27.030	2023-11-08T11:07:27.828	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0.006	0	0.000126	0.0126
16	18.56	18.56	18.56	0.00	0.00	18.55	-0.15	0.32	18.56	0.00	92.97	117.41	2023-11-08T11:50:14.469	2023-11-08T12:40:19.682	0.006	0.006	0.006	0	0	0.006	0	0.006	0.006	0	0.000108	0.0108
17	12.99	18.56	16.71	0.00	18.37	0.00	34.32	52.87	14.85	0.00	168.67	193.11	2023-11-08T12:55:33.269	2023-11-08T13:45:37.403	0.006	0.006	0.006	0	0.006	0	0.006	0.006	0.006	0	0.000126	0.0126
18	0.00	-0.01	0.00	0.00	0.00	0.00	47.75	29.70	0.68	0.00	78.12	102.56	2023-11-09T08:00:22.677	2023-11-09T08:45:00.432	0	0	0.006	0	0	0	0.006	0.006	0.006	0	0.000072	0.0072
19	0.00	-0.01	0.00	0.00	0.00	0.00	48.43	29.70	0.69	0.00	78.80	103.24	2023-11-09T08:45:02.120	2023-11-09T09:20:31.461	0	0	0.006	0.006	0	0	0.006	0.006	0.006	0	0.00009	0.009
20	-0.01	0.93	1.86	2.78	0.00	0.00	19.49	16.71	1.47	0.00	43.22	67.66	2023-11-09T09:30:17.935	2023-11-09T10:15:03.745	0	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0	0.000108	0.0108
21	-0.01	0.93	1.86	2.78	0.00	0.00	19.49	16.70	1.43	0.00	43.18	67.62	2023-11-09T10:15:05.662	2023-11-09T10:45:20.562	0	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0	0.000108	0.0108
22	-0.01	0.00	0.00	0.00	0.00	0.00	-0.04	0.38	0.03	0.00	0.36	24.80	2023-11-09T11:00:02.155	2023-11-09T11:30:00.364	0	0	0.006	0.006	0	0	0	0.006	0.006	0	0.000072	0.0072
23	-0.01	18.56	9.28	0.00	16.71	0.00	23.20	23.20	0.00	18.56	109.50	133.94	2023-11-09T11:35:15.208	2023-11-09T12:05:16.021	0	0.006	0.006	0	0.006	0	0.006	0.006	0	0.006	0.000108	0.0108
24	-0.01	0.00	0.00	0.00	0.00	0.00	23.18	23.20	0.35	0.00	46.72	71.16	2023-11-09T12:09:59.947	2023-11-09T12:40:08.841	0	0	0.006	0.006	0	0	0.006	0.006	0.006	0	0.00009	0.009
25	18.56	18.56	9.28	4.64	0.00	0.00	-0.01	0.32	0.00	9.28	60.63	85.07	2023-11-09T12:45:14.837	2023-11-09T13:15:21.213	0.006	0.006	0.006	0.006	0	0	0	0.006	0	0.006	0.000108	0.0108
26	18.56	18.56	9.28	4.64	0.00	0.00	0.06	0.30	0.00	9.27	60.68	85.12	2023-11-09T13:20:08.104	2023-11-09T13:50:16.090	0.006	0.006	0.006	0.006	0	0	0.006	0.006	0	0.006	0.000126	0.0126
27	5.57	8.35	11.14	0.00	0.00	9.28	41.77	58.44	4.64	0.00	139.19	163.62	2023-11-09T14:20:39.444	2023-11-09T15:00:40.360	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0.006	0	0.000126	0.0126
28	-0.01	0.00	1.85	0.00	0.00	2.78	19.49	16.70	1.29	0.00	42.11	66.55	2023-11-09T15:10:07.250	2023-11-09T15:40:11.989	0	0	0.006	0	0	0.006	0.006	0.006	0.006	0	0.00009	0.009

Exp#	Q_A	Q_B	Q_C	Q_D1	Q_D2	Q_D3	Q_E	Q_F	Q_K4	Q_K5	Flowmeter Total	Site Total	Time Start	Time End	U_A	U_B	U_C	Q_D1	Q_D2	Q_D3	Q_E	Q_F	Q_K4	Q_K5	RSS	%U
29	18.56	18.56	18.56	0.00	0.00	18.56	-0.06	0.32	18.56	0.00	93.07	117.51	2023-11-09T15:50:00.857	2023-11-09T16:30:06.796	0.006	0.006	0.006	0	0	0.006	0	0.006	0.006	0	0.000108	0.0108
30	5.57	13.92	2.78	0.00	3.71	0.00	21.33	50.11	0.00	1.28	98.71	123.15	2023-11-09T16:50:02.293	2023-11-09T17:30:04.556	0.006	0.006	0.006	0	0.006	0	0.006	0.006	0	0.006	0.000126	0.0126
31	0.00	-0.01	0.00	0.00	0.00	0.00	37.07	37.09	0.03	0.00	74.17	98.61	2023-11-10T08:09:19.152	2023-11-10T08:39:30.471	0	0	0.006	0	0	0	0.006	0.006	0.006	0	0.000072	0.0072
32	18.56	18.56	18.56	18.56	0.00	0.00	-0.10	0.32	18.56	0.00	93.03	117.46	2023-11-10T08:49:00.098	2023-11-10T09:19:03.130	0.006	0.006	0.006	0.006	0	0	0	0.006	0.006	0	0.000108	0.0108
33	0.00	-0.01	0.00	0.00	0.00	0.00	18.54	18.55	0.00	0.00	37.08	61.52	2023-11-10T09:29:12.293	2023-11-10T09:59:26.293	0	0	0.006	0.006	0	0	0.006	0.006	0.006	0	0.00009	0.009
34	16.51	16.54	16.51	16.21	0.00	0.00	-0.01	0.00	0.00	15.59	81.35	105.79	2023-11-10T10:10:01.056	2023-11-10T10:53:17.864	0.006	0.006	0.006	0.006	0	0	0	0.006	0	0.006	0.000108	0.0108
35	4.64	4.64	0.00	0.00	0.01	0.00	4.62	4.64	4.64	0.00	23.19	47.63	2023-11-10T11:02:06.039	2023-11-10T11:32:05.908	0.006	0.006	0.006	0	0.006	0	0.006	0.006	0.006	0	0.000126	0.0126
36	-0.01	0.00	0.00	0.01	0.00	0.00	27.84	27.84	0.00	0.00	55.69	80.13	2023-11-10T12:30:00.096	2023-11-10T13:10:06.739	0	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0	0.000108	0.0108
37	18.56	18.56	18.56	18.56	0.00	0.00	18.55	18.56	18.56	0.00	129.92	154.36	2023-11-10T13:15:08.208	2023-11-10T13:55:03.609	0.006	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0	0.000126	0.0126
38	18.56	18.56	18.56	0.00	0.00	18.56	18.56	18.56	0.00	18.56	129.94	154.38	2023-11-10T14:00:12.192	2023-11-10T14:40:13.075	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0	0.006	0.000126	0.0126
39	0.00	-0.01	0.00	6.50	0.00	0.00	19.49	16.70	0.00	0.00	42.69	67.13	2023-11-10T15:05:01.397	2023-11-10T15:35:06.503	0	0	0.006	0.006	0	0	0.006	0.006	0.006	0	0.00009	0.009
40	9.28	9.28	0.00	0.00	0.01	0.00	0.01	0.01	9.28	0.00	27.86	52.30	2023-11-10T15:40:00.740	2023-11-10T16:10:06.764	0.006	0.006	0.006	0	0.006	0	0.006	0.006	0.006	0	0.000126	0.0126
41	18.56	18.56	18.56	0.00	18.49	0.00	27.83	27.84	18.56	0.00	148.42	172.86	2023-11-10T16:15:19.908	2023-11-10T16:45:20.823	0.006	0.006	0.006	0	0.006	0	0.006	0.006	0.006	0	0.000126	0.0126
42	18.56	0.00	0.00	18.56	0.00	0.00	50.22	0.01	0.00	0.00	87.36	111.80	2023-11-11T09:51:39.948	2023-11-11T10:50:10.126	0.006	0.006	0.006	0.006	0	0	0.006	0.006	0	0.006	0.000126	0.0126
43	0.00	18.56	18.56	0.00	0.00	0.00	9.27	55.68	0.00	0.00	102.08	126.52	2023-11-11T11:00:08.579	2023-11-11T12:00:12.439	0	0.006	0.006	0	0.006	0	0.006	0.006	0.006	0	0.000108	0.0108
44	0.00	0.00	0.00	0.00	0.00	0.00	0.01	9.28	0.00	0.00	9.28	33.72	2023-11-11T12:10:19.641	2023-11-11T12:40:27.410	0	0.006	0.006	0.006	0	0	0.006	0.006	0	0.006	0.000108	0.0108
45	0.00	0.00	0.00	0.00	4.64	0.00	9.24	0.01	0.00	0.00	13.89	38.33	2023-11-11T13:02:55.106	2023-11-11T13:28:55.765	0	0	0.006	0	0.006	0	0.006	0.006	0	0	0.000072	0.0072
46	0.00	0.00	0.00	4.64	0.00	0.00	9.25	0.01	0.00	0.00	13.90	38.34	2023-11-11T13:40:36.082	2023-11-11T14:09:08.330	0.006	0.006	0.006	0.006	0	0	0.006	0.006	0	0.006	0.000126	0.0126
47	9.28	0.00	0.00	0.00	0.93	0.00	0.01	0.01	0.93	0.00	11.15	35.59	2023-11-11T14:15:01.192	2023-11-11T14:40:34.068	0.006	0	0.006	0	0.006	0	0.006	0.006	0.006	0	0.000108	0.0108
48	0.00	4.64	0.00	0.00	0.00	0.00	0.01	9.27	0.00	0.00	13.92	38.36	2023-11-11T14:45:06.953	2023-11-11T15:23:18.578	0	0.006	0.006	0	0	0	0.006	0.006	0	0	0.000072	0.0072
49	9.26	0.00	0.00	0.00	0.00	9.28	9.27	18.55	9.28	0.00	55.65	80.09	2023-11-11T16:00:06.250	2023-11-11T17:00:15.344	0.006	0	0.006	0	0	0.006	0.006	0.006	0.006	0	0.000108	0.0108
50	18.56	0.00	0.00	0.00	0.00	18.56	36.98	0.01	0.00	0.00	74.11	98.55	2023-11-12T08:15:12.714	2023-11-12T08:56:17.563	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0.006	0	0.000126	0.0126
51	0.00	18.56	18.56	0.00	0.00	0.00	9.27	37.12	0.00	0.00	83.53	107.96	2023-11-12T09:10:19.711	2023-11-12T09:45:23.482	0	0.006	0.006	0	0	0.006	0.006	0.006	0	0.006	0.000108	0.0108
52	0.00	0.00	0.00	0.93	0.00	0.00	0.01	9.28	0.93	0.00	11.14	35.58	2023-11-12T09:55:08.844	2023-11-12T10:33:40.553	0	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0	0.000108	0.0108
53	0.00	0.00	0.00	0.00	4.64	0.00	9.26	0.01	0.00	0.00	13.91	38.34	2023-11-12T10:44:56.749	2023-11-12T11:20:37.606	0.006	0.006	0.006	0	0.006	0	0.006	0.006	0.006	0	0.000126	0.0126
54	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	24.45	2023-11-12T12:30:00.602	2023-11-12T13:00:00.389	0.006	0	0.006	0.006	0	0	0.006	0.006	0	0.006	0.000108	0.0108
55	0.00	0.00	0.00	1.86	0.00	0.00	0.01	0.00	0.00	0.00	1.87	26.31	2023-11-12T13:05:08.714	2023-11-12T14:01:43.871	0.006	0	0.006	0.006	0	0	0.006	0.006	0	0.006	0.000108	0.0108
56	18.56	18.56	18.56	18.56	0.00	0.00	47.50	92.80	18.56	0.00	233.12	257.56	2023-11-12T14:05:14.356	2023-11-12T14:11:47.965	0.006	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0	0.000126	0.0126
57	0.00	0.00	0.93	0.00	0.00	0.00	0.01	4.64	0.00	0.00	5.58	30.02	2023-11-12T14:30:19.449	2023-11-12T15:30:22.073	0	0.006	0.006	0	0	0	0.006	0.006	0.006	0	0.00009	0.009
58	0.93	0.00	0.00	0.00	0.00	0.93	0.01	0.01	0.00	0.00	1.87	26.31	2023-11-12T15:41:39.323	2023-11-12T16:36:42.637	0.006	0	0.006	0	0	0.006	0.006	0.006	0	0	0.00009	0.009
59	7.42	0.00	0.00	0.00	0.00	7.43	0.00	37.10	5.97	0.00	57.92	82.36	2023-11-13T09:59:23.510	2023-11-13T10:39:29.814	0.006	0	0.006	0	0	0.006	0.006	0.006	0.006	0	0.000108	0.0108
60	7.43	0.00	0.00	0.00	0.00	7.42	0.00	37.12	7.33	0.00	59.31	83.74	2023-11-13T10:46:02.401	2023-11-13T11:15:36.063	0.006	0	0.006	0	0	0.006	0.006	0.006	0.006	0	0.000108	0.0108
61	7.42	0.00	0.00	0.00	0.00	7.42	0.01	37.09	7.41	0.00	59.36	83.80	2023-11-13T11:22:27.678	2023-11-13T11:52:23.423	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0.006	0	0.000126	0.0126
62	9.28	0.93	0.00	0.00	0.93	0.00	18.52	0.00	0.00	0.00	29.67	54.11	2023-11-13T12:10:01.424	2023-11-13T12:38:47.726	0.006	0.006	0.006	0	0.006	0	0.006	0.006	0.006	0	0.000126	0.0126
63	0.93	0.00	3.71	0.00	0.00	0.00	0.01	25.98	0.00	5.54	36.17	60.61	2023-11-13T12:50:20.478	2023-11-13T13:19:27.400	0.006	0	0.006	0	0	0	0.006	0.006	0	0.006	0.00009	0.009

FLUX LAB

Exp#	Q_A	Q_B	Q_C	Q_D1	Q_D2	Q_D3	Q_E	Q_F	Q_K4	Q_K5	Flowmeter Total	Site Total	Time Start	Time End	U_A	U_B	U_C	Q_D1	Q_D2	Q_D3	Q_E	Q_F	Q_K4	Q_K5	RSS	%U
64	4.64	4.64	4.64	4.64	0.00	0.00	29.59	0.01	4.64	0.00	52.80	77.24	2023-11-13T14:30:14.232	2023-11-13T14:44:02.286	0.006	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0	0.000126	0.0126
65	4.64	9.28	6.50	0.00	4.64	0.00	29.64	0.01	0.00	4.63	59.33	83.77	2023-11-13T15:59:57.197	2023-11-13T16:30:01.065	0.006	0.006	0.006	0	0.006	0	0.006	0.006	0	0.006	0.000126	0.0126
66	18.56	0.00	0.00	18.56	0.00	0.00	44.41	0.01	0.00	0.00	81.54	105.98	2023-11-14T08:15:30.074	2023-11-14T09:15:35.680	0.006	0.006	0.006	0.006	0	0	0.006	0.006	0	0	0.000108	0.0108
67	0.00	18.56	18.56	0.00	0.00	0.00	9.27	55.68	-0.01	0.00	102.07	126.51	2023-11-14T09:25:33.216	2023-11-14T10:25:39.759	0	0.006	0.006	0.006	0	0	0.006	0.006	0	0	0.00009	0.009
68	0.00	0.00	0.00	0.00	0.00	0.00	0.01	9.28	-0.02	0.00	9.27	33.71	2023-11-14T10:35:03.583	2023-11-14T11:35:10.493	0	0	0.006	0	0	0	0.006	0.006	0	0	0.000054	0.0054
69	0.00	0.00	0.00	0.00	4.64	0.00	9.21	0.00	-0.01	0.00	13.84	38.28	2023-11-14T11:44:55.704	2023-11-14T11:53:04.610	0	0.006	0.006	0	0.006	0	0.006	0.006	0	0	0.00009	0.009
70	18.56	18.56	18.56	0.00	0.00	18.56	45.90	99.64	18.56	0.00	238.34	262.78	2023-11-14T13:58:06.401	2023-11-14T14:09:07.384	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0.006	0	0.000126	0.0126
71	0.00	4.64	0.00	0.00	0.00	0.00	0.01	9.28	0.00	0.00	13.93	38.37	2023-11-14T14:29:54.462	2023-11-14T15:59:55.332	0	0.006	0.006	0.006	0	0	0.006	0.006	0.006	0	0.000108	0.0108

B: Equipment List and engineering diagrams

Table B-1: List of electrical components

№	Product Name	Quantity
1	FTP 4-Pairs (FOD-CAT6-1KFT)	**305 m/ 2 pack**
2	Leakage Circuit Breaker Box, 4 Way Garage Caravan Consumer Unit 63a 30ma RCD 4MCB 2x6a 20a 32a	**1**
3	Button Switch DC 24V SPDT 5 Pin 5 Pack	**1**
4	AC/DC CONVERTER 24V 31W	**5**
5	SSR RELAY SPST-NO 15A 75-250V	**5**
6	AC/DC CONVERTER 24V 46W	**2**
7	Electriduct 3/4" Flame Retardant Polypropylene	**18**
8	Dustproof Waterproof IP65 Junction ElectricalBox (150mmx110mmx70mm)	**5**
9	Dustproof Waterproof IP65 Junction Electrical Box (200mmx155mmx80mm)	**3**
10	Uenhoy 6 Pcs NPT 1" Cable Glands Waterproof Nylon Cord Grip Cable Glands Strain Relief Cord Connectors	**6**
11	Dual Wall Heat Shrink Tubing (Dia 40mm(1.6")	**2**
12	25 Ft Extension Cord with 3 Outlets, UL Listed 16/3 SJTW, 3-Wire Grounded, 13A 125V 1625W	**1**
13	20 Inch 1 to 4 Extension Cord Splitter, 16/3 SJTW 3 Prong Power Cord.	**2**
14	PORTABLE CORD,250FT.,16 AWG, BLACK Standards - UL FlexibleCord, CSA, MSHAApproved, RoHS Compliant	**540m./7 pack2**
15	Kasonic 25 Ft Extension Cord with 3 Outlets, UL Listed 16/3 SJTW, 3-Wire Grounded, 13A 125V 1625W for Indoor/Outdoor Use - Green	**76,2m./1 pack**

Table B-2: List of Pipeline Equipment

Type	Size	Model	Certification	Quantity
Flow controller	1 1/4 inch	Alicat MCR-3000SLPM-D-485-X/5M	ATEX/CSA Class 1 Zone/Div 2 area rated	2
Flow controller	3/4 inch	Alicat MCR-500SLPM-D-485-X/5M	ATEX/CSA Class 1 Zone/Div 2 area rated	5
Ball Valve	2 inch	68AMLL-2 KITZ	CAN/CGA 3.16-M88 - 125 PSI	1
Solenoid Valve	3/4 inch	Shako PU225A-06 (FKM)	ATEX EExmIIT4 II 2G & 2D	5
PE pipe	2 inch	PE-32-250 GASTITE	CAN/CSA-B137.4	2
PE pipe	1-1/4inch	PE-20-250 GASTITE	CAN/CSA-B137.4	5
PE fitting	2 inch	PECPL-32 GASTITE	CAN/CSA-B137.4	1
PE pipe	3/4 inch	PE-12-250 GASTITE	CAN/CSA-B137.4	3
PE fitting	2 inch	PET-32	CAN/CSA-B137.4	1
PE fitting	2 1-1/4 2 inch	PERT-32-32-20	CAN/CSA-B137.4	2
PE fitting	1-1/4 3/4 1-1/4 inch	PERT-16-16-12	CAN/CSA-B137.4	3
PE fitting	2 inch	TRANS-32	CAN/CSA-B137.4	1
PE fitting	1-1/4inch	TRANS-20	CAN/CSA-B137.4	2
PE fitting	3/4 inch	TRANS-12	CAN/CSA-B137.4	11
PE fitting	2 1-1/4inch	PECPL-20-32	CAN/CSA-B137.4	2
PE fitting	1-1/4 3/4 inch	PECPL-12-20	CAN/CSA-B137.4	2

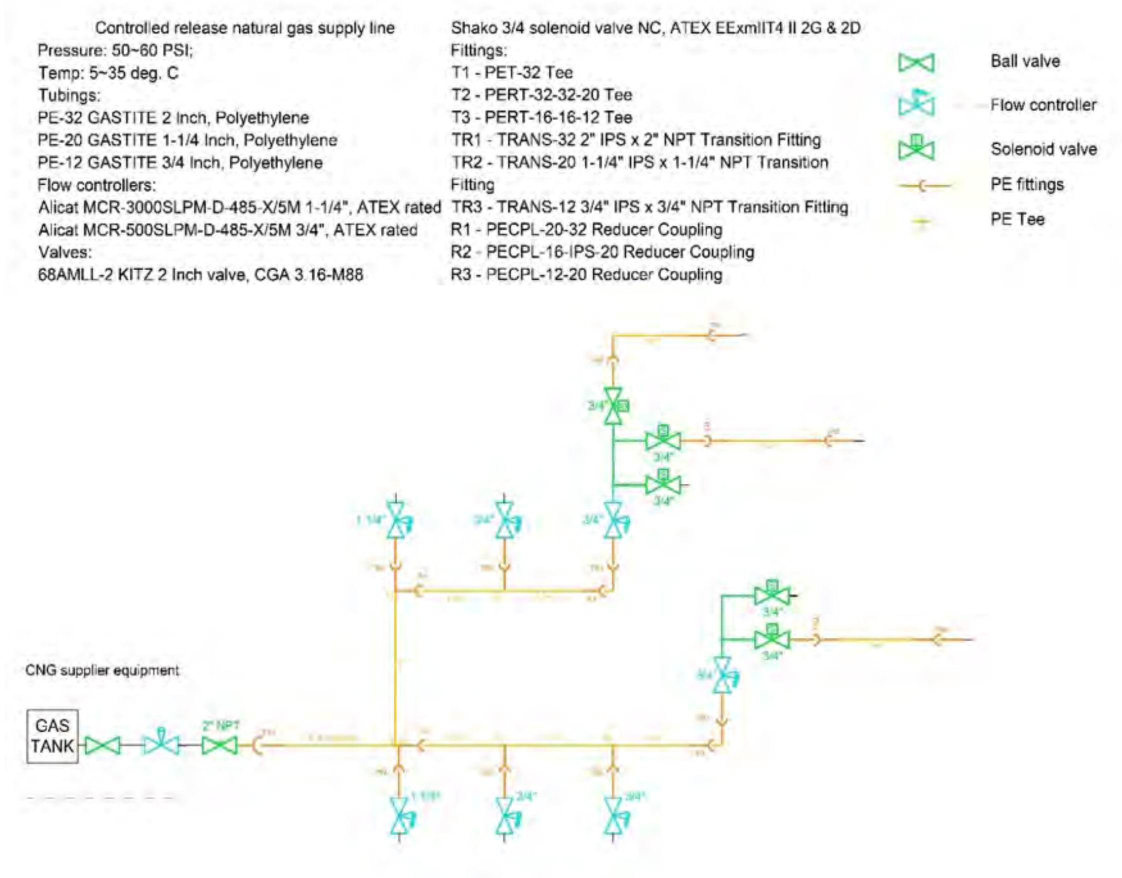

Figure B-1: Piping and instrumentation diagramf piping assembly

PRODUCT

CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

MetSens500

Compact Weather Sensor for Temperature, RH, Barometric Pressure, and Wind with Compass

Measures 5 Common Meteorological Parameters

IEC 61724-1 Compliant

Overview

The MetSens500 compact weather sensor measures wind speed and direction via an ultrasonic sensor, as well as air temperature, relative humidity, and barometric pressure, in a single, combined instrument mounted inside three double-louvered, naturally aspirated radiation shields with no moving parts. An integrated electronic compass allows the MetSens500 to provide accurate, relative wind direction measurements without being oriented in a particular way, making installation easier. WMO average wind speed and direction and gust, temperature, relative humidity, barometric pressure, absolute humidity, air density, and wet bulb temperature data are provided. The MetSens500 is compatible and easily integrated with the MeteoPV Solar Resource Platform and any Campbell Scientific data logger using SDI-12, RS-485, ModbusRS-485, or NMEA RS-232.

Benefits and Features

- Quality measurements
- Fast and simple to install
- Compact, integrated design
- Lightweight and robust

Specifications

Measurements Made	Air temperature, barometric pressure, relative humidity, wind direction, and wind speed.
Sampling Rate	1 Hz
Digital Communication Modes	Serial RS-232, RS-485, SDI-12, NMEA, Modbus, ASCII
IP Rating	66
Compliance	CE, RoHS Where applicable, all individual parameters meet or exceed specifications of IEC 61724-1 (2017, 2021).
Operating Temperature Range	-40° to +70°C
Operating Voltage	5 to 30 Vdc
Typical Current Drain @ 12 Vdc	25 mA (continuous high mode) 0.7 mA (eco-power mode; 1 hour polled)
Weight	0.7 kg (1.5 lb)

For comprehensive details, visit: www.campbellsci.com/metsens500

Air Temperature Measurement

Measurement Range	-40° to +70°C
Resolution	0.1°C
Accuracy	±0.3°C (@ 20°C)

Relative Humidity Measurement

Measurement Range	0 to 100%
Resolution	0.1
Accuracy	±2% @ 20°C (10 to 90% RH)

Barometric Pressure Measurement

Measurement Range	300 to 1100 hPa
Resolution	0.1 hPa
Accuracy	±0.5 hPa (@ 25°C)

Wind Speed Measurement

Measurement Range	0.01 to 60 m s^{-1}
Accuracy	±5% (up to 60 m s^{-1}) ±3% (up to 40 m s^{-1})
Resolution	0.01 m s^{-1}
Starting Threshold	0.01 m s^{-1}

Wind Direction Measurement

Measurement Range	0° to 359°
Accuracy	±3° (up to 60 m s^{-1})
Resolution	1°

Compass

Measurement Range	0 to 359°
Resolution	1°
Units of Measure	Degrees
Accuracy	±3°

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CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

MetSens200

Compact Weather Sensor for Wind with Compass

Measures Wind Speed and Direction

IEC 61724-1 Compliant

Overview

The MetSens200 compact weather sensor measures wind speed and direction via an ultrasonic sensor. An integrated electronic compass allows the MetSens200 to provide accurate, relative wind direction measurements without being oriented in a particular way, making installation easier. WMO average wind speed and direction and gust data are provided. The MetSens200 is compatible and easily integrated with the MeteoPV Solar Resource Platform and any Campbell Scientific data logger using SDI-12, RS-485, ModbusRS-485, or NMEA RS-232.

Benefits and Features

- Quality measurements
- Fast and simple to install
- Compact, integrated design
- Lightweight and robust

Specifications

Measurements Made	Wind direction and wind speed
Sampling Rate	1 Hz
Digital Communication Modes	Serial RS-232, RS-485, SDI-12, NMEA, Modbus, ASCII
IP Rating	66
Compliance	CE, RoHS Where applicable, all individual parameters meet or exceed specifications of IEC 61724-1 (2017, 2021).
Operating Temperature Range	-40° to +70°C
Operating Voltage	5 to 30 Vdc
Typical Current Drain @ 12 Vdc	0.7 mA (eco-power mode; 1 hour polled) 25 mA (continuous high mode)
Weight	0.5 kg (1.1 lb)

Wind Speed Measurement

Measurement Range	0.01 to 60 $m\ s^{-1}$
Accuracy	±3% (up to 40 $m\ s^{-1}$) ±5% (up to 60 $m\ s^{-1}$)
Resolution	0.01 $m\ s^{-1}$
Starting Threshold	0.01 $m\ s^{-1}$

Wind Direction Measurement

Measurement Range	0° to 359°
Accuracy	±3° (up to 60 m s^{-1})
Resolution	1°

Compass

Measurement Range	0 to 359°
Resolution	1°
Units of Measure	Degrees
Accuracy	±3°

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C: Localization assessment maps

Figures C-1 to C-4 shows localization assessment maps for methodologies C, G, L, M and N. Maps show all submitted leak estimate coordinates and active release points that vendors participated in during the study. Leak estimates are shown using circles filled with a single color. White circles with a smaller black circle show release nodes. Squares with hashed black lines indicate active release points and the bounding box is used to determine true positive leak estimates.

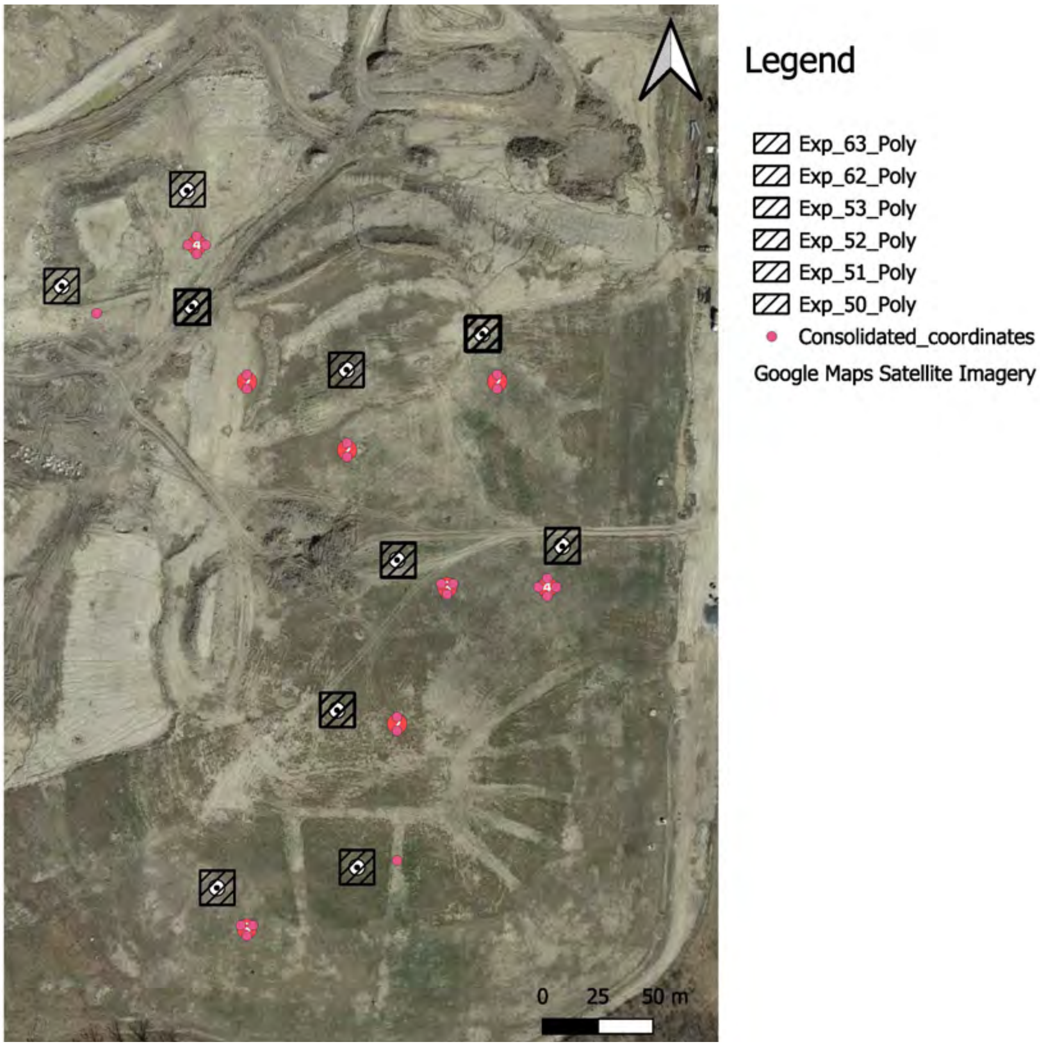


Figure C-1: Vendor C localization assessment map. Overlapping points are shown as a point cluster.

FLUX LAB

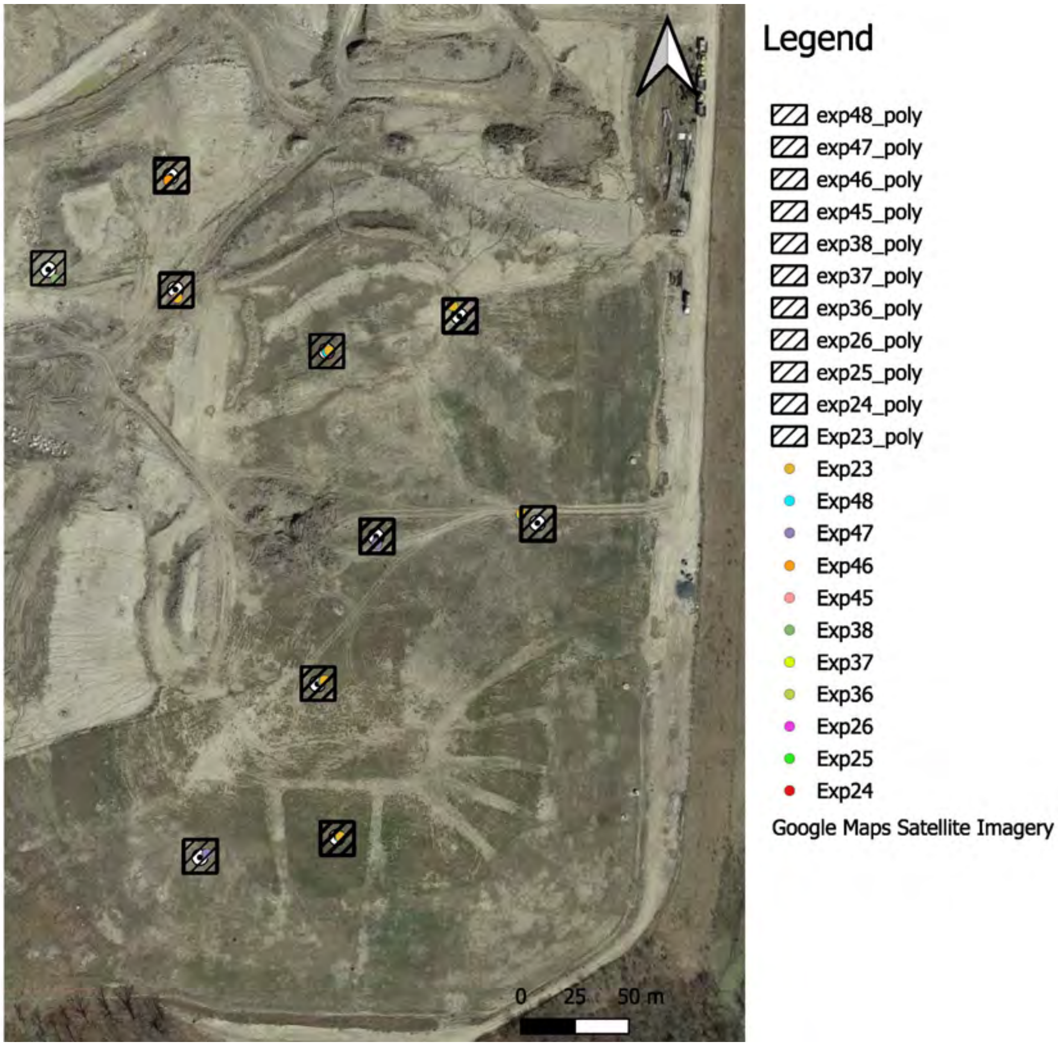


Figure C-2: Vendor G localization assessment map

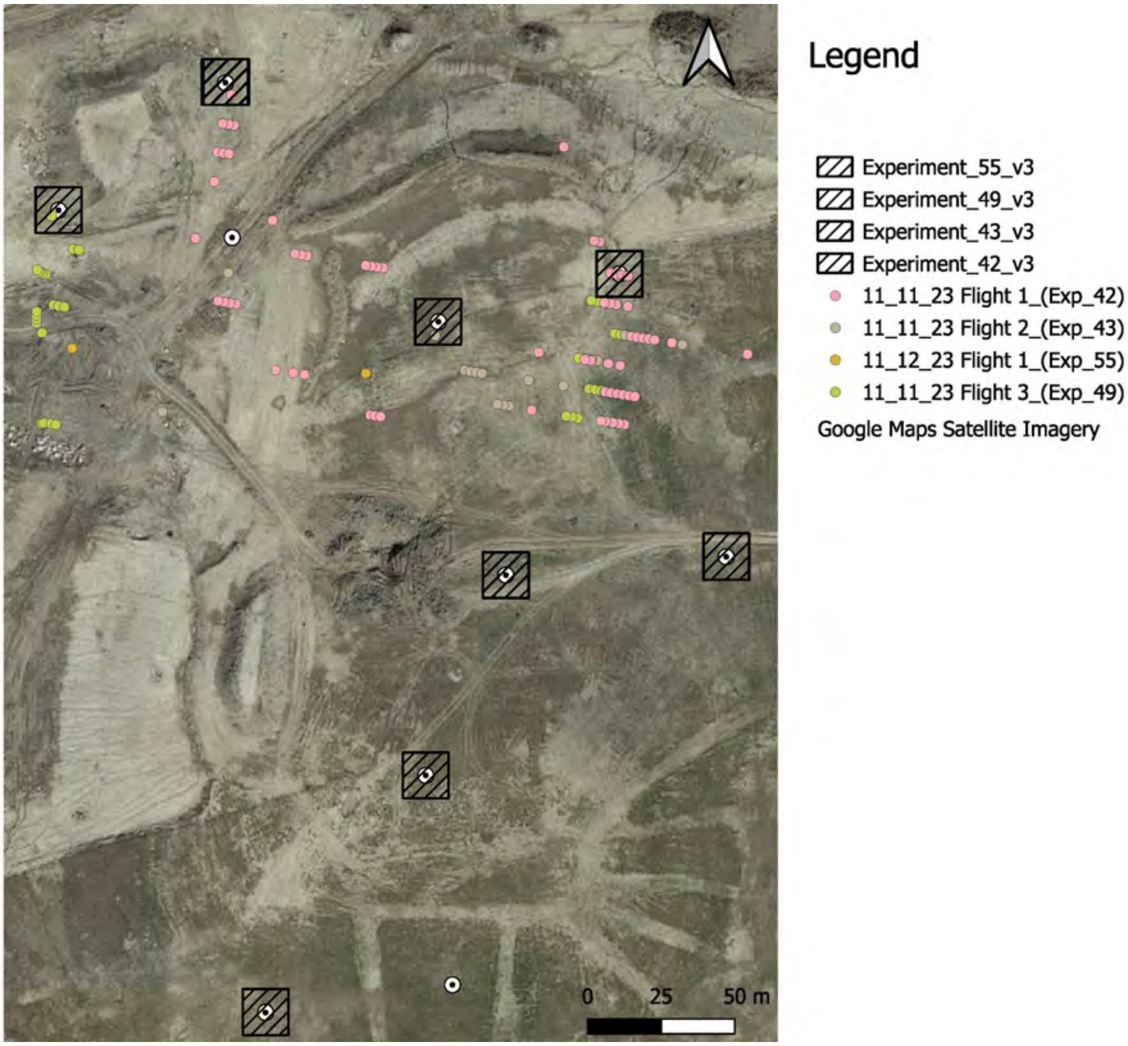


Figure C-3: Vendor L localization assessment map

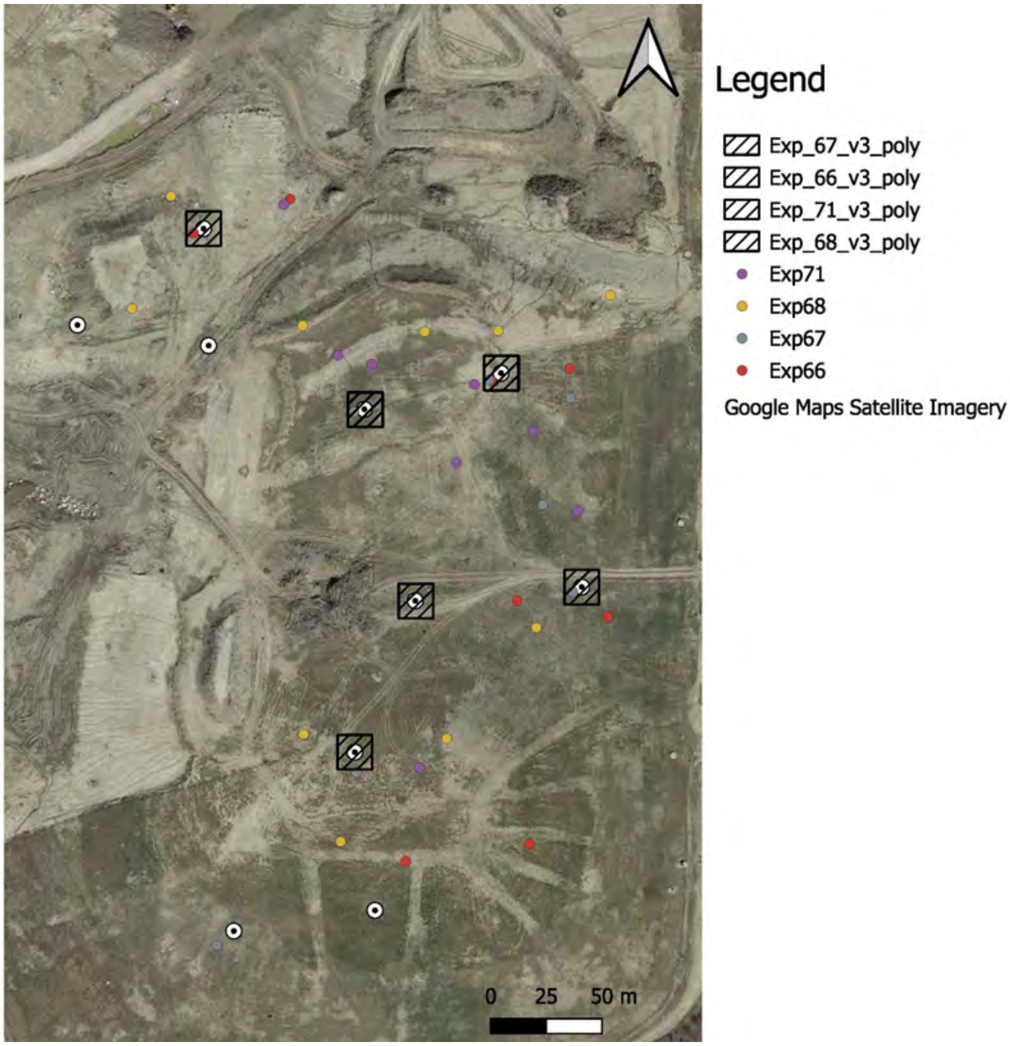


Figure C-4: Vendor M localization assessment map

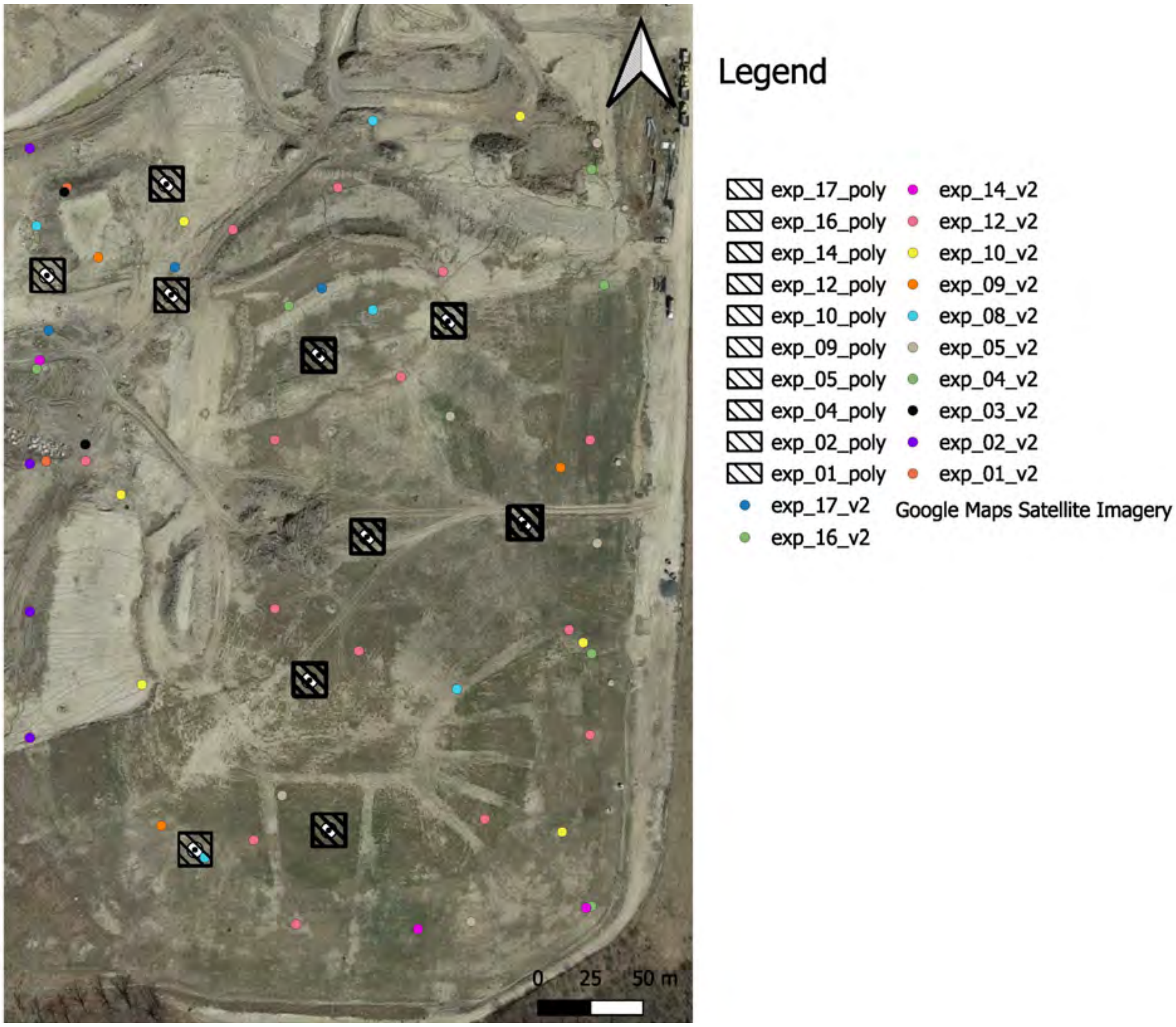


Figure C-5: Vendor N localization assessment map

D: Methodology properties

Table D-1: Methodology summary table

Technology Identifier	Method	R&D ?	Cost Estimates [USD]	Limitations	Vendor Reported minimum detection limit
A	MGPA	No	$5,000 /day	Can operate in most weather conditions. Ideal weather conditions for methane measurement around a landfill include stable and moderate wind speeds, consistent temperatures, absence of precipitation, and stable barometric pressure.	5 kg/hr
B	MGPA	No	$5,000 /day	Can operate in most weather conditions. Ideal weather conditions for methane measurement around a landfill include stable and moderate wind speeds, consistent temperatures, absence of precipitation, and stable barometric pressure.	5 kg/hr
C	UPSEA	No	$5,000-8,000 /day	Any precipitation, humidity exceeding 95%, temperature below 5 degrees Celsius or above 40 degrees Celsius and windspeed exceeding 12 m/s prevent measurements from taking place.	0.02 kg/hr
D	UPSEA	No	$5,000-8,000 /day	Any precipitation and/or windspeed exceeding 18 m/s prevents measurements from taking place.	1 ppb/s
E	MTCEA	No	$5,000 /day	Lightning and heavy rain prevent measurements from taking place.	5 kg/hr
F	APSEA	No	14,000 /day	Very stable atmospheric conditions, high winds or rapidly varying wind directions are not suitable for this method. Precipitation, extreme turbulence and conditions that does not allow visual flight to be observed	3-5 kg/hr

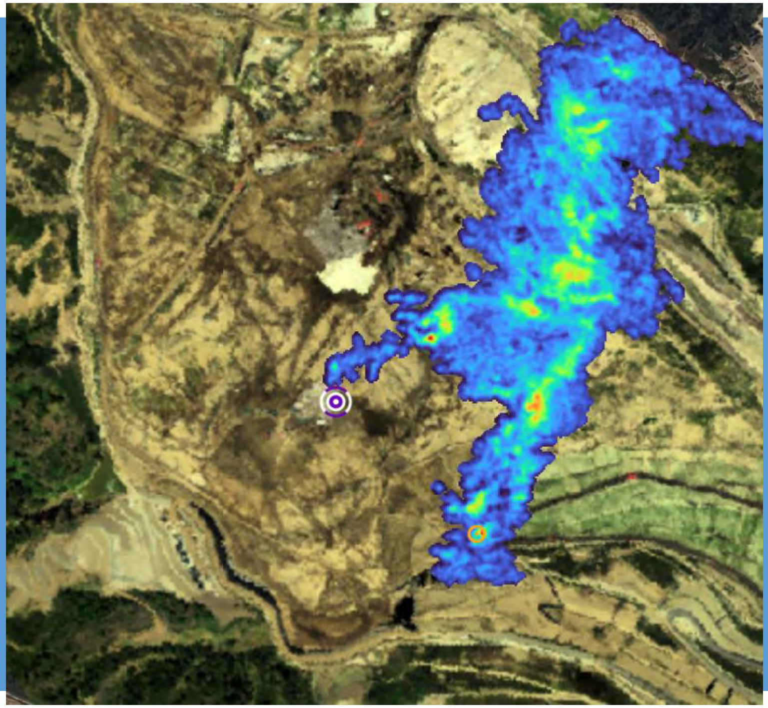
				prevent measurements from taking place.	
G	LiDAR	No	$14,000 /day	Conditions that do not allow visual flight rules to be observed and/or 10 m windspeed below 2 m/s or exceeding 9 m/s prevents measurements from taking place.	0.5 kg/hr
H	SISEA	No	$3,000-6,500 / package	Cloud cover over the site or wind speed exceeding 10 m/s.	100 kg/hr
I	RPSEA	Yes	$7,000-30,000 / year	Requires clear weather conditions to take measurements.	Not available
J	RPSEA	Yes	$7,000-30,000 / year	Below - 40 degrees Celsius	100 ppm at 100 meters
K	RPSEA	Yes	$7,000-30,000 / year	Below - 40 degrees Celsius	1 kg/hr
L	UCSEA	No	$5,000-8,000 /day	Precipitation, snow on ground, wind speed exceeding 6 m/s and visibility below 5 km prevent measurements from taking place.	1 ppm
M	UCSEA	No	$5,000-8,000 /day	Precipitation and windspeed exceeding 7 m/s prevent measurements from taking place.	1 ppm
N	LEA	Yes	$5,000 /day	Can operate in most weather conditions. Ideal weather conditions for methane measurement around a landfill include stable and moderate wind speeds, consistent temperatures, absence of precipitation, and stable barometric pressure.	5 kg/hr

EXHIBIT 3

Air, Climate, and Energy Research Webinar Series

Hosted by EPA's Office of Research and Development

Schedule & Recordings: https://www.epa.gov/air-research/air-climate-energy-research-webinar-series



March 19, 2024 from 3:00 to 4:00 p.m. ET

Airborne Survey – Methane from U.S. Landfills

Webinar Slides: Shared through email from EPA-Webinar-ACE@icf.com.

To Ask a Question: Select **Q&A** at the bottom of the screen. Type your question in the compose box, and then select **send.** *You have the option to submit questions anonymously.*

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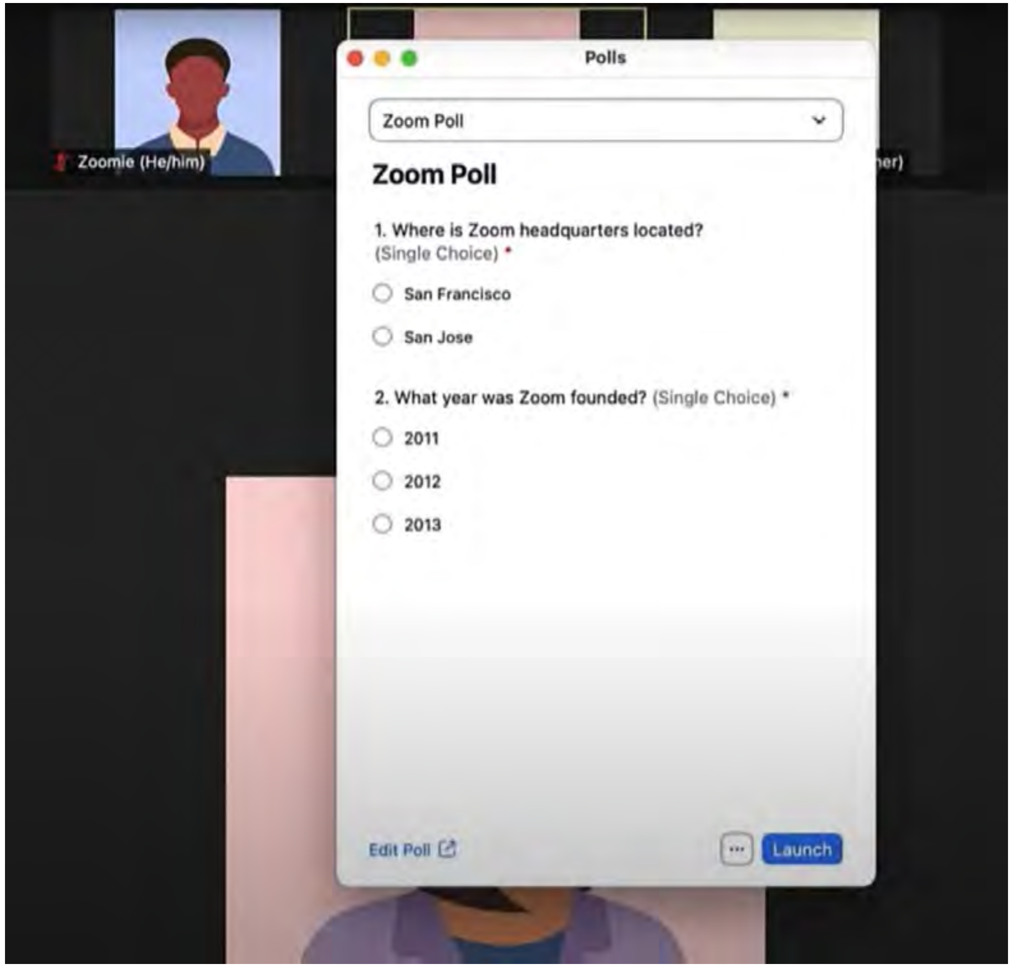

To ask a Question:

1. Select **Q&A** at the bottom of the screen.
2. Type your question in the compose box, and then select **send.** *You have the option to submit questions anonymously.*

For IT Questions:

1. Email EPA-Webinar-ACE@icf.com

EPA

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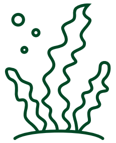


HABS, Hypoxia, and Nutrients Research

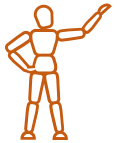
November 20: *Health Effects and Ecology of Anatoxin-Producing Cyanobacteria*

Registration and Additional Information

Small Drinking Water Systems

December 3: *Lead Reduction Updates and Lead Service Line Identification (LSLID) and Replacement*

Registration and Additional Information



Tools and Resources Training

December 5: *ECOTOX Knowledgebase and PFAS Updates*

Registration and Additional Information

Healthy and Resilient Communities Research

December 10: *Allostatic Load and Epigenetic Age Acceleration as Measures of Cumulative Health Impacts*

Registration and Additional Information

Emergency Response Research

December 11: *Regional Research Partnerships to Address High Priority, Near-Term Research Needs: Splash Pads & COTS Flight Simulator to Support Aerial Recon Training*

Registration and Additional Information

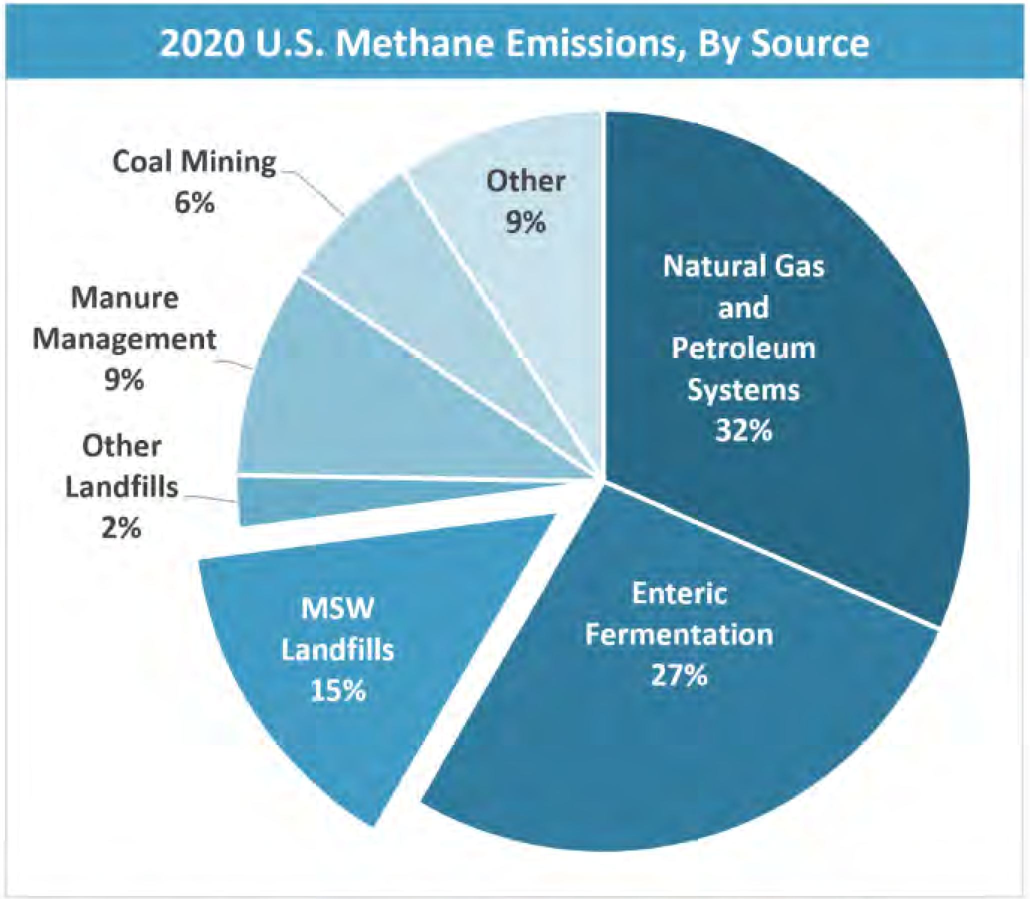
Airborne Survey - Use of Next Generation Emission Measurement (NGEM) Technology to Detect and Measure Landfill Methane Emissions

Susan Thorneloe, Senior Chemical Engineer

Disclaimer: This presentation has been subjected to review by the EPA ORD and approved for publication. Approval does not signify that the contents reflect the views of the Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

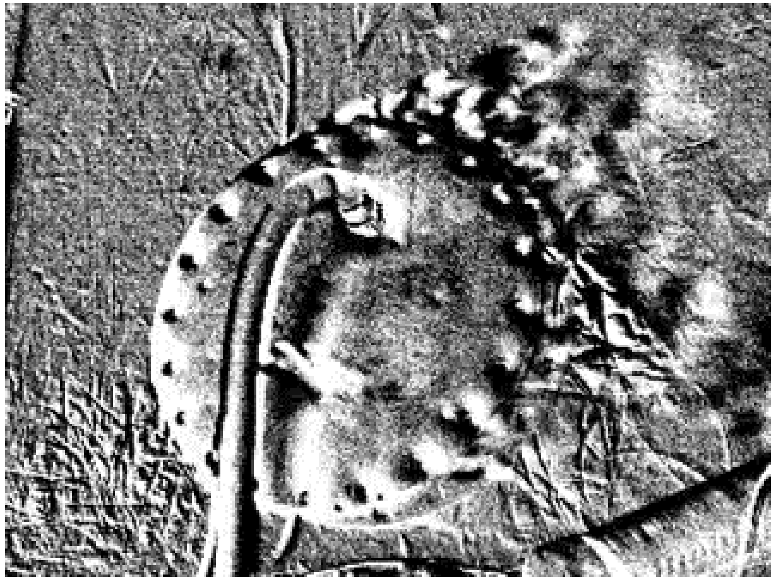
Characterization of Landfill Gas (LFG) and Pollutants

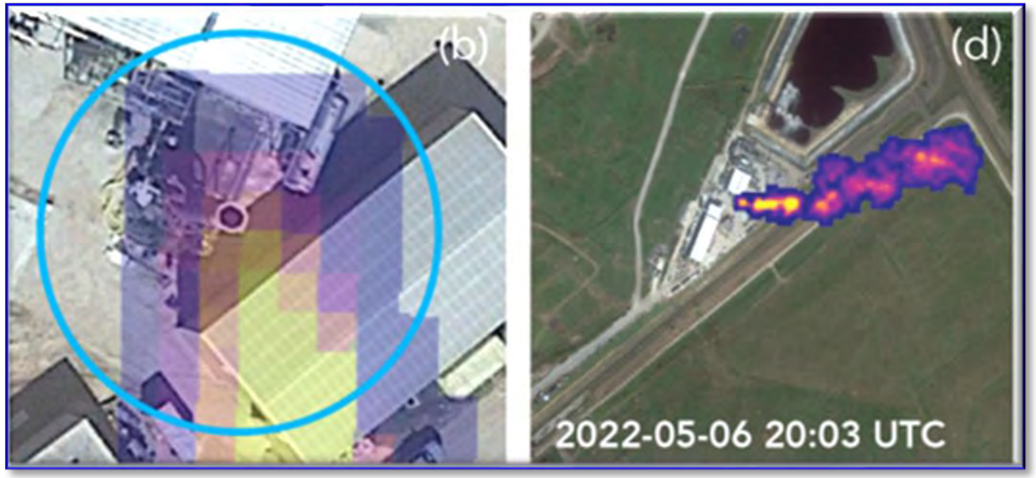
- LFG is roughly 50% methane – potent GHG
- Methane is also flammable and explosive
- VOCs contribute to air quality issues and ozone nonattainment
- HAPs and sulfur emissions affect local health & quality of life



Note: All emission estimates from the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2020.

Examples of **fugitive sources** (can occur on any part of the landfill)





Different fugitive sources not captured through gas capture and control (GCCS)

Cover Integrity Issues

Ground-Based Optical Remote Sensing

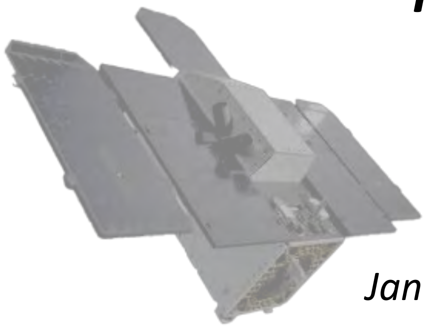
- EPA-ORD research helped drive some of the technology changes that we are now seeing
- In the past, site access was required – that is no longer needed thanks to use of satellites, aircraft, and drones

Next Generation Emission Measurement (NGEM) Technology Options for detecting and quantifying landfill methane are growing at an amazing pace

Emerging Satellite Forms

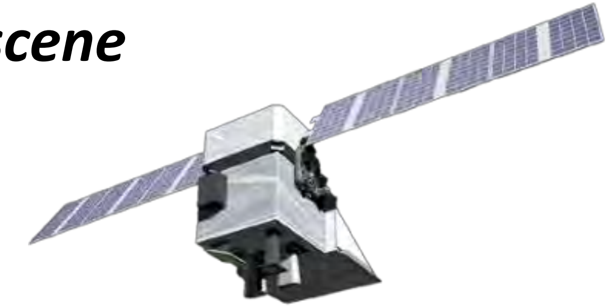
New on the scene

GHGSat



Jan 21, 2024

Carbon Mapper



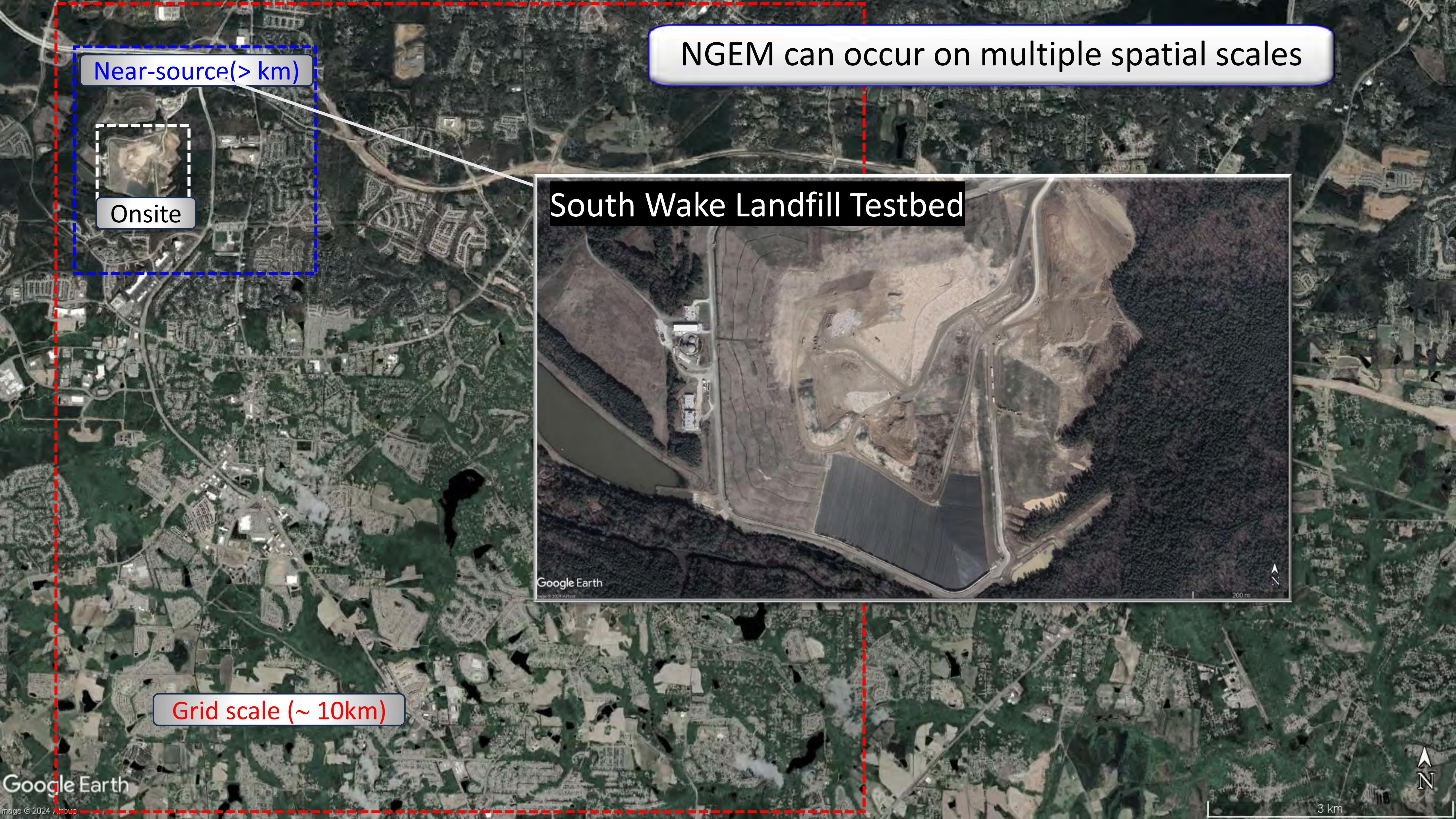
Jan 29, 2024

MethaneSAT

↓

ORD's first look satellite landfill measurements was part of a 2023 NASA evaluation of GHGSat which generated 97 observations of 13 U.S. Landfills. Publications are in process looking at these data in a variety of ways (Max Krause lead).

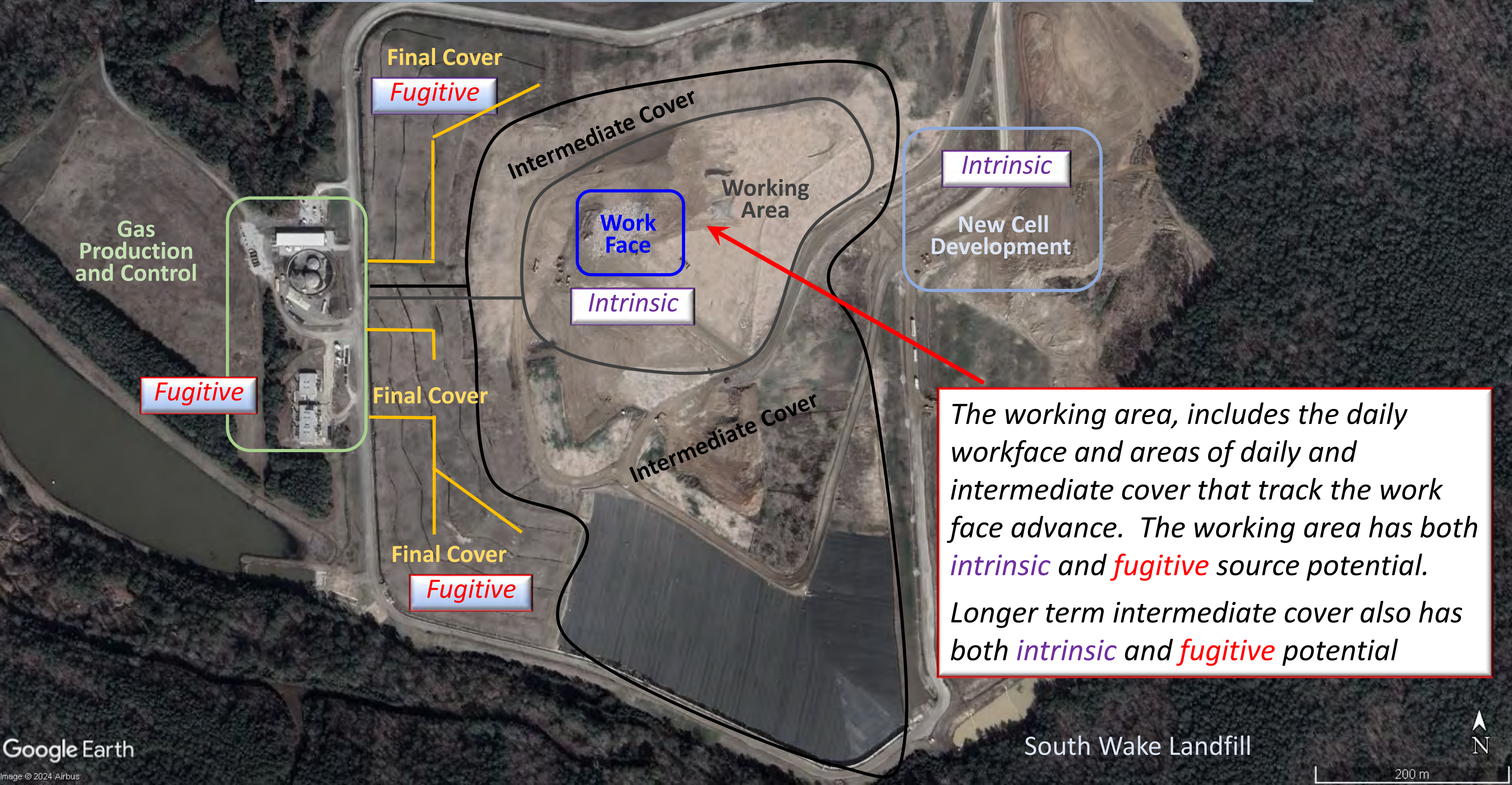
"NASA Commercial Smallsat Data Acquisition (CSDA) Evaluation of GHGSat to Measure Landfill Methane Emissions", Krause M.J., Thoma. E.D., Thorneloe, S., Valin, L., Szykman, J., NASA Report, (*in review*).


NGEM can occur on multiple spatial scales
Near-source(> km)
Onsite
South Wake Landfill Testbed
Grid scale (~ 10km)
Google Earth
Google Earth
3 km
N

Landfill Methane - Source Types

- Landfills have both intrinsic (or expected) emissions and fugitive sources
- Intrinsic emissions are partially controlled but can’t be eliminated and include:
  - Work face
  - Intact cover
  - Maintenance activity
- Fugitive sources include:
  - Cover system failure (surface leaks)
  - Gas extraction system issues (various types)
  - Infrastructure leaks, flare issues, or venting due to malfunction state
- Using NGEM to understand and reduce fugitive emissions is a near-term ORD priority
- Improved understanding and control of intrinsic sources is critical but is longer-term

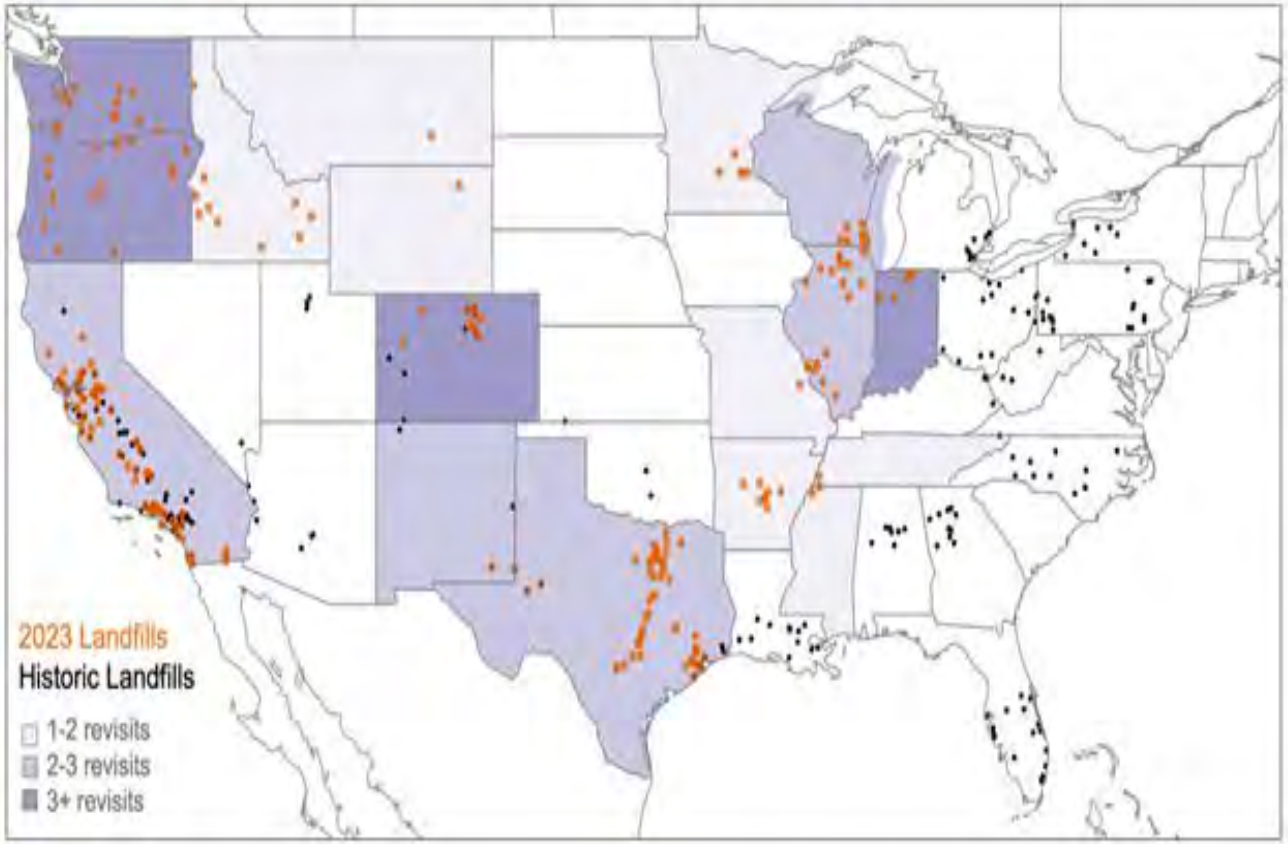
What source type dominates on different areas of landfill facility?



The working area, includes the daily workface and areas of daily and intermediate cover that track the work face advance. The working area has both intrinsic and fugitive source potential.

Longer term intermediate cover also has both intrinsic and fugitive potential

Multi-year surveys using aircraft have produced datasets on landfill methane emissions helping to detect large leaks and quantify methane: Carbon Mapper/NASA-JPL landfill flights from 2016 - 2024



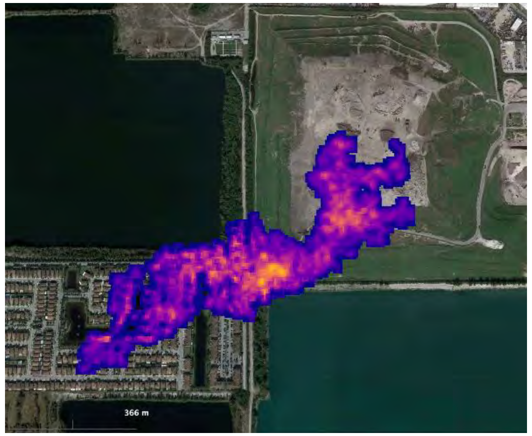
Quantifying methane emissions from United States landfills", Cusworth et al. 2023https://www.science.org/doi/10.1126/science.adi7735

Findings:

- Detection rate for "large" landfills is high: 50% of landfills had large point-source detections (compare to oil & gas where only 0.5-1% detected)
    - Emission persistence is high: 60% persistence even after 8+ flights (oil & gas ~20%)
- Correlation to the EPA Greenhouse Gas Reporting Program (GHGRP) is low. Half of sites are above GHGRP, half below. Emissions from airborne craft about 2.4 times higher than GHGRP (findings in Science publication)

High emission methane point sources observed in many regions outside California

Florida



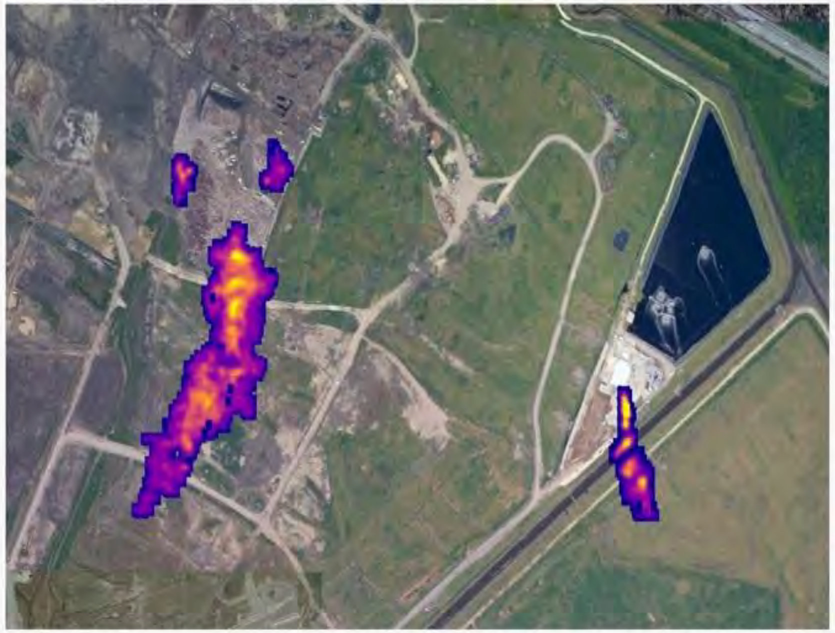
Georgia

Alabama

Louisiana

Amid reports of "super emitters," experts say getting the emissions numbers right is essential to curbing a potent climate pollutant.

By James Bruggers and Phil McKenna (Inside Climate News), Amy Green (WMFE) and Robert Benincasa (NPR)
July 13, 2021



Remote sensing of methane from high altitude aircraft reveals plumes of the gas coming from the open face, on the left, and from a vent, on the right, at the River Birch landfill outside New Orleans in April 2021. Researchers from the University of Arizona, Arizona State University, NASA's Jet Propulsion Laboratory, and Carbon Mapper calculate the rate of methane venting at approximately 2,000 kilograms per hour, which would be 48 metric tons per day. Credit: University of Arizona, Arizona State University, NASA JPL and Carbon Mapper.

Many similar examples in CA, CO, NV, LA, MI, OH, PA

Independent Validation of the remote sensing methods from NASA-JPL and Scientific Aviation

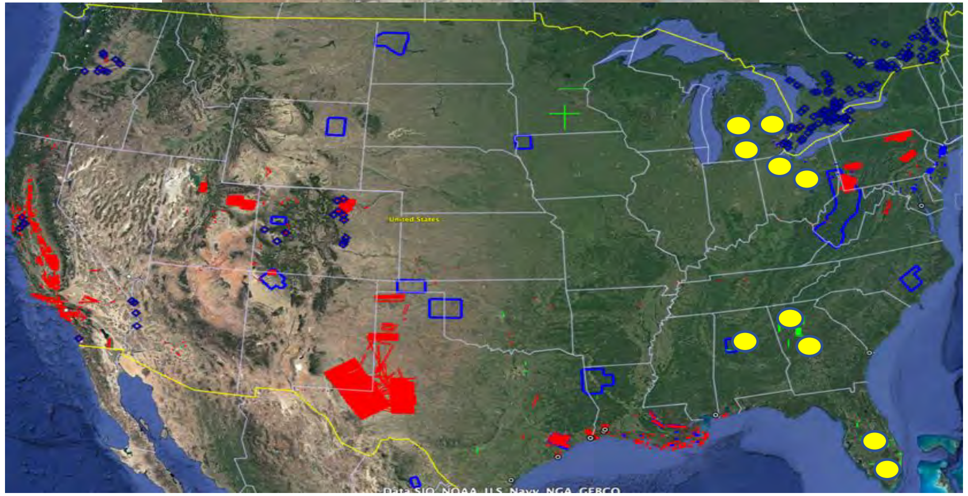
(1) NASA-JPL researchers surveyed California landfills using a high-altitude remote sensing (aircraft). Additional observations by CM efficiently measured high-emission point sources at hundreds of landfills over large regions.

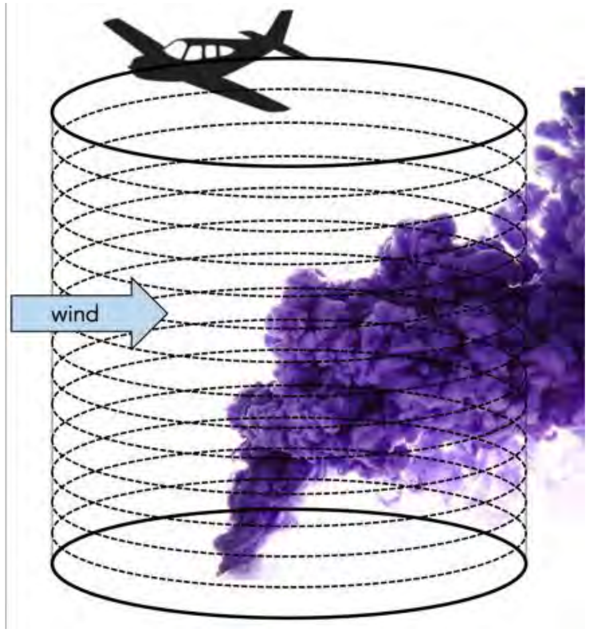
(2) Scientific Aviation (SA) was deployed to provide independent validation of the NASA-JPL/Carbon Mapper measurements using low altitude in-situ sensing aircraft that captures "total" emissions (diffuse and point sources)

Carbon Mapper has also participated in blinded controlled release experiments (Stanford)

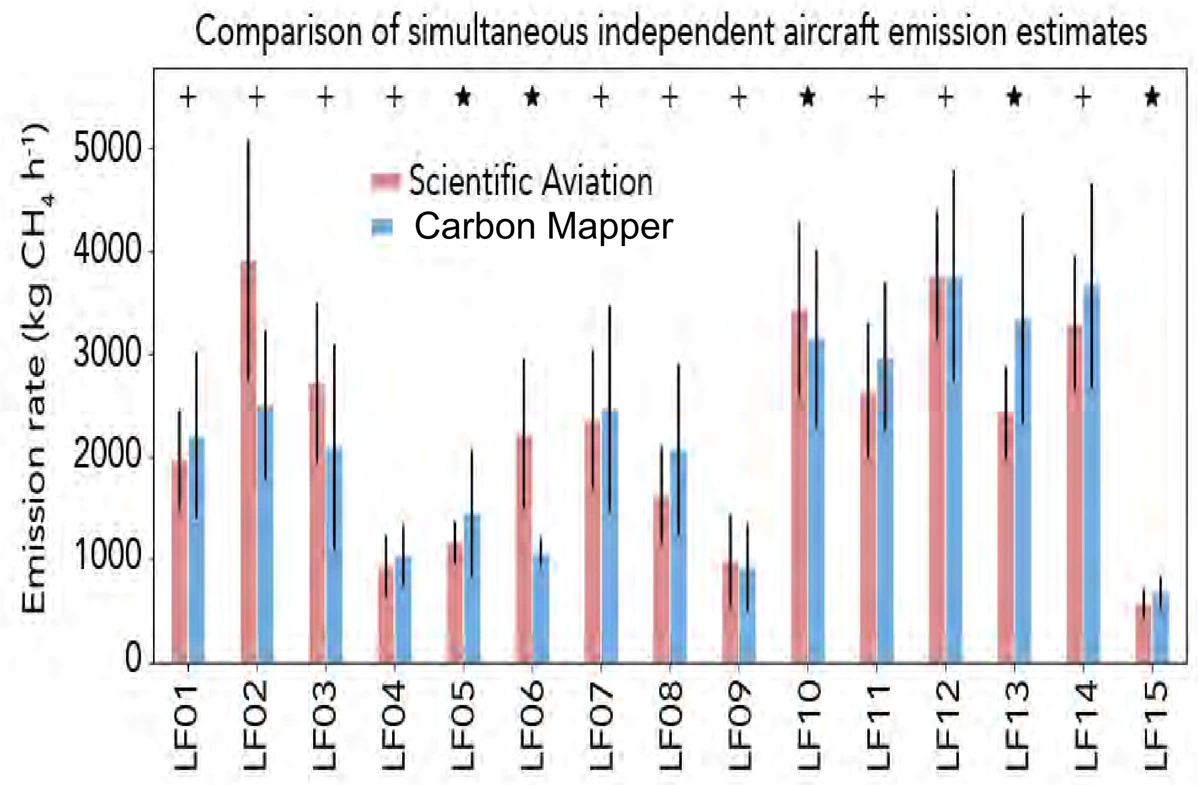
Yellow dots: coordinated validation surveys with both aircraft

Red/blue/green lines: broader regional remote sensing surveys





Results from comparison of simultaneous Carbon Mapper and Scientific Aviation Measurements

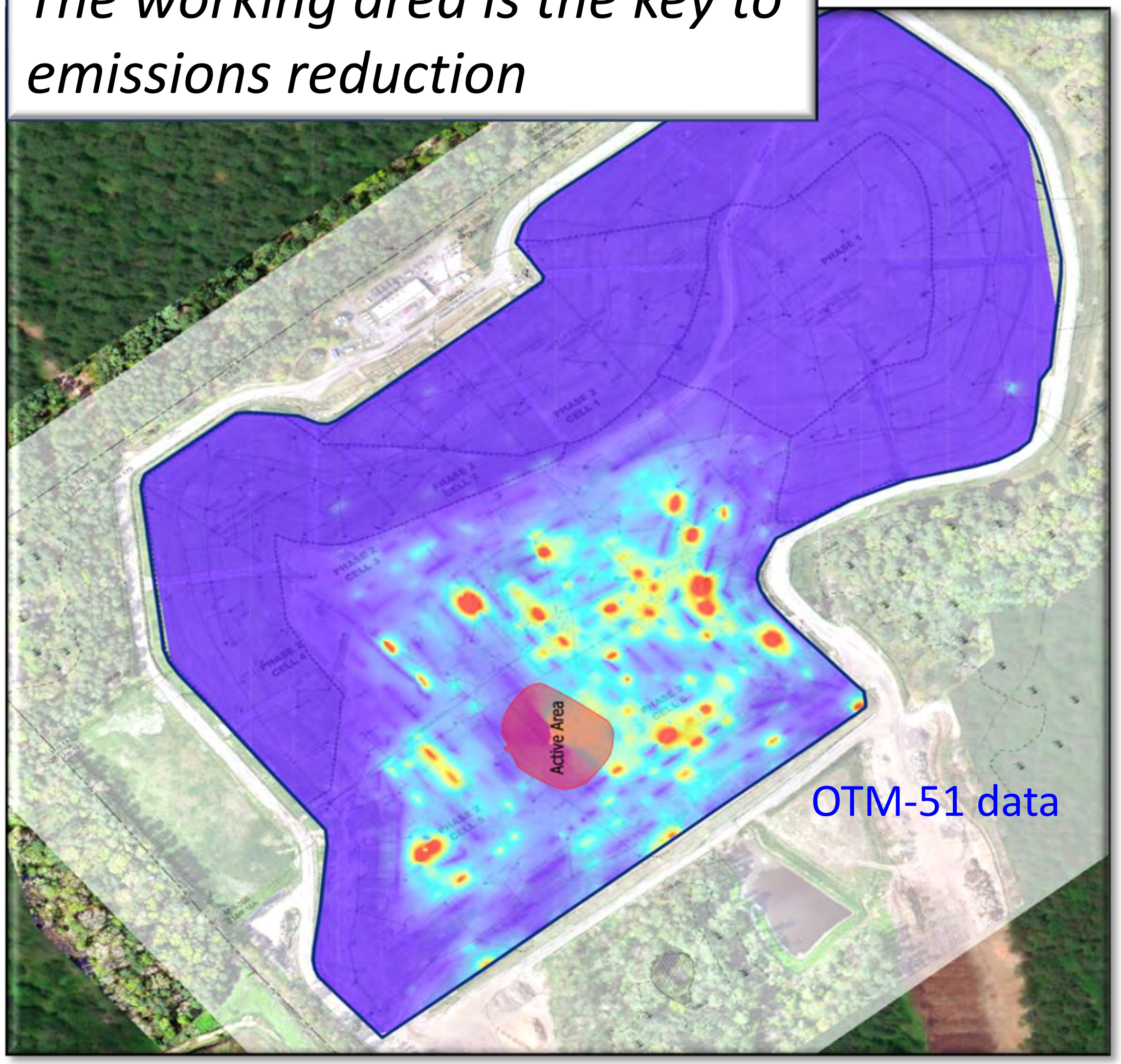


- Airborne hyperspectral imagery (Carbon Mapper) detects discrete point-like sources and general CH_4 enhancements to some degree
- Airborne flux surface (Draft OTM-58A, Champion X/ Sci. Aviation) is a whole facility measurement approach
- Currently, point-like sources appear to represent a significant fraction of whole facility emissions

Quantifying methane emissions from United States landfills", Cusworth et al. 2023https://www.science.org/doi/10.1126/science.adi7735

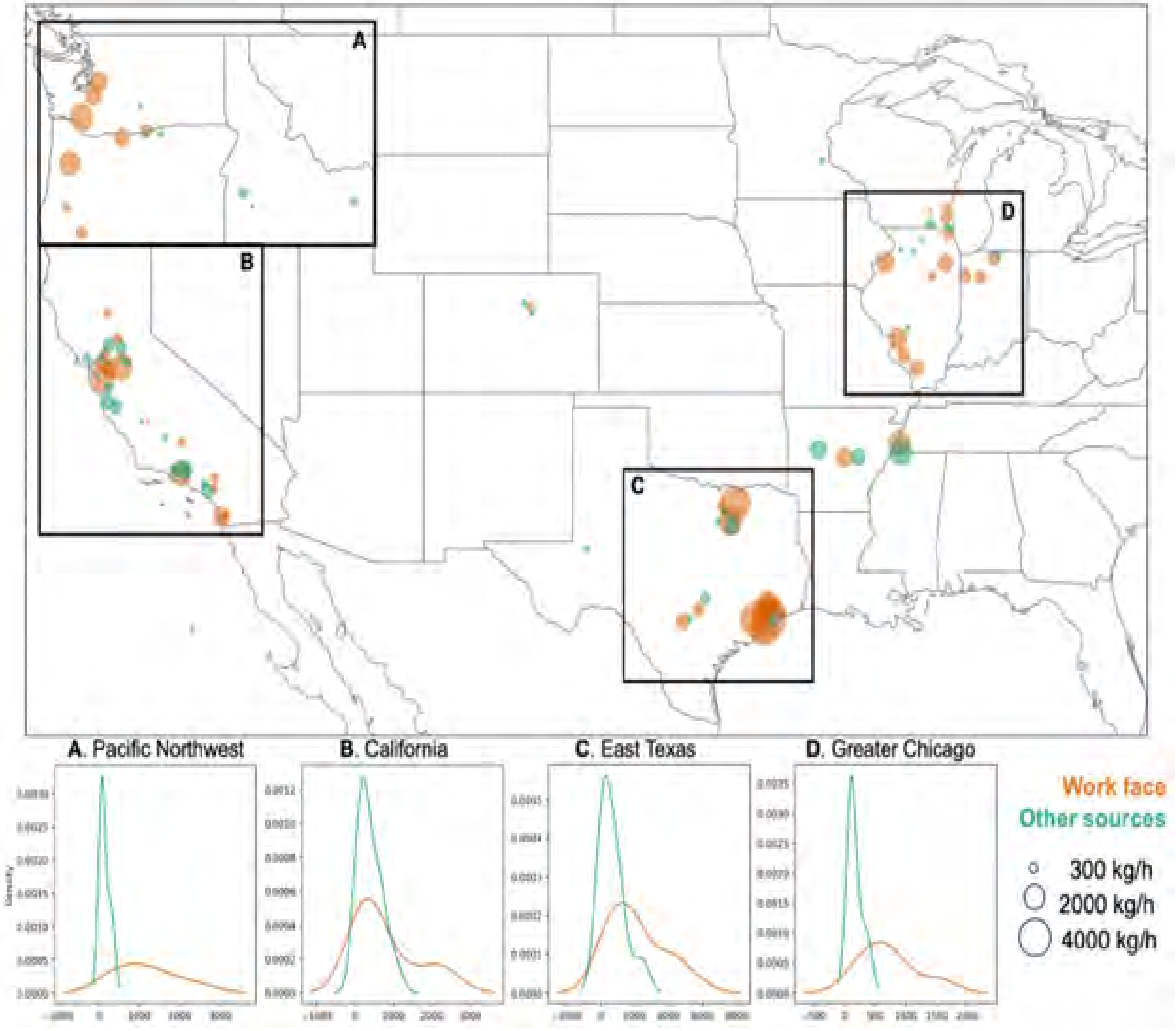
Working Face Emissions

The working area is the key to emissions reduction



***"Understanding and Reducing Fugitive Landfill Emissions Using Combined Well Performance and Methane Air Monitoring"*, AWMA Measurements Meeting Sims et al., 2023**

Measurements from Aircraft

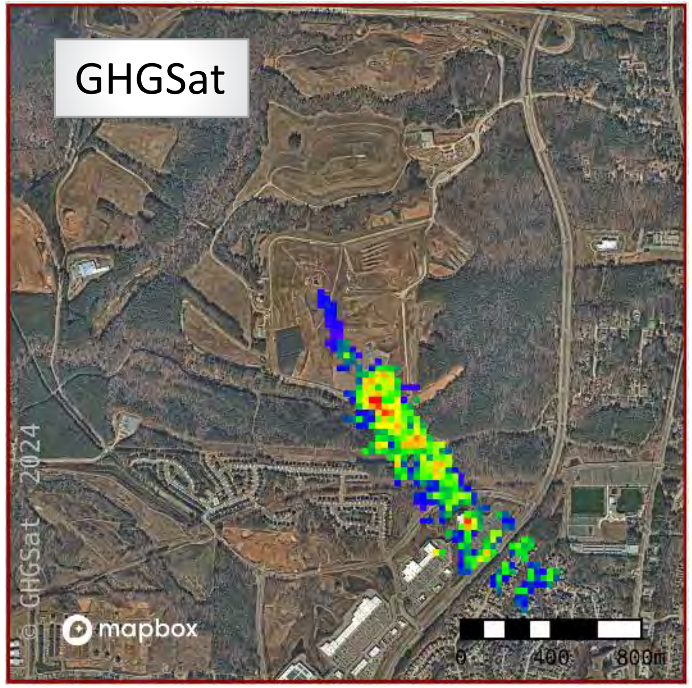


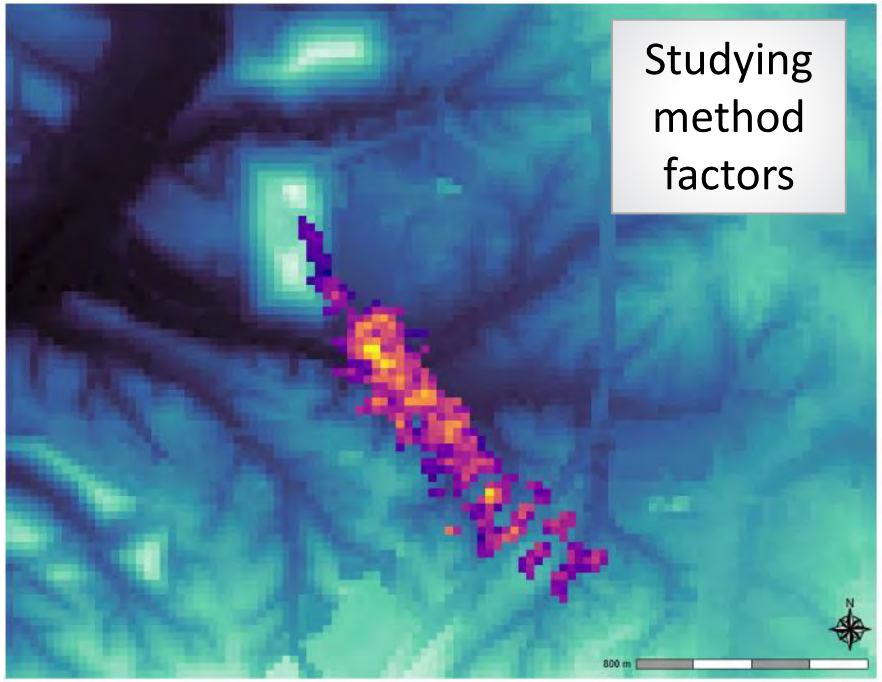
- Focus of 2nd manuscript (through partnership between EPA, Carbon Mapper, and NASA) is to investigate aircraft remote sensing data to attribute work face emissions to total fugitive landfill methane. Anticipate publication in ES&T in near future.
- Have conducted additional aircraft measurements at 14 landfills in NC, SC, and GA. Emission measurements occurred fall 2025 to further investigate landfill methane leaks and quantification.
- Time resolved GCCS data are needed along with landfill design and operating conditions that affect fugitive loss. Also need data on meteorological conditions including barometric pressure. Focus is to determine total fugitive loss versus amount of gas collected through GCCS.

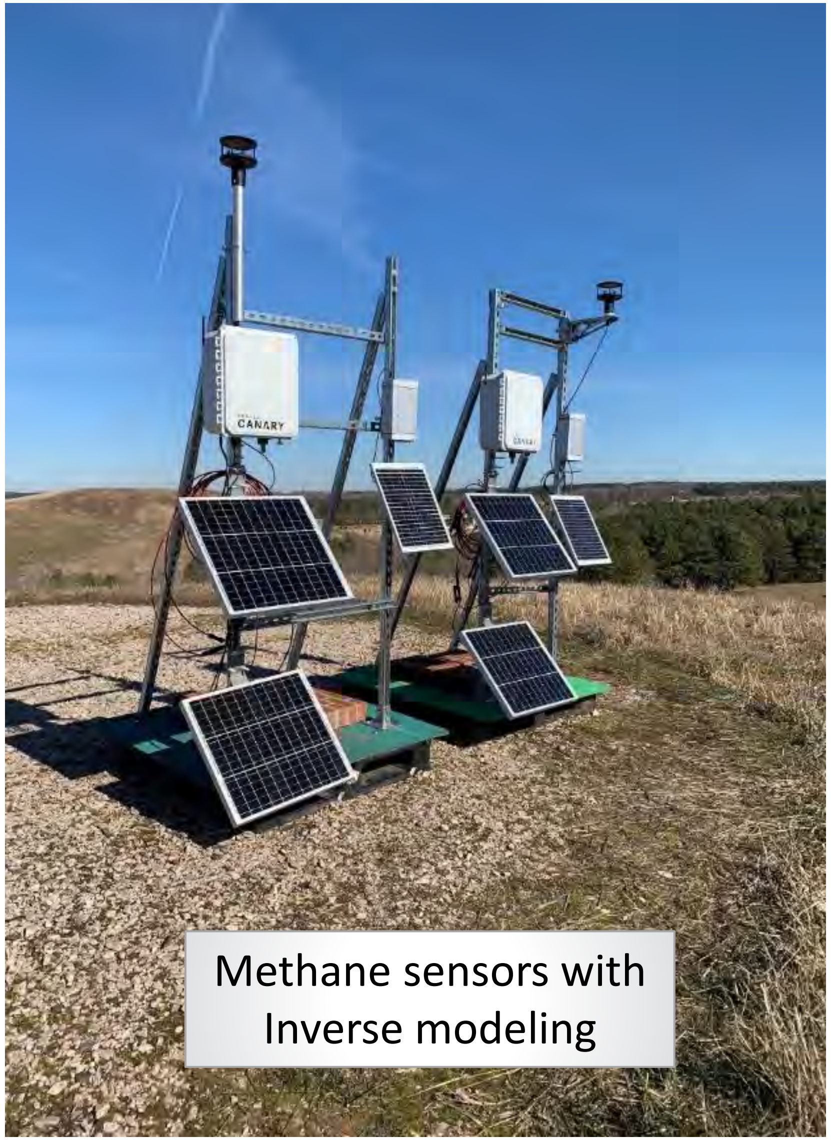
"Investigating Major Sources of Methane Emissions at US Landfills", Scarpelli et al, ES&T, accepted, in press).

Next publication will use data from fall 2024 measurements on landfills in NC, SC, and GA to further explore work face emissions.

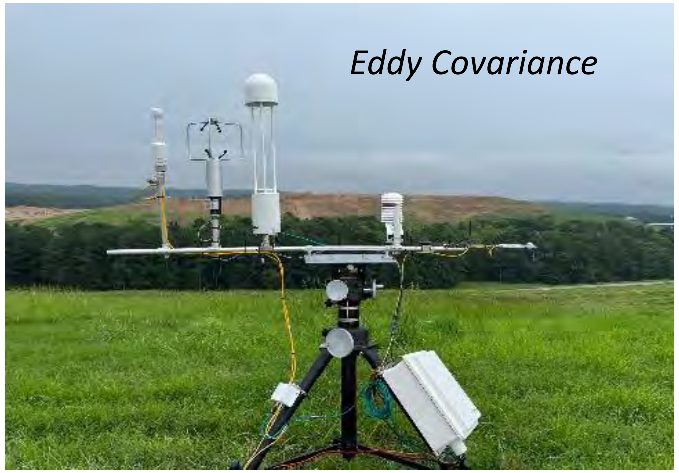
Multi-tier Method Comparisons at EPA South Wake Landfill Testbed







- 21 GHGSat observations to date
- 6 multi-unit sensor stations installed
- 8 wind measurement positions
- Future advanced wind field and Solar column methane measurements supported by parametrized CFD flow field modeling



Methane Point Sensor Trials at EPA ORD Test Range

- Cross platform reference comparisons with simulated methane plumes *(fixed placed sensors and UAV forms)*
- Conclusion: Methane sensors have come a long way in recent years. The hardware is there.

"An evaluation of commercial methane sensors using controlled release testing", Champion, W.M, et al (in preparation)

Commercial methane sensor testing at EPA RTP
August 2023 – January 2024

Handheld Methane Tunable Diode Lasers (TDLs)

ORD refers to this as manual column sensor emission assessment (MCSEA)

More established models

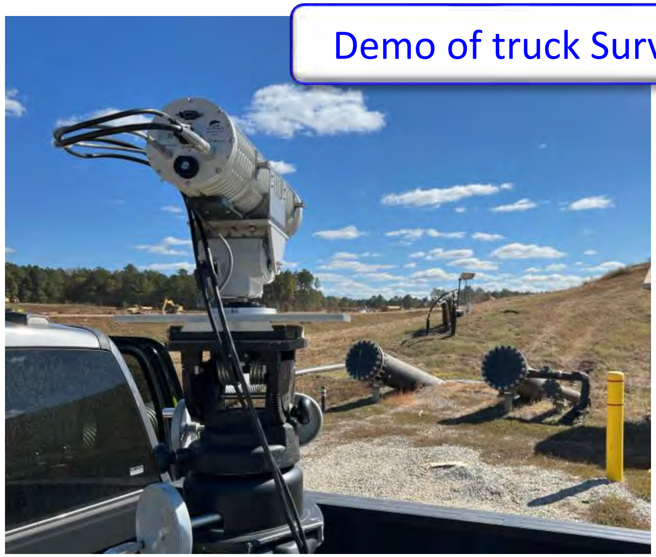
- Handheld TDLs are column sensors and variations of this tech are used on UAVs (downward looking laser)
- Handheld TDLs are mature and proven (for other applications) and have clear value for landfill fugitive emission assessment
- Collaborative near-term method development is needed

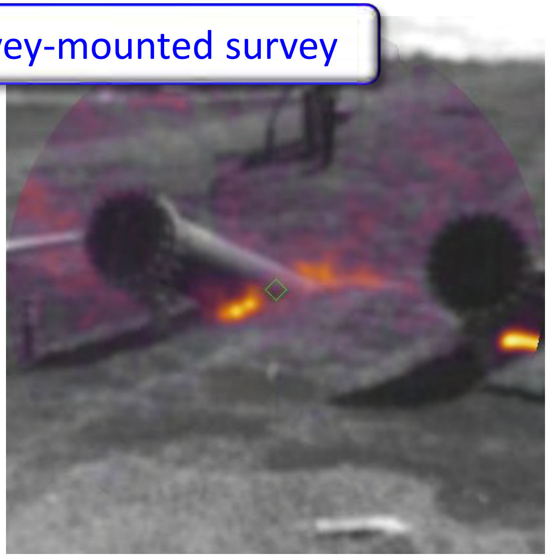
There are many sensors in this class.

What performance is needed?

Emerging Column Sensor Forms (e.g., QLM LiDAR)

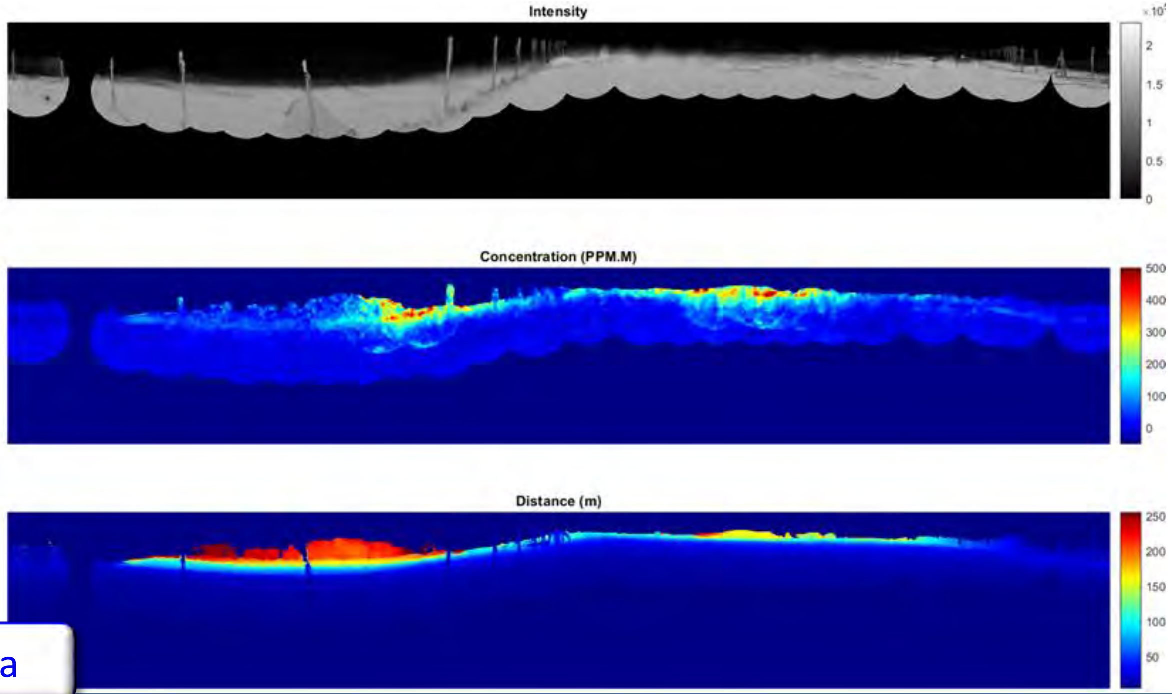
Demo of truck Survey-mounted survey





Demo of continuous scanning of large area

- A “step up” from TDLs but not as sensitive
- Companies like QLM and Bridger Photonics
- Deployed from trucks or aircraft (UAVs one day)
- Can provide 24-hr scanning for diurnal studies
- These data are from QLM pilot on 10/17/24
- Can quantify (with proper wind field data)



Added Value of Any UAV-based Approach

UAV surveys can produce valuable metadata that can be used by the operators to reduce emissions. Here are examples of aerial imagery showing problematic cover conditions.

Adapted from 2024 Sniffer Services and Solutions 20240809.pptx (with permission)

Time-resolved GCCS data (three types)

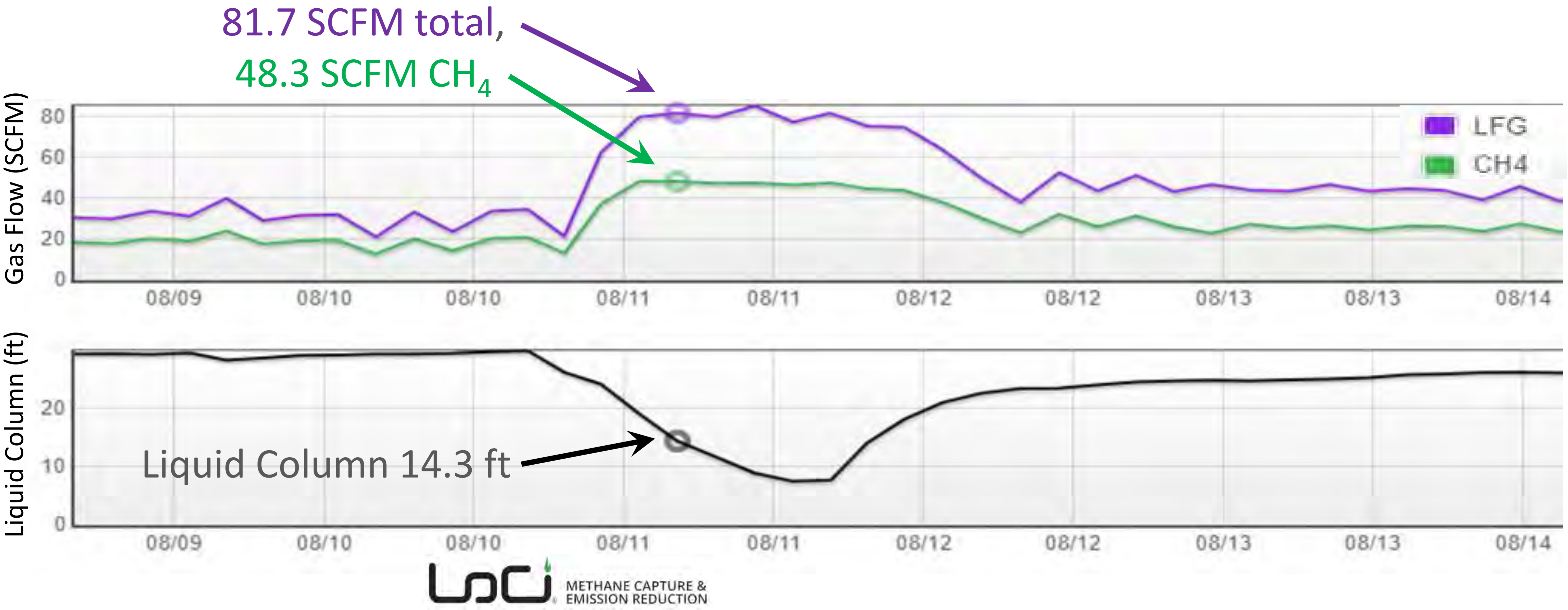
Aggregate - one location
(at flare)

Partitioned - few locations
(on header pipes)

Each well - many locations
(auto well-tuning)

Individual well data can add value

Improvement in gas collection during flooded well pump out



Environmental Research & Education Foundation (EREF), Summit on Quantification of Landfill Emissions, October 24- 25, 2023, Chicago IL, https://cfpub.epa.gov/si/, Record ID: 359503.

EPA Landfill STAR Awardees

University of Wisconsin, Jamie Schauer (Lead)

Analysis of Continuous Monitoring Data with Inverse Atmospheric Models to Improve Landfill Gas Emissions Data and Elucidate Drivers of Emissions

Five STAR Awards
4 regular, 1 early career
Total funding of $4,592,430

University of Delaware, Paul Imhoff (Coms Lead)

Evaluation and Control of Emissions from Municipal Solid Waste (MSW) Landfills: Direct Measurement and Modeling

Colorado University – Boulder, Mike Hannigan (Lead)

Integrating Measurements Across Platforms to Feasibly Assess Emissions and Mitigation of Methane and VOCs from Landfills

University of California - Berkeley, Dimitrios Zekkos (Lead)

Next-generation landfill monitoring: a multi-scale approach to measuring emissions for evaluating and financing interventions

Miami University, Jiayu Li (Early Career)

Integrating Multi-source Data for Landfill Methane Emission Quantification

For additional information on EPA STAR, please contact Serena Chung <chung.serena@epa.gov>

Next Steps

- Will be working with EPA colleagues, industry, NGOs, academia and others to evaluate what next generation measurement (NGEM) technologies work best for landfill leak detection and quantification of methane (mass emission rate).
- A multi-tier NGEM approach is likely with collection and evaluation of performance data where technology is deployed at landfills
- NGEM advancements from oil and gas applications have accelerated the pace of NGEM technology for landfill applications - However, we recognize unique characteristics and variability across landfills that make leak detection and quantification of methane more difficult.
- STAR efforts will provide landfill specific data for 9 landfills evaluating different NGEM technologies
- We thank Carbon Mapper, CARB, ECCC, EDF, EREF, NASA, industry, and others helping to advance detection of landfill leaks and methane quantification technologies that are resulting in near term carbon reduction at US landfills.

Exhibit 3

National Waste & Recycling Association[SM]
Collect. Recycle. Innovate.

June 24, 2024

Via Electronic Mail and Hand Delivery

The Honorable Michael S. Regan
Administrator
U.S. Environmental Protection Agency
Office of the Administrator
1200 Pennsylvania Avenue NW
Washington, D.C. 20460
Regan.Michael@epa.gov

Gautam Srinivasan
Associate General Counsel
U.S. Environmental Protection Agency
Air and Radiation Law Office
1200 Pennsylvania Avenue NW
Washington, D.C. 20460
Srinivasan.gautam@epa.gov

Re: **Petition for Reconsideration: Greenhouse Gas Reporting Program Subpart HH, Municipal Solid Waste Landfills**

Dear Administrator Regan and Associate General Counsel Srinivasan:

Enclosed please find attached a Petition for Reconsideration submitted by the National Waste & Recycling Association (NWRA) with respect to the rule entitled *Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule*, 89 Fed. Reg. 31802 (April 25, 2024), docket No. EPA-HQ-OAR-2019-0424. NWRA's Petition for Reconsideration is limited to Subpart HH of the Greenhouse Gas Reporting Rule, which is applicable to Municipal Solid Waste Landfills, and EPA's determination therein to reduce default landfill gas collection efficiency values for reporters under the rule.

NWRA appreciates EPA's consideration of this Petition and hopes to work cooperatively with EPA toward improvements in the accuracy of landfill sector emissions reporting. Please feel free to contact the undersigned at agermain@wasterecycling.org, or outside counsel for NWRA, Carol McCabe at cmccabe@mankogold.com or Matt Morrison at matthew.morrison@pillsburylaw.com, with any questions you may have.

Respectfully submitted,

Anne Germain
Chief Operating Officer and Senior Vice President
of Technical and Regulatory Affairs
National Waste & Recycling Association

Enclosure

cc: Jennifer Bohman, EPA Office of Atmospheric Programs (via electronic mail)
Julius Banks, EPA Greenhouse Gas Reporting Branch (via hand delivery)
Carol F. McCabe, Manko, Gold, Katcher & Fox (via electronic mail)
Kelly A. Hanna, Manko, Gold, Katcher & Fox (via electronic mail)
Matthew W. Morrison, Pillsbury, Winthrop, Shaw, Pittman (via electronic mail)
Steve R. Brenner, Pillsbury, Winthrop, Shaw, Pittman (via electronic mail)

The National Waste & Recycling Association's
Petition for Reconsideration of The Final Rule:
Revisions and Confidentiality Determinations for Data Elements
***Under the Greenhouse Gas Reporting Rule*,**
89 Fed. Reg. 31802 (April 25, 2024)
Docket No. EPA-HQ-OAR-2019-0424

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PETITION FOR RECONSIDERATION TO THE U.S. ENVIRONMENTAL PROTECTION AGENCY

I. <u>Introduction</u>

On April 25, 2024, the United States Environmental Protection Agency ("EPA") finalized updates to the Greenhouse Gas Reporting Program rules ("GHGRP"), codified under Title 40, part 98 of the Code of Federal Regulations and effective January 1, 2025 ("Final Rule").[1] The Final Rule is a culmination of two Notices of Proposed Rulemakings: the Data Quality Improvement Proposal and the 2023 Supplemental Proposal.[2] In finalizing the respective changes across part 98, EPA articulated its two overarching goals: (1) improving the quality of data collected from municipal solid waste ("MSW") landfills; and (2) strengthening applicable reporting requirements. The Final Rule includes updates to subpart HH of the GHGRP, applicable to MSW landfills, including unanticipated changes to methane emissions calculation methodologies that form the subject of this Petition for Reconsideration.

Specifically, in the Final Rule, EPA unexpectedly reduced the collection efficiency values contained in Table HH-3 and applied in equations HH-7 and HH-8 to calculate methane emissions from MSW landfills subject to the GHGRP ("Reporters").[3] As proposed in the 2023 Supplement, the lowered collection efficiencies would have applied only to "non-regulated" Reporters who are not required to and opt not to conduct surface methane emissions monitoring ("SEM") under applicable federal rules. EPA proposed to retain the same, higher collection efficiencies applicable to "regulated" landfills that are required to, or opt to, conduct SEM.

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[1] *Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule*, 89 Fed. Reg. 31802 (April 25, 2024) ("Final Rule").
[2] *Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule*, 87 Fed. Reg. 36920 (June 21, 2022) ("Data Quality Improvements Proposal"); *Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule*, 88 Fed. Reg. 32852 (May 22, 2023) ("2023 Supplemental Proposal").
[3] 2023 Supplemental Proposal, 88 Fed. Reg. 32861.

Relatedly, EPA proposed to impose a new "correction term" within equations HH-6, HH-7, and HH-8 for landfills conducting SEM to adjust emissions values based on the number of locations with concentration above 500 parts per million above background identified during surface measurement periods. Taken together, EPA's proposal expressly coupled collection efficiency adjustments with SEM practices. In its Final Rule, however, EPA took an impermissible and unanticipated U-turn, decoupling collection efficiency from SEM and site-specific performance measures and imposing significantly reduced collection efficiencies across all Reporters, without adequate prelude or justification. Moreover, by requiring Reporters to apply a reduced collection efficiency irrespective of whether they are conducting SEM, EPA is effectively requiring the majority of Reporters to overstate their greenhouse gas emissions. These changes do nothing to achieve EPA's two stated goals of improving data quality and strengthening reporting requirements.

The Petitioner is the National Waste & Recycling Association ("NWRA" or "the Petitioner"). NWRA is the leading voice of the North American waste and recycling industry on advocacy, education, and safety. The industry provides essential services that benefit our local communities and businesses by assisting our customers in achieving their environmental and sustainability aspirations. NWRA supports and promotes regulatory advancements and policies that benefit the solid waste industry and improve the quality of life for all Americans. Association members operate in all 50 states and the District of Columbia and can be found in most, if not all, U.S. congressional districts. Waste and recycling facilities number nearly 18,000 scattered throughout the U.S., mirroring population centers. Our nearly 700 members are a mix of publicly traded and privately owned local, regional and Fortune 500 national and international companies. NWRA represents approximately 70 percent of the private sector waste and recycling market.

Members of NWRA are directly and adversely affected by EPA's promulgation of the Final Rule, which cannot plausibly be considered the logical outgrowth of the 2023 Supplemental Proposal. NWRA and other interested parties were not afforded adequate notice of EPA's ultimate decision to reduce existing collection efficiencies identified in subpart HH of the GHGRP for all landfills, irrespective of whether a landfill was conducting SEM. While NWRA shares EPA's stated objective of ensuring accurate quantification and reporting of greenhouse gas emissions, the Agency's finalized approach undermines that shared objective by adopting a methodology that will overestimate methane emissions, despite an abundance of scientific evidence that more closely aligns with EPA's proposed approach to base emission estimates on site-specific factors like SEM. The Final Rule will also cause reporting under the GHGRP to be at odds with other federal reporting and permitting programs, as well as the landfill sector's established practices regarding sustainability and GHG reporting.

Since EPA's decision to lower collection efficiencies in subpart HH of the Final Rule is procedurally flawed and substantively unwarranted, NWRA respectfully requests that EPA reconsider this important aspect of subpart HH of the Final Rule.[4]

II. <u>Background to the Final Rule</u>

In its Fiscal Year 2008 Consolidated Appropriations Act,[5] Congress directed EPA to promulgate regulations requiring "mandatory reporting of greenhouse gas emissions above appropriate thresholds in all sectors of the economy of the United States."[6] Congress articulated,

[4] NWRA has also filed a petition for judicial review of the Final Rule in the United States Court of Appeals for the District of Columbia Circuit.
[5] 121 Stat. 1844, Pub. Law 110-116 (Dec. 26, 2007).
[6] *Id.* at 2128.

in light of the "growing scientific consensus" that humans were contributing to the accumulation of greenhouse gases in the atmosphere, leading to increased global temperatures, that a "comprehensive and effective national program of mandatory market-based limits and incentives on emissions of greenhouse gases" should be implemented to "slow, stop, and reverse" emissions in such a way which does not "significantly harm the United States economy."[7] Congress issued an accompanying joint statement directing EPA to use its existing authority under the federal Clean Air Act, 42 U.S.C. § 7401 *et seq.*, to develop the mandatory greenhouse gas reporting rule.

In accordance with this Congressional directive, EPA finalized its first version of the GHGRP on October 30, 2009, utilizing its information-gathering authority under Section 114 of the Clean Air Act.[8] The original GHGRP Rule included MSW landfills that generated over 25,000 metric tons of carbon dioxide equivalent or more per year as a source category and was promulgated under Title 40 of the Code of Federal Regulations, part 98, subpart HH.[9]

Since 2009, the GHGRP has been updated numerous times.[10] On June 21, 2022, EPA published a Notice of Proposed Rulemaking ("NPRM") in the Federal Register proposing certain updates to the GHGRP, referred to as the Data Quality Improvements Proposal.[11] Thereafter, EPA issued another NPRM to supplement the Data Quality Improvements Proposal—the 2023 Supplement[12] (collectively, the "Proposed Rules")—once again seeking comment from interested parties regarding proposed changes geared toward improving the quality of data

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[7] *Id.* at 2152.
[8] *Mandatory Reporting of Greenhouse Gases*, 74 Fed. Reg. 56260, 56264.
[9] *See id.* at 56267.
[10] *Rulemaking Notices for GHG Reporting*, EPA (last updated May 31, 2024), https://www.epa.gov/ghgreporting/rulemaking-notices-ghg-reporting.
[11] Data Quality Improvements Proposal, 87 Fed. Reg. 36920 (June 21, 2022).
[12] 2023 Supplemental Proposal, 88 Fed. Reg. 32852 (May 22, 2023).

collected from MSW landfills and strengthening reporting requirements. The 2023 Supplement included proposed changes to several methodologies within subpart HH used to calculate methane emissions from MSW landfills subject to the rule.

On April 25, 2024, EPA finalized its updates to the GHGRP, including changes to collection efficiency values in table HH-3. However, the finalized collection efficiencies differed starkly from those in the Proposed Rules, specifically the 2023 Supplement. Interested parties, including the Petitioner, were completely surprised by and unprepared for this change.

A. <u>The Proposed Rules</u>

In the 2023 Supplemental Proposal, EPA proposed several changes to the GHGRP that it said would lead to more accurate emissions calculations, based on its conclusion that high emission events may be occurring where there is "a leaking cover system due to cracks, fissures, or gaps around protruding wells."[13] In order to address this concern, EPA proposed two ways in which collection efficiency or emission estimates would be adjusted, both related to SEM. First, EPA proposed to amend Equations HH-6, HH-7, and HH-8 for regulated reporters (those that are subject to SEM requirements), by adding a "correction term." Equation HH-6 is used to calculate methane emissions using modeled methane generation and measured methane recovery, while equations HH-7 and HH-8 are used in tandem to calculate methane generation and emissions using methane recovery and estimated gas collection efficiency.[14] EPA noted that the three equations did not "directly account for periods where surface issues reduce the gas collection efficiency and/or reduce the fraction of methane oxidized."[15] To address that concern, EPA

[13] *Id.* at 32877–78. EPA also proposed other measures in the 2023 Supplemental Proposal to address a "poorly operating or non-operating gas collection system" and a "poorly operating or non-operating destruction device." NWRA commented on these proposed measures, which are not addressed in this petition.
[14] *See* 40 CFR 98.343(c)(3)(i).
[15] 2023 Supplemental Proposal, 88 Fed. Reg. 32878.

proposed a way to correct the estimated methane emissions based on monitored exceedances at the surface of the landfill. This proposed correction was based on conclusions from a study cited by EPA, *Heroux*, et al., and its internal citations, which suggested that methane "flux" (*i.e.*, the exchange of methane emissions and naturally occurring substances between Earth's surface and its atmosphere) is proportional to the measured methane concentration at six centimeters above the ground.[16] The proposed correction term would require Reporters subject to SEM to input the "leak duration days" (the number of days since the last monitoring event at the specified location) and the "surface methane concentration for the mth measurement that exceeds 500 parts per million above background."[17] The proposed correction term accounted for the fact that regulated landfills must record as a monitored exceedance, and take corrective action to address, any location with a reading of 500 ppm or more above background. EPA proposed to allow non-regulated landfills to elect to conduct SEM as well, so as to avail themselves of the use of the correction term when calculating their methane emissions using equations HH-6, HH-7, and HH-8.[18]

The second method by which EPA considered an adjustment of collection efficiency based on SEM was a proposed adjustment to the gas collection efficiency values in Table HH-3, as utilized in equations HH-7 and HH-8, applicable *only* to landfills that are not required to conduct SEM under other federal provisions or decline to elect to conduct SEM pursuant to proposed 40 CFR § 98.346(g)(7).[19] Specifically, EPA proposed to include a new set of gas

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[16] *Id.*
[17] *Id.* at 32931. "Regulated" landfills are subject to such SEM requirements under the NSPS program, 40 CFR part 60, WWW or XXX; the EG program, subparts Cc or Cf; or Federal plans, 40 CFR part 62, subparts GGG or OOO. *Id.* at 32877–78.
[18] *See id.* at 32932 (proposing to implement elective surface-emissions monitoring for landfills with landfill gas collection systems that are not required to conduct such under an existing federal program under a new subsection, 40 CFR § 98.346(g)(7)).
[19] *Id.* at 32879.

collection efficiency values in Table HH-3, applicable to landfills that do not conduct SEM, that are "10 percent lower than the current set of collection efficiencies."[20] EPA proposed that the current set of collection efficiencies would be retained, and would "only be applicable for landfills that are conducting [SEM] according to the landfills rule requirements." [21] Since the vast majority of landfills conduct surface emission monitoring,[22] EPA's proposal would have lowered the collection efficiencies for *only* a relatively small subset of Reporters.

EPA's proposal rested on the conclusions of a study by the Environmental Integrity Project ("EIP Study")[23] that collection efficiencies of non-regulated landfills were 20% lower, on average, than regulated landfills. In discussing the EIP study conclusion relating to SEM, EPA stated: "These results make sense because the objective of the surface methane concentration measurements are to ensure proper gas collection and non-regulated landfills that do not conduct these measurements would not necessarily have such checks in place and may be expected to have higher emissions."[24] The EIP study results focused on a limited number of landfills in the state of Maryland that, when compared to the values reported under subpart HH, showed collection efficiencies that were 10% lower than regulated landfills under the GHGRP.

EPA specifically requested comment on: its proposal to lower collection efficiencies for landfills with gas collection systems that do not conduct SEM; the selection of a 10 percent collection efficiency reduction rather than the 20 percent reduction for those non-regulated landfills; and whether EPA should select an alternative value for non-regulated landfills based on

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[20] *Id.*
[21] *Id.*
[22] EPA-HQ-OAR-2019-0424-0256, Attachment A.
[23] EIP, *Greenhouse Gas Emissions from Maryland's Landfills* (2021), https://environmentalintegrity.org/wp-content/uploads/2021/06/MD-Landfill-Methane-Report-6.9.2021-unembargoed_with-Attachments.pdf).
[24] 2023 Supplemental Proposal, 88 Fed. Reg. at 32878.

the supporting data.[25] NWRA provided comment with respect to these proposed changes.[26] In addition to comments noting the technical and substantive inadequacy of the EIP Study, NWRA also noted that EPA's proposal and reliance on the EIP Study failed to account for other major factors that are more influential with respect to collection efficiencies at regulated and non-regulated landfills, including federal requirements to provide comprehensive controls, meet prescriptive timelines, and limit system downtime. NWRA also incorporated by reference the comments of Morton Barlaz, who likewise noted that EPA failed to identify all the factors that can affect collection efficiency, such as the type of cover and well density.[27] NWRA further noted that the equation HH-8 methodology accounts for these differences already, obviating the need for reduced collection efficiencies as proposed.

NWRA also provided comment on the proposed correction term, asking EPA to consider other studies that show significant variability in the correlation between surface emissions exceedances and methane flux. Specifically, we noted that the *Heroux*, et al. study EPA used to support the purported correlation was conducted over 20 years ago based on data from a single landfill in Canada.

Importantly, NWRA asked that EPA delay the finalization of any of the proposed revisions to subpart HH until the Solid Waste Industry for Climate Solutions ("SWICS") finalized its revisions to the third version of its white paper entitled *Current MSW Industry Position and State-of-the-Practice on LFG Collection Efficiency, Methane Oxidation, and Carbon Sequestration in Landfills*. The SWICS White Paper is a compilation of peer-reviewed data and studies relating to a broad range of MSW landfills, and it was undertaken for the

[25] *Id.* at 32879.
[26] *See* EPA-HQ-OAR-2019-0424-0255.
[27] NWRA incorporated by reference the comments of Morton Barlaz. *See* EPA-HQ-OAR-2019-0424-0286.

express purpose of creating a methodology that would result in more accurate inventories of methane from landfills. In relevant part, NWRA noted that the SWICS paper will "move toward a more quantified basis for GCCS collection efficiency assessment….and a revisit on the current state-of-the-practice on collection efficiencies, oxidation, carbon storage, methane generation in landfills and destruction efficiencies."[28]

B. <u>Final Rule</u>

In the Final Rule, EPA stated that, "[f]ollowing the consideration of comments received, we are not taking final action on the surface-emissions monitoring correction term that was proposed. *Instead*, we are finalizing the proposed lower collection efficiencies in table HH-3 to subpart HH but applying the reduced collection efficiencies for *all* reporters under subpart HH."[29] In making this decision, EPA conceded, consistent with NWRA's comments, that the *Heroux*, et al. study was insufficient, alone, to support the implementation of the correction term, because it was over two decades old and focused on one landfill in Canada.[30] Upon review of the additional studies identified by commenters, including those identified by NWRA, EPA agreed that there was indeed significant variability in measured surface concentrations and methane emissions flux across different landfills.[31] Due to "high uncertainty," EPA indicated that it is reassessing the appropriateness of a correction term and "evaluating other direct measurement technologies for assessing more accurate, landfill-specific gas collection efficiencies."[32]

With respect to the proposed collection efficiencies, EPA concluded that it "expected that the surface emissions correction factor would result in lower emissions than those calculated

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[28] *See* EPA-HQ-OAR-2019-0424-0255.
[29] Final Rule, 89 Fed. Reg. at 31853 (emphasis added).
[30] *Id.* at 31855.
[31] Final Rule, 89 Fed. Reg. at 31855.
[32] *Id.*

using the 10-percentage point decrease in collection efficiency[.]"[33] Based on EPA's review of other studies correlating surface methane concentrations with methane flux," EPA stated its belief that a "more central tendency correlation factor is projected to yield emissions similar to a 10-percentage point decrease in collection efficiency."[34] EPA went on to state that "all the measurement study data" reviewed suggests that current collection efficiencies are overstated on average by 10-percentage points or more.[35] In making this point, EPA cited two studies that were not included in either the preamble or the docket for the Proposed Rules: *Duan et al.*, 2022 and *Nesser et al.*, 2023.[36] EPA asserted that the *Nesser* study, which observed 38 landfills subject to SEM requirements, provides evidence that most observed landfills had lower or similar measured collection efficiencies to those reported under subpart HH.[37] EPA further concluded that "[s]imilar low average collection efficiencies were noted by *Duan* et al.," and that those efficiencies justified its decision to finalize the lower default collection efficiencies for all landfills.[38]

III. <u>Requested Reconsideration of the Collection Efficiency Values</u>

Pursuant to Section 307(d)(7)(B) of the Clean Air Act, EPA "shall convene a proceeding for reconsideration of [a] rule and provide the same procedural rights as would have been afforded had this information been available at the time the rule was proposed" so long as the party seeking reconsideration can demonstrate: (1) "that it was impracticable to raise such

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[33] *Id.* at 31856.
[34] *Id.*
[35] *Id.*
[36] *Id.* (citing Duan, Z., et al., *Efficiency of gas collection systems at Danish landfills and implications for regulations*, 139 WASTE MANAGEMENT 269–78 (2022), https://doi.org/10.1016/j.wasman.2021.12.023.; Nesser, H., et al., *High-resolution U.S. methane emissions inferred from an inversion of 2019 TROPOMI satellite data: contributions from individual states, urban areas, and landfills*, EGUSPHERE [preprint] (2023), https://doi.org/10.5194/egusphere-2023-946; and supplement https://egusphere.copernicus.org/preprints/2023/egusphere-2023-946/egusphere-2023-946-supplement.pdf.
[37] Final Rule, 89 Fed. Reg. at 31856.
[38] *Id.* at 31856.

objection" during the public comment period or that "the grounds for such objection arose after the period for public comment (but within the time specified for judicial review)"; and (2) "such objection is of central relevance to the outcome of the rule." 42 U.S.C. § 7607(d)(7)(B).

The Petitioner could not practicably raise procedural and substantive objections to EPA's finalization of Table HH-3's reduced collection efficiencies by 10 percentage points, applicable to *all* Reporters under subpart HH, because EPA did not afford adequate notice of this change to interested parties prior to the public comment period. As such, the change to collection efficiency in HH-3 applicable to all Reporters under the Final Rule is not the "logical outgrowth" of the Proposed Rules. EPA is required to convene proceedings for reconsideration, so that interested parties may raise relevant substantive objections that are of central relevance to the outcome of the rule.

A. <u>EPA did not afford interested parties with adequate notice of the lowered collection efficiencies applicable to all Reporters; therefore, the Final Rule is not the "logical outgrowth" of the Proposed Rules.</u>

The practicability of raising an objection during the public comment period is dependent on EPA providing adequate notice of the changes it purports to finalize. The Clean Air Act incorporates the notice requirements set forth in the Administrative Procedure Act, by stipulating "[i]n the case of any federal rule to which this subsection applies, notice of a proposed rulemaking shall be published in the Federal Register, as provided under Section 553(b) of Title 5[.]" § 7607(b)(3). The APA's notice requirements are designed (1) to ensure that agency regulations are tested via exposure to diverse public comment, (2) to ensure fairness to affected parties, and (3) to give affected parties an opportunity to develop evidence in the record to support their objections to the rule and thereby enhance the quality of judicial review." *Int'l Union, United Mine Workers of America v. Mine Safety & Health Admin.*, 407 F.3d 1250, 1259

(D.C.Cir.2005). Notice, courts have recognized, must come from the agency's Notice of Proposed Rulemaking. *Chesapeake Climate Action Network v. EPA*, 952 F.3d 310, 320 (D.C. Cir. 2020). Because agencies "do not quite have the prerogative of obscurantism reserved to the legislatures," they must adhere to a "high standard of articulation" in expressing the "data [of] critical degree" in their Notices of Proposed Rulemakings. *United States v. Nova Scotia Food Prod. Corp.*, 568 F.2d 240, 252 (2d Cir. 1977). Notice, therefore, cannot be "bootstrap[ped]" from a comment received during the comment period after a Notice of Proposed Rulemaking has been published. *Fertilizer Inst. v. EPA*, 935 F.2d 1303, 1312 (D.C.Cir.1991). In this respect, if agencies "fail[] to disclose to interested persons the factual material upon which the agency was relying," the elements of fairness which are "essential to any kind of administrative action" are vitiated by preventing agencies from submitting comments of "cogent materiality." *Nova Scotia*, 568 F.2d at 249, 252.

Moreover, without adequate notice, it is widely recognized that a final rule does not equate to the "logical outgrowth" of the proposal. *See, e.g.*, *Envtl. Integrity Project v. EPA*, 425 F.3d 992, 996 (D.C. Cir. 2005); *Northeast Md. Waste Disposal Auth. v. EPA*, 358 F.3d 936, 951-52 (D.C. Cir. 2004); *Alon Ref. Krotz Springs, Inc. v. EPA*, 936 F.3d 628, 648 (D.C. Cir. 2019) (stating that the "impracticability prong" of Section 307(d)(7)(B) covers "instances when the final rule was not a logical outgrowth of the proposed rule"). A final rule is the "logical outgrowth" of a proposed rule only if interested parties "should have anticipated that the change was possible, and thus reasonably should have filed their comments on the subject during the notice-and-comment period." *Env't Integrity Project v. EPA*, 425 F.3d 992, 996 (D.C. Cir. 2005).

In contrast, agencies cannot justify changes implemented in a final rule by placing an "unreasonable burden on commentors not only to identify errors in a proposed rule but also to contemplate why every theoretical course of correction the agency might pursue would be inappropriate or incorrect." *Chesapeake Climate Action Network*, 952 F.3d at 320 (holding that a party's ability to comment on an *issue* generally does not in and of itself demonstrate sufficient notice from EPA). While an agency "need not subject every incremental change in its conclusions after each round of notice and comment to further public scrutiny before final action," *Sierra Club v. Costle*, 657 F.2d 298, 352 (D.C. Cir. 2981), interested parties must be able to anticipate that the change was possible, and could have submitted comments relating to such. *Northeast Md. Waste Disposal Auth.*, 358 F.3d at 952 (finding that a final rule which collapses the proposed rule's three categories into two is the logical outgrowth of the proposed rule); *Envt'l Integrity Project*, 425 F.3d at 996 ("The Court will refuse to all agencies to use the rulemaking process to pull a surprise switcheroo on the regulated entities.").

Here, the Petitioner did not have adequate notice of EPA's decision to impose lower collection efficiencies upon *all* Reporters. Rather, the Petitioner had notice that EPA was considering an adjustment to collection efficiencies and emission calculations tied to SEM practices; EPA indicated that it may lower collection efficiencies by 10% for those MSW landfills not conducting SEM and by a correction term for those that do conduct SEM and for which surface emissions were detected above defined thresholds. EPA did not indicate anywhere in the Proposed Rules that it was considering an across the board lowering of collection efficiencies regardless of SEM practices and results. Indeed, the very basis for EPA's proposal in the first instance was a concern about accurately accounting for "methane emissions from large release events that are currently not quantified under the GHGRP" including those that may result from "emissions from leaking cover systems due to cracks, fissures, or gaps around protruding wells"[39]—issues that would be detectable by SEM. EPA's decision in the Final Rule had nothing to do with SEM at all—in fact, as discussed above, EPA pivoted away from SEM and in its place adopted an across-the-board reduction in collection efficiencies based in large part on newly identified data.

While it is true that EPA is not obligated, and cannot be reasonably expected, to subject "every incremental change in its conclusions" to additional rounds of notice and comment before final action, this change is not incremental. *See Sierra Club*, 657 F.2d at 352. The Petitioner could not and did not anticipate EPA's final action, especially given that EPA requested comment regarding: (1) the "new set of proposed collection efficiencies for landfills with gas collection systems that do not conduct surface methane concentration measurements"; (2) EPAs "selection of 10 percent lower collection efficiencies for landfills that are not monitored for surface methane rather than selecting a 20 percent lower value as suggested by the commenters that referenced the [EIP Study] data"[40]; and (3) supporting data on whether EPA should select an "alternative collection efficiency value than the proposed 10 percent difference or the 20 percent difference[.]"[41] Based on these requests for comment, the Petitioner reasonably expected EPA to: finalize the collection efficiencies as proposed for non-regulated Reporters; lower the values applicable to non-regulated Reporters in accordance with the percentages identified in the EIP Study; retain the status quo; or, if commenters pointed to scientific data that supported some "alternative" value for non-regulated landfills, subject interested parties to another round and notice and comment on a different proposed value based on the new scientific data. *See United*

[39] 2023 Supplemental Proposal, 88 Fed. Reg. at 32877–78.
[40] *Id.* at 32878; EIP, *Greenhouse Gas Emissions from Maryland's Landfills* (2021), https://environmentalintegrity.org/wp-content/uploads/2021/06/MD-Landfill-Methane-Report-6.9.2021-unembargoed_with-Attachments.pdf).
[41] 2023 Supplemental Proposal, 88 Fed. Reg. at 32879.

States v. Nova Scotia Food Prod. Corp., 568 F.2d 240, 252 (2d Cir. 1977). In no event did EPA suggest that it was evaluating a collection efficiency reduction for all Reporters as a standalone measure, uncoupled from SEM as a factor on which that value should be based.

NWRA submitted comments in accordance with EPA's requests, in part because we disagree that SEM is a strong indicator of overall collection efficiency, especially as extrapolated to a quantification of annualized emissions. Further, NWRA disagreed with the technical information proffered by EPA to support its proposal. Specifically, the Petitioner's comments questioned the adequacy of the EIP Study on the basis that it was not properly peer-reviewed in accordance with EPA's General Assessment Factors[42] and Peer Review Policy.[43] NWRA also commented that the EIP Study, which focused on 14 landfills in Maryland only, was not representative of MSW landfills subject to subpart HH across the entire United States. In addition, NWRA pointed out that the equation HH-8 methodology, as-is, adequately accounts for the factors which legitimately and substantially influence the difference in collection efficiencies between landfills conducting SEM and landfills not conducting SEM. Accordingly, NWRA asked that EPA either maintain the status quo or await publication of comprehensive, representative data in the updated version of the SWICS White Paper, a document that EPA has relied upon in the past. NWRA's comments were also substantially influenced by the proposed "correction term," which EPA proposed in tandem with the lowered collection efficiencies. Though we objected to lowering collection efficiencies at all, we at least recognized that, coupled with the correction term, there existed an incentive for non-regulated landfills to conduct

[42] Summary of General Assessment Factors for Evaluating the Quality of Scientific and Technical Information (June 2003) (available at https://www.epa.gov/sites/default/files/2015-01/documents/assess2.pdf).
[43] Peer Review Handbook (4th Edition 2015) (available at https://www.epa.gov/sites/default/files/2020-08/documents/epa_peer_review_handbook_4th_edition.pdf).

SEM, consistent with the original goals articulated by Congress in directing EPA to establish the GHGRP.[44]

If the Petitioner had been on notice of the remote possibility that EPA would finalize lower collection efficiencies applicable to *all* Reporters, without regard to SEM, the Petitioner certainly would have submitted corresponding comments, outlining the broad range of scientific reasons why EPA should not do so. But since EPA failed to provide such notice, EPA's finalized collection efficiencies cannot permissibly be considered the "logical outgrowth" of its original proposal.

The situation here is unlike other cases in which the D.C. Circuit has found that the final rule was a "logical outgrowth" of a proposed rule. For example, in *Northeast Maryland Waste Disposal Authority v. EPA*, the Circuit Court held that a final rule which collapses the proposed rule's three categories into two *is* the logical outgrowth of the proposed rule. 358 F.3d 936, 953 (D.C. Cir. 2004). Rather, EPA's action here is akin to situations where the Circuit has found a lack of logical outgrowth. In *International Union*, for example, the agency's proposed rule provided that "[a] minimum air velocity of 300 feet per minute must be maintained" to ventilate underground coal mines.[45] The final rule, however, provided that "[t]he maximum air velocity in the belt entry must be no greater than 500 feet per minute, unless otherwise approved in the mine ventilation plan."[46] The D.C. Circuit vacated the final rule because, although "[t]here were some comments during the hearings urging the Secretary to set a maximum velocity cap," the Agency "did not afford a ... public notice of its intent to adopt, much less an opportunity to comment on, such a cap." *International Union*, 407 F.3d at 1261. Like the concept of air velocity in

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[44] 121 Stat. 1844, Pub. L. 110-116 (Dec. 26, 2007).
[45] 68 Fed. Reg. 3936, 3965 (Jan. 27, 2003).
[46] 69 Fed. Reg. 17,480, 17,526 (Apr. 2, 2004).

International Union, the general concept of collection efficiency may have been raised in the 2023 Supplement, but the Final Rule's across the board decrease in collection efficiencies for all landfills is not consistent with the Proposed Rules, nor was it foreseeable from the Proposed Rules. EPA's final action here "finds no roots in the agency's proposal," *Kooritzky v. Reich*, 17 F.3d 1509, 1513 (D.C. Cir. 1994), equating to an impermissible "surprise switcheroo." *Envt'l Integrity Project v. EPA*, 425 F.3d 992, 996 (D.C. Cir. 2005).

EPA has attempted to support its collection efficiency "switcheroo" by citing two new scientific studies that allegedly support the lowering of collection efficiencies as applicable to *all* Reporters, without regard to SEM. Specifically, EPA states that "[a]ll the measurement study data [] reviewed suggests that current GHGRP collection efficiencies are overstated on average by 10-percentage points or more," citing to *Duan et al.*, 2022[47] and *Nesser et al.*, 2023.[48] As explained below, neither these studies nor the EIP Study support EPA's final decision.

Further, from a notice standpoint, EPA did not cite to either the *Duan* or *Nesser* studies in the Proposed Rules. The *Nesser* study was advanced by the paper's co-author, Hannah Nesser, in her comment in response to EPA's 2023 Supplement. [49] The paper itself was published online on June 13, 2023, only a few weeks before the close of the public comment period on July 22, 2023. The information contained therein was not even publicly available so as to inform EPA's proposals advanced on May 22, 2023, in the 2023 Supplement. In relying on entirely new data within the *Nesser* paper, EPA attempts to impermissibly "bootstrap" notice from a comment. *See*

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[47] Duan, Z., et al., *Efficiency of gas collection systems at Danish landfills and implications for regulations*. 139 WASTE MANAGEMENT 269–78 (2022), https://doi.org/10.1016/j.wasman.2021.12.023.

[48] Nesser, H., et al., *High-resolution U.S. methane emissions inferred from an inversion of 2019 TROPOMI satellite data: contributions from individual states, urban areas, and landfills*. EGUSPHERE [preprint] (2023), https://doi.org/10.5194/egusphere-2023-946.

[49] EPA-HQ-OAR-2019-0424-0306. The paper was published online on June 13, 2023, only a few weeks before the close of the public comment period on July 22, 2023.

Fertilizer Inst. V. EPA, 935 F.2d 1303, 1312 (D.C.Cir.1991). EPA cannot reasonably assert that the final collection efficiencies are the "logical outgrowth" of the 2023 Supplement by relying on a study introduced via comment, without providing other interested parties the opportunity to review and comment on the study as well, for the purpose for which it is offered. *See, e.g.*, *United States v. Nova Scotia Food Prod. Corp.*, 568 F.2d 240, 251 (2d Cir. 1977).

Even more unacceptable is EPA's reliance on the *Duan* study. EPA did not cite or refer to *Duan* in either proposed rule; nor was it cited by an interested party during the public comment process. EPA's sudden reliance on *Duan* appears to be a post-hoc rationalization for its Final Rule, rather than appropriately identified support for a proposal that was properly noticed. Indeed, in this rulemaking, EPA has expressly acknowledged that newly cited studies introduced during the comment period warrant the agency's further consideration. As described *supra*, EPA proposed to implement a "correction term" to equations HH-7 and HH-8 that it hoped would more accurately quantify emissions by "account[ing] for periods where surface issues reduce the gas collection efficiency and/or reduce the fraction of methane oxidized."[50] In NWRA's comments on the proposal, we objected to the addition of the correction term on the basis that EPA's cited sources, namely *Heroux, et al.* and its internal sources, do not "adequately capture the complexity of the attempted correlation between surface emission exceedances and methane flux."[51] We asked that EPA consider other studies which show significant variability in the alleged correlation. In response, EPA stated that it would "continue to review additional information on existing and advanced methodologies and new literature studies and consider ways to effectively incorporate these methods and data in future revisions under subpart HH[.]"[52]

[50] 2023 Supplemental Proposal, 88 Fed. Reg. at 32878.
[51] EPA-HQ-OAR-2019-0424-0319.
[52] Final Rule, 89 Fed. Reg. at 31855.

EPA also indicated that it would take time to further consider the implementation of a correction term in light of newly advanced data, without taking any action in the Final Rule.[53] Consistent with its response to comments on the correction term, EPA should have acknowledged that more study of collection efficiency values is needed and should have subjected the 10-percent across-the board reduction collection efficiencies to an additional round of notice-and comment. *See, e.g.*, *Mexichem Specialty Resins, Inc. v. EPA*, 787 F.3d 544, 554 (D.C. Cir. 2015) (EPA may determine that affording a party seeking reconsideration the "same procedural rights" requires the initiation of rulemaking to gather additional data" to inform its decision).

B. The finalized collection efficiencies should be reconsidered because the Petitioner's objections are of "central relevance to the outcome of the rule."

An objection is of central relevance if it "provides substantial support for the argument that the regulation should be revised." *Coal. For Responsible Regulation v. EPA*, 684 F.3d 102, 125 (D.C. Cir. 2012); *Kennecott Corp. v. EPA*, 684 F.2d 1007, 1019 (D.C. Cir. 1982) ("Because the reasonableness and accuracy of the forecast data is critical to whether a smelter can qualify for [a nonferrous smelter order], Asarco and Magma's objections to that data, if well-founded, would clearly have been "'of central relevance.'").

The finalized collection efficiencies should be reevaluated and revised because they were central to the proposed and Final Rules. Indeed, emissions calculations are the crux of the GHGRP. EPA has articulated its over-arching goal to increase the accuracy of emissions calculations, so that Reporters, and more broadly the public at large, can understand whether and to what extent an entity is contributing to greenhouse gas emissions.[54] Universal required

[53] *Id.*
[54] Final Rule, 89 Fed. Reg. at 31884 ("[T]ransparent, standardized public data on emissions allows for accountability of polluters to the public who bear the cost of the pollution. The GHGRP serves as a powerful data resource and provides a critical tool for communities to identify nearby sources of GHGs and provide information to state and local governments.").

changes in calculation methodologies, therefore, should be considered carefully by EPA, especially where it has added a new methodology that overestimates emissions across the reporting sector. At a minimum, the "central relevance" requirement for reconsideration is satisfied in circumstances such as this, where there are well-founded objections pertaining to "critical" portions of the rule. *See Kennecott*, 684 F.2d at 1019.

Indeed, EPA's finalization of understated collection efficiencies, and the lack of support thereof, undermine the very purpose and objective of the GHGRP—to promote the accurate and comprehensive collection and reporting of greenhouse gas emission data. These failures will, in turn, harm the Petitioner's members. The finalized collection efficiencies will result in discrepancies among state and federal programs that require methane emissions reporting. With respect to federal programs, EPA has used GHGRP data on MSW landfills to "inform the development of the 2016 NSPS and EG for landfills." [55] Similarly, the "benefits of improved reporting also include enhancing existing voluntary programs, such as the Landfill Methane Outreach Program (LMOP)."[56] Moreover, EPA recognizes that "[s]everal states use GHGRP data to inform their own policymaking."[57] GHGRP emission estimates will also be at odds with EPA's own emissions factors in AP-42, as well as state permitting programs, which allow for a range of collection efficiencies and the recognition that higher collection efficiencies may be achieved at some sites that are designed and engineered to collect and control landfill gas.[58]

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[55] *Id.*
[56] *Id.*
[57] *Id.*
[58] *See* AP-42, at 2.4-6, https://www3.epa.gov/ttnchie1/ap42/ch02/final/c02s04.pdf

> "To estimate controlled emissions of CH4, NMOC, and other constituents in landfill gas, the collection efficiency of the system must first be estimated. Reported collection efficiencies typically range from 60 to 85 percent, with an average of 75 percent most commonly assumed. Higher collection efficiencies may be achieved at some sites (i.e., those engineered to control gas emissions). If site-specific collection efficiencies are available (i.e., through a comprehensive surface sampling program), then they should be used instead of the 75 percent average."

Without accuracy and consistency across these programs, Reporters and agencies will not be able to appropriately identify and address emissions-related issues at affected facilities.

To the extent that GHGRP reported emissions are overestimated compared to reported emissions under other programs, such discrepancies will also add complexity to sustainability reporting and permitting, negatively impacting and complicating information provided to shareholders and third parties, and subjecting Reporters to risk. As a practical matter, the lowered collection efficiencies will have a compounding effect across multi-facility companies and may act as a disincentive to increase gas collection given that EPA's final rule now assumes inefficiencies among Reporters using HH-8. This is because HH-8, in general, assumes that emissions are directly proportional to the amount of landfill gas that is recovered and destroyed. Thus, the lowered collection efficiencies in the new rule could disincentivize higher actual collection.

Moreover, absent reconsideration, the final rule may have broad unintended consequences on policies designed to reduce greenhouse gas emissions. EPA's Renewable Fuel Standard ("RFS") program, for example, requires gasoline and diesel producers to incorporate renewable fuels into the Nation's transportation fuel supply.[59] Congress sought to accomplish this mandate in large part by encouraging the increased production and use of cellulosic biofuels—including renewable natural gas derived from landfill biogas—with the goal of achieving lower costs for consumers, reduced GHG emissions, better air quality, and greater energy independence.[60] Other policies have built upon the success of the RFS program, offering

[59] *See* 40 C.F.R. § 80, subpart M.
[60] *Renewable Fuel Standard (RFS) Program: Standards for 2023–2025 and Other Changes*, 88 Fed. Reg. 44468, 44471 (July 12, 2023).

additional incentives for landfill methane capture, which waste sector stakeholders rely on in making business decisions around the installation of bio gas processing equipment.

States such as California, Oregon, Washington, and New Mexico have also developed Clean Fuel Standard programs[61] to encourage the use of low-carbon transportation fuels by providing credit to renewable fuel producers on a sliding scale based on the carbon intensity of each fuel. Unfortunately, the finalized collection efficiencies will have a negative impact on the carbon intensity scores of fuels sourced from landfill-derived biogas, resulting in reduced financial incentives for the production of renewable natural gas and potentially disincentivizing projects aimed at capturing methane emissions from waste sector operations. Congress has similarly incentivized the implementation of clean energy projects under the Inflation Reduction Act of 2022 ("IRA")[62], making tax credits available to taxpayers using a "technology-neutral" approach. The IRA specifically included a suite of tax credits designed to reward renewable fuel producers for lowering the carbon intensity scores of their fuels.[63] Similar to the negative impacts of the final rule associated with the aforementioned Clean Fuel Standard programs, EPA's finalized collection efficiencies will reduce the value of various tax credits for the production or generation of renewable natural gas, clean hydrogen, renewable electricity, and sustainable aviation fuel—potentially resulting in lost opportunities to capture landfill methane for beneficial use. Finally, to the extent that future legislative actions would contemplate a "carbon tax" or similar financially based implications for greenhouse gas emissions, it is

[61] Cal. Code Regs. tit. 17, § 95480; Or. Admin. R. 340-253-0000; Wash. Rev. Code Ann. § 70A.535.005; New Mexico House Bill 41 (requiring the Environmental Improvement Board to promulgate regulations to initiate the program no later than July 1, 2026).
[62] 136 Stat. 1818, Pub. L. 117–169 (Aug. 16, 2022).
[63] *See* 26 U.S.C. § 6426.

imperative that the quantification of such emissions is reliable and accurate. EPA should set a high standard under the GHGRP for such accuracy.

C. **<u>EPA lacks adequate technical justification for the finalized reduction in collection efficiencies.</u>**

As finalized, the lowered collection efficiencies are technically unjustified, and the proffered bases do not support EPA's change in position.

An agency action is arbitrary and capricious if there does not exist a "rational connection between the facts found and the choices made." *Motor Vehicle Mfrs. Ass'n of U.S., Inc. v. State Farm Mut. Auto. Ins. Co.*, 463 U.S. 29, 43 (1983). A rational connection between the facts found and the choices made does not exist if, among other reasons, the agency failed to consider an important aspect of the problem or the agency offers an explanation for its decision that runs counter to the evidence. *Id.* Both shortcomings are present here. In the 2023 Supplement, EPA purported to address "methane emissions from large release events" and focused on whether landfills were using SEM to address "leaking cover systems due to cracks, fissures or gaps around protruding wells" as a basis on which to adjust collection efficiency.[64] But in the Final Rule, EPA dismissed SEM as a consideration and relied only on study papers, including two that were newly cited, to support an across the board reduction in collection efficiencies, rather than focusing on methane emissions from large release events as it did in the 2023 Supplemental Proposal. In so doing, EPA prevented comment that would have addressed overall collection efficiencies across the MSW landfill sector rather than emissions associated with large release events, including those that occur via cover problems that are addressed by SEM. Such material comments would have advanced arguments falling within the "relevant factors" that EPA is

[64] 2023 Supplemental Proposal, 88 Fed. Reg. at 32877–78.

required to consider before finalizing a regulation. Without consideration of such important input, EPA ignored "important aspects of the problem" relating to landfill collection efficiency and greenhouse gas emissions. *Motor Vehicle Mfrs. Ass'n of U.S., Inc. v. State Farm Mut. Auto. Ins. Co.*, 463 U.S. 29, 43 (1983). While reviewing courts are generally deferential with respect to decisions involving agency expertise, *Logic Tech. Dev. LLC v. FDA*, 84 F.4th 537, 549 (3d Cir. 2023); *GenOn REMA, LLC v. EPA*, 722 F.3d 513, 526 (3d Cir. 2013), agencies are forbidden from reaching "whatever conclusions [they] like" and defending such positions "with vague allusions to [their] own expertise." *Sierra Club v. EPA*, 972 F.3d 290 (3d Cir. 2020) ("Although EPA has offered vague allusions to the inability of unspecified plants to meet a lower standard, the agency has deprived us of the ability to review its decision by showing its work."). Put simply, an agency action must be "reasonable and reasonably explained." *FCC v. Prometheus Radio Project*, 592 U.S. 414 (2021). This was not.

In the Final Rule, EPA acted arbitrarily by relying on scientific data that was not presented in either of the Proposed Rules. Just as importantly, EPA also failed to adequately explain how the scientific conclusions of the studies on which it relied—which involved the use of remote sensing data to quantify landfill emissions—support the final collection efficiencies without regard to SEM. In fact, in the Final Rule EPA underscored the dangers of relying on such technologies at this juncture. There, EPA stated that it was "not taking final action at this time regarding the incorporation of other direct measurement technologies" such as satellite imaging, aerial measurements, vehicle mounted measurement or continuous sensor networks because "most top-down facility measurements are taken over limited durations (a few minutes to a few hours) typically during the daylight hours when specific meteorological conditions exist (*e.g.*, no cloud cover for satellites; specific atmospheric and wind speed ranges for aerial measurements)."[65] EPA further recognized that these methods of measurement "may not be representative of the annual CH_4 emissions from a facility, given that many emissions are episodic."[66] Consequently, EPA concluded, "[e]xtrapolating from limited measurements to an entire year therefore creates risk of either over or under counting actual emissions."[67] In this respect, EPA's decision to heavily rely upon *Nesser* and similar studies, whose findings are the result of satellite imaging, in supporting a broad-based and unqualified reduction in collection efficiency values, is puzzling. EPA makes no effort to explain this discrepancy in logic, which has resulted in a Final Rule that runs counter to the agency's own findings.[68]

1. **The Nesser Study does not support EPA's collection efficiency determination.**

EPA cites the *Nesser* study for the general proposition that "recent aerial studies indicate methane emissions from landfills may be considerably higher than bottom-up emissions reported under subpart HH for *some* landfills" and further notes that such higher emissions may be attributable to "poorly operating gas collection systems or destruction devices and leaking cover systems."[69] But EPA fails entirely to explain how the *Nesser* study, which was based on its review of only 38 landfills, supports a broad-based collection efficiency reduction applicable to

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[65] Final Rule, 89 Fed. Reg. at 31856.
[66] *Id.*
[67] *Id.*
[68] This petition focuses on the introduction of scientific data from Nesser, et al., 2023 and Duan et al., 2022. EPA also referenced two additional studies: Oonk, H., *Efficiency of landfill gas collection for methane emissions reduction*, 2 GREENHOUSE GAS MEASUREMENT AND MANAGEMENT, 129–145 (2012) https://doi.org/10.1080/20430779.2012.730798; and Arcadis, *Quantifying Methane Abatement Efficiency at Three Municipal Solid Waste Landfills; Final Report*. Prepared for U.S. EPA, Office of Research and Development, Research Triangle Park, NC. EPA Report No. EPA/600/R–12/ 003. (Jan. 2012). https://nepis.epa.gov/Exe/ZyPDF.cgi/P100DGTB.PDF?Dockey=P100DGTB.PDF.
It is unclear whether EPA relies on these studies to support its assertion that historical collection efficiencies are overstated, because EPA fails to adequately explain the relevance of these studies and how they support the finalization of the lowered collection efficiencies. Final Rule, 89 Fed. Reg. at 31856.
[69] Final Rule, 89 Fed. Reg. at 31854 (emphasis added).

the more than 1,000 landfills[70] that are subject to reporting under the GHGRP.[71] Just as critically, EPA does not explain the basis on which such collection efficiencies can be appropriately or accurately measured with satellite imagery—a key concern for the Petitioner.

The *Nesser* study uses 2019 satellite (TROPOMI) data at approximately 25 x 25 km resolution to estimate methane emissions for grid cells in the contiguous United States with 2012 reported methane emissions larger than 0.1 Mg /(km year).[72] *Nesser* alleges that landfill emissions are 51% higher than the Greenhouse Gas Inventory ("GHGI") indicates.[73] The study compared optimized emissions for 73 individual landfills to those reported under the GHGRP and alleges to have found a median 77% increase in emissions relative to reported values.[74] Of the 73 studied landfills, 38 of the facilities recovered gas and reported an average efficiency of 0.5 (0.33 – 0.54) compared to the reported average of 0.61.[75] However, the collection efficiency reported in the 2019 GHGI was either within or higher than the author's reported uncertainty range for 15 of the 38 landfills.[76] Moreover, the study found no correlation (R2 = 0.00) between GHGRP emissions and the landfill estimates. The correlation did not improve when considering only facilities that do or do not capture landfill gas.[77] In summary, NWRA believes that the *Nesser* study introduces several uncertainties, which, taken separately or collectively, undermine its use as a basis for EPA's action:

- The range reported is not a credible (confidence) interval for the estimated emissions but is the range of the eight members of the ensemble. This range only accounts for

[70] EPA-HQ-OAR-2019-0424-0256, Attachment A.
[71] Final Rule, 89 Fed. Reg. at 31856.
[72] *Nesser, et al.*, at 2, 4.
[73] *Id.* at 26.
[74] *Id.*
[75] *Id.* at 19.
[76] *Id.*
[77] *Id.*

the uncertainty introduced by the optimized boundary conditions, bias correction, and regularization factor, and does not account for the uncertainty in the measurements, transport model or and source attribution methods.

- Emission sources not included in the 2012 GHGI are not accounted for. The source aggregation approach assumes that the 2012 reported fractional sectoral contributions are correct in each 25 x 25 km grid cell.
- The study only quantified 70 of the 1297 landfills that reported to the GHGRP in 2019.
- Satellite data can only be collected during clear daytime conditions, so landfills in areas with snow or high cloud cover were less likely to be quantified. With a low (3%) success rate, TROPOMI data may be as few as 12 measurements over the course of a year for a given site, biased toward clear summertime conditions.
- The study does not discuss whether readings occurred during landfill operating hours.
- It is our understanding that TROPOMI is an open-source satellite in geosynchronous orbit, meaning that measurements are taken at the same time each day, thus failing to account for key differences in nighttime values. EPA's own work discusses that 99% of landfills have more negative temporal pressure during days compared to the rest of the time leading to overestimating methane emission. While not published, EPA should be aware of work done within its own agency regarding this topic.

Indeed, even the authors acknowledge the risks inherent in relying on such data: "[o]ur landfill attribution approach, which relies on a prior estimate from 2012, may therefore misallocate emissions to the Puente Hills Landfill instead of to co-located oil and gas operations".[78] Further, the study goes on to say, "[c]ompared to TROPOMI, both the prior and posterior GEOS- Chem simulations produce similar coefficients of determination (R2) and root-mean-square errors (RMSEs)," indicating that using the authors' estimated emission rates fail to explain any additional variability in the satellite measurement compared with the 2012 reported values.[79]

By not accounting for all the sources of uncertainty in the model and measurements in the reported uncertainty range, the authors have failed to demonstrate that the difference between the observed and reported collection efficiencies is statistically significant. The variation in observed collection efficiencies and significant sources of uncertainty in the observations do not provide sufficient justification for a 10% reduction in collection efficiency across the board.

2. The Duan Study does not support EPA's collection efficiency determination.

EPA similarly fails to explain how the conclusions of the *Duan, et al.*, 2022 study support its decision to lower collection efficiencies and uncouple collection efficiency from SEM. In fact, the conclusions set forth in the *Duan* study more closely *support* EPA's 2023 Supplement proposal to tie collection efficiency to SEM.

The *Duan* study observed 23 Danish landfills using a tracer gas dispersion method.[80] Gas collection efficiencies were calculated by taking the collected methane gas and dividing it by the sum of collected methane, methane emitted into the atmosphere, methane oxidized in cover soil, methane migrated laterally, and methane stored in the landfill body.[81] As a result, the study concluded that Danish landfills, on average, have lower collection efficiencies than other

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[78] *Id.*
[79] *Id.* at 13.
[80] Duan, Z., et al., *Efficiency of gas collection systems at Danish landfills and implications for regulations*, 139 WASTE MANAGEMENT 270 (2022), https://doi.org/10.1016/j.wasman.2021.12.023.
[81] *Id.*

countries, and suggested that such was the result of shallow wells, lack of gas collection in some areas, and low recovery due to minimal production.[82] The study based its conclusions on "whole-site methane," even when collection systems did not cover the site. Sites that had discontinuous GCCS operations had high collection efficiencies (94-95%) when the system ran, but lower collection efficiencies when the GCCS was turned off, leading to lower average collection efficiencies.[83]

Notably, the *Duan* study acknowledged the complexity associated with quantifying gas production, emissions, and collection efficiency.[84] The study stated, "[a]t landfills with well-designed liner and cover systems and aggressive gas collection approaches, efficiency can be as high as above 90%, as observed in previous studies (e.g. UK-J and Redwood landfills) based on whole-site emissions measurements."[85] Further, the study noted "[i]f gas collection has not been established in every cell at a landfill—for example, if no gas collection occurs at active cells—using average efficiency will underestimate the actual gas collection efficiency in closed cells."[86] Based upon the complexity of calculation and landfill-dependent factors, the study actually suggests coupling collection efficiency with SEM.[87] This acknowledgment better comports with EPA's proposal in the 2023 Supplement, rather than what was finalized in the Final Rule. In sum, the *Duan* study agrees that a one-size-fits-all approach is inappropriate when it comes to landfill collection efficiency—an implication that is directly at odds with EPA's decision to

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[82] *Id.* at 277.
[83] *Id.* at 274.
[84] *Id.* at 275 ("Landfill gas production and emissions are determined by many factors, such as waste composition, waste age, disposed waste amount, landfill design and operation, lack meteorological conditions, etc."); *see also id.* at 276 ("Gas collection efficiency depends on the phase of the landfills, design, and management of the LFG collection system, the presence or type of top cover, etc.").
[85] *Id.* at 270.
[86] *Id.* at 276.
[87] *Id.* Specifically, it states that "surface methane concentration screening could be conducted to identify significant release points or areas, following which any identified major leaks should be repaired."

lower default collection efficiencies across the board. With little more than a few sentences supporting EPA's use of this study in the Final Rule, EPA has failed to establish a rational connection between *Duan* and lowered default collection efficiency values irrespective of SEM.

Further diminishing any justification for reliance on the *Duan* study is the fact that it pertains to Danish landfills that are not representative of landfills across the United States. EPA has agreed with NWRA's contention that the data the agency used to support the proposed correction term—which rested on an analysis conducted using a dynamic flux chamber covering a surface area of 0.2 m^2 over 20 years ago at one landfill in Canada—could not adequately support the proposal.[88] Similarly, here, EPA should not rely on a study evaluating Danish landfills, especially where the authors state that there are stark differences between U.S. and Danish landfills. Specifically, the study states that the "measured emissions normalized to the disposed waste mass and areas of the landfills in Denmark are *significantly* lower than" normalized emissions of U.S. landfills, which may be the result of Denmark's 1997 ban on landfilling organic waste.[89] Consequently, relying on the *Duan* study is unacceptable, especially in light of EPA's outward refusal to rely on studies not found to be "nationally representative" of MSW landfills.[90]

3. **<u>The EIP and Duren Studies do not support EPA's collection efficiency determination.</u>**

Although EPA cites to both the EIP Study and the *Duren et al.*, 2019[91] study in the 2023 Supplement, EPA fails to adequately explain how either of these studies support its decision to

[88] Final Rule, 89 Fed. Reg. at 31855.
[89] *Duan et al.*, at 276.
[90] Data Quality Improvements Proposal, 87 Fed. Reg. at 37009.
[91] Duren et al., *California's Super Emitters*. 575 NATURE 180¬84. 7 (2019), https://doi.org/10.1038/s41586-019-1720-3.

lower collection efficiencies by 10% across all categories of affected landfills. As such, EPA's decision, which relies on these papers, is not supported.

EIP's findings rest on their discovery of a math error in the State of Maryland's methane emissions calculation for landfills. The study pointed out that the Maryland Department of the Environment calculated emissions as 10% of uncollected gases and 90% oxidized instead of 90% uncollected and 10% oxidized. From there, the study discussed how few landfills have gas collection and control systems—21 out of 40—with only four subject to federal requirements under the New Source Performance Standards program. EIP ultimately suggests two solutions: (1) more widespread implementation of gas collection systems, and (2) organics diversion. It compares collection efficiencies of facilities with gas collection and control systems that are subject to NSPS (76% collection efficiency) and those that voluntarily install such systems (55% collection efficiency): "EPA estimates that the average collection system harnesses 75% of the gas generated in the waste heap." However, EIP then notes that Maryland landfills have system collection efficiencies that range from 5-95%, with an average of 59%.

As stated in NWRA's comments to the 2023 Supplement, Maryland landfills are not representative of landfills across the United States and represent a low number of federally regulated landfills. Therefore, the data from this study should not be extrapolated to other landfills in the U.S. for comparing subpart HH collection efficiencies and LandGEM modeling-based collection efficiency. EPA exacerbated this misplaced reliance by failing to consider key variables in its analysis, including differences in waste disposal streams (and associated differences in potential methane generation capacity), calculation methodologies for collection efficiencies based on reported collection volumes, and the significance of federal expansion timelines and downtime limitations over the performance of SEM.

In addition, EPA failed to articulate a rational explanation with respect to how the study's conclusions support the across-the-board reductions in collection efficiencies seen in the Final Rule, and failed to address the concerns raised by NWRA in its comments. Ultimately, EPA went from using the EIP Study to support reduced collection efficiencies for facilities not conducting SEM, to reducing collection efficiencies for all Reporters regardless of SEM. Interestingly, EPA could not cite this study, or any other for that matter, to "support further reductions in gas collection efficiencies for voluntary gas collection systems."[92] Even in light of EPA's scientific and technical expertise, the use of the EIP Study to support the finalized changes is not "reasonable [or] reasonably explained." *FCC v. Prometheus Radio Project*, 592 U.S. 414 (2021).

To the extent that EPA's finalized collection efficiencies were promulgated using conclusions from *Duren et al.*, 2019, such reliance is likewise misguided. The *Duren* study conducted five campaigns between 2016 through 2018 to survey more than 272,000 "infrastructure elements" in California using an airborne imaging spectrometer that the authors alleged "can rapidly map methane plumes."[93] However, the *Duren* study conceded "[t]he fact that we did not detect a larger population of smaller methane point sources across the landfill sector suggests that most of those facilities emit methane as area sources that cannot be detected with this method."[94] EPA similarly acknowledged this shortcoming in its Technical Support Memo:

> *It is important to note that only landfills with anomalous emissions could be quantified by the aerial methods used by Duren, et. al., (2019) and that these emissions only occurred at 7 percent of the surveyed landfills. However, when these anomalous emissions occur, the CH4 emissions reported to the EPA under Subpart HH are consistently lower than the measured emission rates extrapolated to annual*

[92] Final Rule, 89 Fed. Reg. at 31856.
[93] *Duren, et al.*, at 180.
[94] *Id.* at 182.

> *estimates……… Because the California aerial study of Duren, et. al., (2019) could not quantify the emissions from 93% of the landfills that did not have anomalous emissions, this study does not provide evidence that the Subpart HH methodologies are inaccurate or unbiased under typical conditions that exist for most landfills.*[95]

The *Duren* study also failed to discuss diurnal issues or times of flights (*e.g.*, whether flights were conducted during the daylight hours), and it relied on a "persistence" factor that is inappropriate for multiple reasons. In this original publication, *Duren* gave landfills a blanket "100%" persistence factor, meaning that it extrapolated estimated emissions results to the entire year, which EPA has recognized as inappropriate.[96] Moreover, use of this persistence factor is inappropriate because the authors filtered their runs to weed out flights where they didn't get a detection, or the detection was unreliable for various QA/QC reasons.

Further, the *Duren* study never addresses whether the same plume may have been detected on multiple flyovers. This information is important, because it could either exaggerate or undermine the 100% persistence concept that is fundamental to emission quantification based on such remote observations. For example, different plumes would have different calculated emissions, with no one plume being appropriate for extrapolation. Further, the reality of variable emissions points reflect the variable nature of emissions over time. Assuming continuous emissions could easily overlook low- or even no-emissions days, in direct conflict with the notion of "100% persistence."

As another example, *Duren*'s methodology for calibrating wind data also relies on the work done by others in the Four Corners region, which is a very flat, desert type area that is inappropriate for other types of topography, including the canyon-topography landfills located in

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[95] EPA-HQ-OAR-2019-0424-0256 Technical Support for Supplemental Revisions to subpart HH; Municipal Solid Waste Landfills, at 3.

[96] *See discussion supra* in Section III.C.1.

California. These calculations are highly sensitive to accurate wind modeling, making *Duren*'s use of a wide geographic NOAA data area questionable. In particular, *Duren's* approach was to use NOAA data, and subdivide the area around the landfill into 3 km squares, averaging the 9 closest squares into the "average site windspeed and direction" and applying that to the detected concentrations.[97] But plumes are not formed in that manner in challenging topographical areas. As with the point above, more recent publications from *Duren* and others, as well as other industry presentations, recognize that canyon landfills are notoriously difficult from which to quantify emissions.

Like *Nesser*, which utilized satellite data to support its findings, the integrity of the aerial measurements collected in *Duren* cannot provide adequate support for the lowered collection efficiencies across the entire MSW landfill sector for the same reasons.[98]

4. <u>**Other papers and emerging studies do not support EPA's reduction in collection efficiency determination.**</u>

EPA, industry participants, and third parties continue to actively assess the value of remote sensing techniques for landfill emission quantification. While there is great interest and optimism around this topic, specific conclusions around collection efficiency values are premature. For example, in its comments to the 2023 Supplemental Proposal, Carbon Mapper has pointed out that there is "no existing system to validate or revise GHGRP reporting" based on "observed emissions rates using remote sensing."[99] Instead, Carbon Mapper suggested an multi-tiered monitoring approach to validate reported annual emissions by using a system to quantify "total site-wide emission sources" using "high-frequency to continuous monitoring."[100]

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[97] *Duren* et al., at 181.
[98] *See supra*, Section III.C.1.
[99] EPA-HQ-OAR-2019-0424-0324, at 5.
[100] *Id.* at 5.

In addition, in responding to EPA's stated concern in the 2023 Supplemental Proposal about large release events, Carbon Mapper recommended the use of site-specific data to aid in assessing these events to avoid double counting, including "construction periods and locations, type of GCCS and combustion devices, any use of automated well tuning, monitoring methods used (including non-regulatory, voluntary monitoring), and cover types used."[101]

To the extent that EPA intended to rely on top-down, direct measurement technologies to support the reduction in collection efficiencies, EPA improperly extrapolated data that, if collected on a continual basis, would tend to prove the opposite conclusion. For example, a study by *Cusworth*, et al. found that "[o]n average, aerial emission rates were a factor of 2.7 higher than GHGRP for all landfills and a factor 1.4 higher for landfills with 10+ unique overpasses. Consistent with this study, independent assessments of US emission inventories have indicated a needed 1.25 to 1.5 scaling of waste emissions to reconcile inventories with in situ ground-based measurements and coarse resolution satellite observations."[102] These findings emphasize even the Nesser authors' direct acknowledgement that the average of more point-in-time observations for a single site tends to agree more closely with annual inventory estimates; providing evidence that there is not enough data to support the extrapolated claim that observations are more representative than annual inventory estimates. The recency of the *Cusworth* publication reinforces the imperative raised by the Petitioners in their comments: that EPA should wait to promulgate changes to subpart HH in anticipation of forthcoming data that will provide more appropriate support for comprehensive changes.

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[101] *Id.* at 5.
[102] Cusworth, et al., *Quantifying methane emissions from United States landfills*. 383 SCIENCE 1499 (2024).

As discussed *supra* in Sections III.C.1 and III.C.2, remote sensing measurements using satellite and aircraft systems like TROPOMI and AVIRIS-NG, described in *Nesser*, et al., 2024 and *Duren*, et al., 2019, can only be made during daylight hours, causing landfill emission rates derived from these approaches to be biased high because the measurements are made during active landfilling operations and do not capture the period when the landfill is not receiving waste. Another study, *Delkash*, et al., 2022, used eddy covariance ("EC") measurements to assess diurnal variations in methane emissions and "showed that short-term tracer correlation method ("TCM") measurements conducted between 12:00 and 18:00 overestimate diurnal emissions estimated by the EC tower up to 73% at this site."[103] The EC methodology is able to operate continuously to capture concentration measurements to support emissions estimates over longer durations in a wide range of meteorological conditions and atmospheric stability classes. The study reported significant diurnal variation in methane flux at one landfill where EC and TCM were deployed over three seasons, and found that daytime methane flux rates were up to 23 times higher than nighttime fluxes.[104] Moreover, the daily average of EC observations presented a lower estimated emission rate when compared to tracer correlation method observations, a methodology similar to that used in the *Duan*, et al., 2019 study. While the *Delkash* study included only one landfill, its findings point to the potential bias of relying on daytime only measurements to determine landfill emissions rates, particularly when those rates will then be compared to annual rates like the GHGRP. The study, therefore, stands for the same conclusion articulated above: assessing the accuracy of the GHGRP modeled rates requires measurement methods that continuously monitor both point-source and diffuse emissions so as to better

[103] Delkash, et al., *Diurnal landfill methane flux patterns across different seasons at a landfill in Southeastern US*, 144 WASTE MANAGEMENT 76, 85 (2022).
[104] *Id.* at 76.

understand diurnal and seasonal variations to compare point-in-time observations to annual emissions inventory estimates.[105]

IV. <u>Basis for Relief and Proposed Next Steps</u>

Overall, EPA does not articulate a rational connection between the scientific and technical evidence relating to landfill collection efficiency and the decision to stray from its proposal and apply a uniform approach to collection efficiency values uncoupled from SEM. While NWRA did not support the SEM-based approach advanced by the 2023 Supplemental Proposal for the reasons expressed in our comments, we acknowledge the importance of site-specific design and performance factors in assessing collection efficiency. EPA's Final Rule is the opposite of a site-specific approach, based on SEM or otherwise. We expected the Final Rule to be the logical outgrowth of the proposal to tie collection efficiency adjustments to SEM. We also recognized that the proposed coupling of collection efficiencies and SEM served as an incentive for "non-regulated" landfills to implement SEM to avail themselves of the higher collection efficiencies. Lowering collection efficiency regardless of SEM now may have an unintended effect—if Reporters know that they can never achieve greater than 85% efficiency in estimating emissions under the GHGRP, there is little incentive to increase efficiency. EPA's simple explanation that lowered collection efficiencies are warranted in light of the agency's review of "direct measurement data for landfills" leaves an unfillable gap in reasoning and logic, warranting reconsideration.

NWRA and its members recognize the importance of developing technologies and ongoing studies and analyses of direct measurements and remote sensing data. The MSW landfill sector is deeply engaged in this work, in partnership with EPA's Office of Air and Radiation as

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[105] *Id.* at 85; *see also* Stark, et al., *Investigation of U.S. landfill GHG reporting program methane emission models*, 186 WASTE MANAGEMENT, 86, 86, 91 (2024).

well as its Office of Research and Development, Carbon Mapper, GHG Sat, RMI and others. Through SWICS and company-specific data analyses, NWRA anticipates that it will have a substantial set of data to share with EPA in the very near term, after appropriate quality control and assessment is complete. The data will consist of direct measurements, correlated with site-specific SEM and operational conditions, and evaluations of resulting emission impacts. NWRA will share this data with EPA in the proposed reconsideration period to help inform EPA's perspective on collection efficiencies. Most importantly, to the extent that these advancements assist in the strengthening of emission quantification and information, and thereby provide avenues for improvements in methane capture, the GHGRP should be structured to acknowledge and account for such improvements. The Final Rule unfortunately has the opposite effect, by imposing reduced collection efficiencies across the board, based on overgeneralized and qualitative theories that do not support the determination that was made.

As set forth at length above, NWRA requests that EPA grant reconsideration of the reduced collection efficiencies set forth in Table HH-3 of the Final Rule. Interested parties were not afforded the opportunity to comment on EPA's finalized collection efficiencies because they were not a "logical outgrowth" of the Proposed Rules.

To the extent that EPA declines to grant reconsideration on the bases set forth in Section 307(d)(7)(B) of the Clean Air Act, the Petitioner asks that EPA treat this submittal as a petition for rulemaking under the Administrative Procedure Act, 5 U.S.C. § 553(e), which is a "procedural right." *Massachusetts v. EPA*, 415 F.3d 50, 53 (D.C. Cir. 2005) *rev'd and remanded on other grounds by* 549 U.S. 497, 527 (2007); *Friends of the Earth v. EPA*, 934 F. Supp.2d 40, 54 (D.D.C. 2013) ("EPA is required to respond to a citizen petition for rulemaking.").

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Exhibit 4

National Waste & Recycling Association[SM]
Collect. Recycle. Innovate.

SWANA
SOLID WASTE ASSOCIATION OF NORTH AMERICA

July 21, 2023

Submitted electronically via
https://www.regulations.gov
Ms. Jennifer Bohman
U.S. Environmental Protection Agency
EPA Docket Center
Air and Radiation Docket
Mail Code 28221T
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Re: **Comment Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule; Docket ID No. EPA-HQ-OAR-2019-0424; Supplemental Notice of Proposed Rulemaking**

Dear Ms. Bohman:

On behalf of the National Waste & Recycling Association (NWRA) and Solid Waste Association of North America (SWANA) (collectively, "Landfill Industry Commenters"), set forth herein are comments to the Supplemental Notice of Proposed Rulemaking on Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule, published at 88 Fed. Reg. 32852-32947 (May 22, 2023); Docket ID No. EPA-HQ-OAR-2019-0424 (the "Proposed Rule").

The Landfill Industry Commenters represent companies, municipalities, and professionals in the solid waste industry. The NWRA is a not-for-profit trade association representing private solid waste and recycling collection, processing, and management companies that operate in all fifty states. SWANA is a not-for-profit professional association in the solid waste management field with more than 10,000 members from both the private and public sectors across North America. Our members strive to deliver collection, composting, recycling, and disposal services that are protective of the environment in a safe, science-based, and technologically advanced manner. It is important that regulatory policy enables us to continue to deliver these essential services.

The Landfill Industry Commenters have long been partners with EPA in developing data, methods and best practices governing the operation of municipal solid waste landfills, including the development of emission estimates and data governing the quantification of greenhouse gas emissions associated with our members' operations. We have been active participants in the rulemaking process for the Greenhouse Gas Reporting Program ("GHGRP"), and likewise are pleased to participate in this rulemaking process for the Proposed Rule.

Overview of Comments

The Landfill Industry Commenters submitted comments to the Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule, 87 Fed. Reg. 36920-37119 (June 21, 2022). A copy of our comment letter is attached hereto at Tab "A", and is incorporated into this submittal. In addition, the Landfill Industry Commenters offer supplemental comments relating to certain aspects of the Proposed Rule, as set forth below.

As a general matter, the Landfill Industry Commenters are supportive of the Agency's efforts under the GHGRP to ensure accurate estimates of GHG emissions to support various programs under the Clean Air Act and to inform policy determinations with respect to mitigating such emissions and climate risk. The solid waste sector has itself promoted these goals through the collection of data, initiation of studies, and partnering with leading scientists and academics in the field. We have shared those efforts with the Agency in its development of the GHGRP, and will continue to do so in the context of the Proposed Rule, as set forth below. However, we are concerned with the scope, scientific basis, and burden of several aspects of the Proposed Rule as it applies to municipal solid waste landfills.

We believe that the Agency would exceed its legal authority under Section 114 of the Clean Air Act and/or would contravene its own data quality and decision-making standards if certain aspects of the Proposed Rule are finalized. In short, the Agency is considering changes to Subpart HH of Part 98 that will not further its goals, and are based on data and conclusions that are unsupported by the scientific literature. As explained further herein, the Agency has proposed changes that would tend to overcorrect perceived gaps or undercounting of methane emissions from municipal solid waste landfills based on limited datasets and critical assumptions underlying third-party studies of landfills located in California and Maryland. As further described herein, we do not believe that those observations are representative of the municipal solid waste landfill sector as a whole, and are not an appropriate basis for Agency decision-making.

By contrast, and as explained below in detail at section 2 of this letter under the heading Subpart HH, the Solid Waste Industry for Climate Solutions ("SWICS") has assembled a comprehensive, peer reviewed set of data and information that directly addresses the reporting elements and calculations that the Proposed Rule would seek to capture. SWICS version 3 is forthcoming this year; the Landfill Industry Commenters ask the Agency to delay adoption of the proposed changes to Subpart HH pending further discussions and sharing of data by and among industry representatives and EPA. In addition, for the reasons set forth herein, the Landfill Industry Commenters believe that the Agency should not finalize Subpart B of the Proposed Rule governing Energy Consumption.

Global Warming Potentials

The Landfill Industry Commenters request that EPA clarify that any new GWP for methane would be used prospectively and not retroactively, and to consider the economic impact of additional years of reporting for the landfill sector under Subpart HH based on that GWP.

Further, the Landfill Industry Commenters have a specific concern regarding how EPA's use of the new GWP for methane of 28 could impact MSW landfills that have previously exited the program, if appropriate clarifications are not made to Subpart HH. As context, Landfill Industry Commenters note that the 2013 amendment to GWP acknowledged the unique nature of MSW landfills by revising Subpart HH §98.340, Definition of the source category, to provide a methane-based approach to defining the source category, using the 2013 reporting year to clarify that the new GWP would not be applied retroactively to sources that had already been excluded from the program based on prior reporting and GWP. This approach, which we likewise recommend here, will not decrease the number of currently existing MSW landfills subject to the GHGRP, but would exclude those closed MSW landfills that have already exited the program and are no longer required to report. As such we propose EPA make the following revisions to be consistent with EPA's 2013 approach:

§ 98.340 Definition of the source category.

(a) This source category applies to municipal solid waste (MSW) landfills that accepted waste on or after January 1, 1980, unless all three of the following conditions apply.

(1) The MSW landfill did not receive waste on or after January 1, ~~2013~~ ***of the year after the year during which the change in GWP is published in the Federal Register as a final rulemaking.***

(2) The MSW landfill had CH4 generation as determined using Equation HH–5 and, if applicable, Equation HH–7 of this subpart of less than 1,190 metric tons of CH4 in the 2013 reporting year **or 1,000 metric tons of CH4** ***of the year after the year during which the change in GWP is published in the Federal Register as a final rulemaking.***

(3) The owner or operator of the MSW landfill was not required to submit an annual report under any requirement of this part in any reporting year prior to ~~2013~~ ***of the year after the year during which the change in GWP is published in the Federal Register as a final rulemaking.***

Subpart HH

1. Data Quality and Proposed Revisions to Subpart HH

The Proposed Rule does not meet EPA's data quality and scientific standards, and thus cannot be supported as an appropriate exercise of EPA's rulemaking authority under Section 114 of the Clean Air Act. Indeed, EPA repeatedly states in the preamble to the Proposed Rule that the purpose of the proposal is to improve the quality and consistency of the rule and to provide for the collection of improved data under the GHGRP. *See, e.g.*, 88 Fed. Reg. at 32852. However, EPA's proposal in some instances is based on externally generated data and assumptions that do not meet EPA's standards for scientific and technical information which it may rely upon, and therefore are not well founded. For example, EPA's *Summary of General Assessment Factors For Evaluating the Quality of Scientific and Technical Information* (June 2003) (available at https://www.epa.gov/sites/default/files/2015-01/documents/assess2.pdf) (hereinafter "General Assessment Factors") established five factors for the Agency's evaluation of externally generated information: 1) soundness - the extent to which the scientific and technical procedures, measures, methods or models employed to generate the information are reasonable for, and consistent with, the intended application; 2) applicability and utility - the extent to which the information is relevant for the Agency's intended use; 3) clarity and completeness - the degree of clarity and completeness with which the data, assumptions, methods, quality assurance, sponsoring organizations and analyses employed to generate the information are documented; 4) uncertainty and variability - the extent to which the variability and uncertainty (quantitative and qualitative) in the information or in the procedures, measures, methods or models are evaluated and characterized; and 5) evaluation and review - the extent of independent verification, validation and peer review of the information or of the procedures, measures, methods or models. An evaluation of the General Assessment Factors in the context of the studies and data cited in support of the Proposed Rule, as detailed below, demonstrate that EPA must expand its review of data and then allow stakeholders to review such information prior to finalizing the Proposed Rule provisions addressing municipal solid waste landfills.

Likewise, EPA's *Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information by the Environmental Protection Agency* (October, 2002) (available at https://www.epa.gov/sites/default/files/2020-02/documents/epa-info-quality-guidelines_pdf_version.pdf) (hereinafter "Integrity of Information Guidelines") require the Agency to ensure and maximize the quality of information that EPA disseminates. A key element of the Integrity of Information Guidelines is EPA's Peer Review Policy, which provides that major scientifically and technically based work products (including scientific, engineering, economic, or statistical document) related to Agency decisions should be peer-reviewed. EPA's *Peer Review Handbook* (4th Edition 2015) (available at https://www.epa.gov/sites/default/files/2020-08/documents/epa_peer_review_handbook_4th_edition.pdf) establishes guidance for implementing the policy. Finally, President Biden's *Memorandum on Restoring Trust in Government Through Scientific Integrity and Evidence-Based Policymaking* (Biden, 2021) (available at https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/memorandum-on-restoring-trust-in-government-through-scientific-integrity-and-evidence-based-policymaking/) announced the policy of the Biden Administration to make evidence-based decisions guided by the best available science and data, stating that *[w]hen scientific or technological information is considered in policy decisions, it should be subjected to well-established scientific processes, including peer review where feasible and appropriate*.

As set forth below, the Landfill Industry Commenters are concerned that the Agency's reliance on externally generated data and information that is incomplete and has not been peer reviewed, fails to comport with EPA's own standards and policies for scientific data, and will undercut its otherwise worthy objectives for GHGRP reporting by municipal solid waste landfills under Subpart HH. Further, in each of the proposed changes discussed below, the Agency appears to be adding complexity and burden to the reporting scheme, without a showing of a commensurate or greater benefit in terms of data accuracy or completeness. Subpart HH affected sources are already subject to considerable conservatin reporting under the existing program – the added obligations set forth in the Proposed Rule would unreasonably add to that conservatism in a manner that will tend to overestimate emissions at the expense of reporters.

a. Duren Study and fRec and fDest

Citing an aerial study by Duren, et.al as a basis for its proposal, the Agency noted in its preamble that the proposed revisions to Subpart HH in the Proposed Rule would account for "methane emissions from large release events that are currently not quantified under the GHGRP." 88 Fed. Reg. at 32877; Duren, R.M. et.al., 2019*: California's Methane Super-Emitters,"* Nature 575, 180-184, 7 November 2019. The Agency identified three potential causes for large releases of methane: 1) a poorly operating or non-operating gas collection system; 2) a poorly operating or non-operating destruction device; and 3) a leaking cover system due to cracks, fissures, or gaps around protruding wells. *Id.* Notably, EPA's own Technical Support Memo acknowledges that:

> *It is important to note that only landfills with anomalous emissions could be quantified by the aerial methods used by Duren, et. al., (2019) and that these emissions only occurred at 7 percent of the surveyed landfills. However, when these anomalous emissions occur, the CH4 emissions reported to the EPA under Subpart HH are consistently lower than the measured emission rates extrapolated to annual estimates……… Because the California aerial study of Duren, et. al., (2019) could not quantify the emissions from 93% of the landfills that did not have anomalous emissions, this study does not provide evidence that the Subpart HH methodologies are inaccurate or unbiased under typical conditions that exist for most landfills.*

Memo from Liz Goodiel to Docket ID No. EPA-HQ-OAR-2019-0424, *Technical Support for Supplemental Revisions to Subpart HH; Municipal Solid Waste Landfills*, at p. 3. In addition to this express limitation acknowledged by EPA, its analysis of the California aerial surveys fails to take into account the large percentage of landfills for which the aerial surveys did not detect anomalous emissions. The Landfill Industry Commenters also agree with and incorporate by reference the observations made by Morton Barlaz, in his review of the Duren paper and associated Agency conclusions, set forth in a comment letter submitted separately to the rulemaking docket. Barlaz's observations include, importantly, that EPA fails to identify all of the factors that can affect collection efficiency, such as type of cover and well density. As such, the Agency's proposal for adjustments to reporting do not fully capture all of the factors affecting overall collection efficiency, which is already subject to numerous assumptions and qualifications under Subpart HH. Further, EPA's reliance on the California aerial studies in determining the need for rule revision does not appear to comport with its General Assessment Factors; in particular, the soundness of the assumptions and conclusions arising from that study and their application across the landfill sector, as well as the level of completeness of the data set for the purposes intending to be served.

Specifically, the California aerial surveys do not correlate identified plumes with anecdotal periods of GCCS system maintenance, construction, or other downtime event - events that would already be captured in the current fRec and fDest methodologies. It is therefore likely that at least some of the anomalous events surveyed were already captured in GHGRP submissions. Second, the California aerial surveys do not determine whether identified plumes are from the same release event for different overpasses, which are frequently on the same day – leading to reliability questions for the calculated "Persistence" when trying to inform changes to annual emissions reporting methodologies. These two points lead the Landfill Industry Commenters to question whether the "anomalous emissions" identified are actually exclusive to the emissions estimates reported through GHGRP. Further, the Landfill Industry Commenters point to the Duren paper's Supplemental Table 5, in which 4 of 30 "landfill – 4A1 Managed Waste Disposal Sites" have a calculated emissions rate less than the GHGRP reporting threshold of 114 kg/hr (1,000 metric tons / annum). The Landfill Industry Commenters view these relatively low detection and quantification levels as casting doubt on the theory that diffuse area emissions cannot be detected by this methodology – at least for sites that report much larger calculated emissions through Subpart HH calculations. Given that the extrapolating of the aerial surveys' calculated emissions rates to whole-year emissions amounts is inappropriate due to diurnal and seasonal variation, one would still expect aerial survey to find methane plumes from areas susceptible to methane emissions already identified by Subpart HH methodologies (areas with only daily cover, areas with no GCCS, etc). These plumes would then need to be subtracted from the "anomalous emissions" to determine exclusive, additional emissions – a calculation step not explored by the Duren paper. The calculated emissions rates fall within the reported range of GHGRP emissions rates and therefore don't present clear evidence that the emissions are actually anomalous. Further, for the 93% of landfills that were not identified as having persistent plumes, the paper cannot determine any emissions rate, neither in comparison to GHGRP reporting thresholds nor GHGRP reported emissions – a key consideration given the proposed changes affecting the entire Subpart HH sector. Lastly, the Duren paper generates individual source uncertainties ranging from +/- 4% to +/-95%, which they comment is consistent with "the theoretical best-case performance of 15-50% uncertainty for an equivalent precision instrument and ideal plumes…". The Landfill Industry Commenters do not believe these ranges comport with the General Assessment Factors.

Although EPA states that the proposed changes to the definitions of fRec and fDest are intended to capture large release events, they would likely not serve that purpose and instead would add burden rather than value to landfill reporting. Most importantly, far from generating data relating to large release events, the revisions would instead tend to capture very limited and/or marginal data related to very short and otherwise typical operational periods. First, the Agency proposes revisions to the term fRec, as used in Equations HH-7 and HH-8, to exclude from the calculation of landfill gas collection system operations those circumstances in which systems may be operating "poorly" such as when pressure, temperature, or other parameters indicative of system performance are outside of normal variances. *See* 88 Fed. Reg. at 32877 and 32931. The Landfill Industry Commenters believe that this seemingly simple language makes little sense and will be impossible to implement in the context of a typical gas collection system, which may consist of hundreds of wells and other components. In particular, use of the term "normal variances" is misleading, because gas collection systems are dynamic rather than static and require constant adjustment, all of which are expected aspects of system operation and the very basis for EPA's selection of the work practice standards underlying the Municipal Solid Waste Landfill NSPS and NESHAP standards. In fact, pressure, temperature and other parameters are adjusted quite frequently and system components and cover are subject to frequent repairs, none of which would be expected to affect the overall collection efficiency that is otherwise taken into account within the NSPS, the NESHAP and Subpart HH. Further, with a lack of clear direction as to how to account for such periods of "poor" operation as compared to "normal variances", which concept is undefined, reporters will inevitably arrive at various means of defining these periods, thus leading to inconsistency and unreliability in reporting. Finally, reducing collection system operating hours to only include periods of "normal" operation effectively double counts the gas collected during those periods by reducing the calculated fRec value to the same extent as if the collection system were not operating, resulting in potentially significant overestimation of emissions. Accordingly, the Landfill Industry Commenters request that EPA remove the word "normally" from the first sentence and remove "or poor operation, such as times when pressure, temperature, or other parameters indicative of operation are outside of normal variances," from the second sentence of the proposed definition of fRec.

Likewise, the proposed revision to the term fDest would attempt to define and exclude periods when the destruction device is operating "poorly" such that the calculation of annual operating hours for the destruction device should include only "those periods when flow was sent to the destruction device and the destruction device was operating at its intended temperature or other parameter indicative of effective operation. For flares, the times when there is no pilot flame present must be excluded from the annual operating hours for the destruction device." *See* 88 Fed. Reg. at 32878, 32931. Again, the Landfill Industry Commenters believe that this level of detail in Subpart HH reporting is neither necessary nor warranted in order to ensure that reported data is robust, and instead would tend to overcorrect a perceived problem. A large portion of landfill gas control devices are open flares, which have no parameter for monitoring effective operation other than the presence of flame. The default EPA methane destruction efficiency for open flares is 99%. Regardless of operating temperature, the destruction efficiency of enclosed flares is always as high or higher than the destruction efficiency of open flares due to residence time within the flare stack. Further, most landfill gas destruction devices, such as flares, are equipped with automatic shutoffs in the event that temperature falls below a set point, loss of flame, or other applicable parameter to ensure proper operation, and such shutdown occurs quickly to prevent prolonged periods of operation at low temperature, loss of flame, or other applicable parameter. Likewise, startup procedures are well defined and designed to proceed through the sequence deliberately and safely. While these periods are defined by manufacturers' specifications for safe operations, it would be extremely difficult to pinpoint the duration of these events on an individual or collective basis in an attempt to quantify the insignificant increased emissions during these periods. Even at low temperatures, some landfill gas destruction is occurring within the device, and therefore exclusion of these periods from the calculation would incorrectly over report GHG emissions during those periods since fDest would be calculated as if the device were free-venting the gas with no combustion during the period. (In fact, if a control device is operating with the presence of flame, virtually all methane is destroyed regardless of operating temperature – the default methane destruction efficiency for control devices is 99%, regardless of device type.) Accordingly, the Landfill Industry Commenters suggest that the definition of fDest should exclude the proposed reference to "intended temperature or other parameter indicative of effective operation."

The sentence addressing the pilot flame should also be removed from the proposed revision of fDest, because it is confusing, unnecessary, and technically incorrect. First, a pilot is not typically required to maintain combustion in landfill gas flares and is only used during the startup process. The presence of a flame, either the pilot or the main flame, shows the flare is operating and destroying gas. To prevent the unnecessary combustion of pilot fuel (typically propane), landfill gas flares do not typically run with a continuous pilot flame. Instead, the flare startup sequence starts by a spark lighting the pilot flame. After the presence of a pilot flame is confirmed, the landfill gas fail-closed valve opens, and landfill gas is introduced into the flare combustion process. After a brief period of time (usually several minutes) the pilot turns off. However, the presence of flame continues to be monitored. If the presence of flame is no longer detected, the flare shuts down and the fail-closed valve shuts to prevent venting of unburned gas. Periods where there is no flame (either pilot or main) are addressed by the first sentence of the f_{dest} definition and therefore need not be separately addressed.

Finally, we recommend removing the phrase "… as measured at the nth measurement location" from the first sentence of fDest description. This text is unnecessary and adds confusion by implying that the time gas is sent to the nth measurement location equals the time gas is sent to the control device, which is not necessarily the case when more than one control device is associated with the measurement location. Because flares and other destruction devices are designed with fail-closed valves or other devices to prevent venting of gas when they are not operating, applying the definition as written overestimates emissions when a measurement location has more than one destruction device and all devices are not operating at the same time.

Based on all of the above, the Landfill Industry Commenters suggest the following definition of fDest:

> *Fraction of hours the destruction device associated with the n^th^ measurement location was operating during active gas flow calculated as the annual operating hours for the destruction device divided by the annual operating hours flow was sent to the destruction device. If the gas is transported off-site for destruction, use $f_{dest,n} = 1$. If the volumetric flow and CH_4 concentration of the recovered gas is measured at a single location providing landfill gas to multiple destruction devices (including some gas destroyed on-site and some gas sent off-site for destruction), calculate $f_{dest,n}$ as the arithmetic average of the f_{dest} values determined for each destruction location with that measurement location.*

b. EIP Study and Collection Efficiency

In addition to the Duren study, EPA considered a study of Maryland landfills undertaken by the Environmental Integrity Project ("EIP"), in which EIP calculated collection efficiency for the studied landfills based on data reported to the state GHG inventory for 2017, using collected landfill gas as a portion of modeled landfill gas generation. Despite the inherent deficiencies in comparing actual to modeled data, the EIP study concluded that collection efficiencies for landfills with voluntarily installed landfill gas collection and control systems (for which no surface methane emission monitoring was required) were 21 percentage points lower than the collection efficiencies for landfills with federal mandated landfill gas collection and control systems (for which surface methane emission monitoring was required). EIP 2021. *Greenhouse Gas Emissions From Maryland's Landfills: Underestimated and Under Regulated*. June 9. Available at: https://environmentalintegrity.org/wp-content/uploads/2021/06/MD-Landfill-Methane-Report-6.9.2021-unembargoed_with-Attachments.pdf (hereinafter, "EIP Study").

EPA then compared the collection efficiencies reported by EIP for 14 of those Maryland landfills which also reported under Subpart HH of the GHGRP for reporting year 2017, and concluded that there was a 22-percentage point difference between the EIP collection efficiencies for those landfills with voluntary landfill gas collection and control systems and those with federally mandated landfill gas collection and control systems. EPA then also compared the reported collection efficiencies for those same 14 landfills as reported under Subpart HH and concluded that there was a 13-percentage point difference between the Subpart HH collection efficiencies for those Maryland landfills with voluntary gas collection systems and those with federally mandated landfill gas collection systems. On that basis, the Agency proposes additional default collection efficiencies in Table HH-3 to account for the apparent reduced collection efficiencies observed for landfills for which surface methane emission monitoring is not performed. *See* Memo from Liz Goodiel to Docket ID No. EPA-HQ-OAR-2019-0424, *Technical Support for Supplemental Revisions to Subpart HH; Municipal Solid Waste Landfills,* at p. 8. Specifically, the EPA proposes new 10-percent lower collection efficiencies for landfills for which surface emission monitoring is not conducted.

EPA's reliance on the EIP Study in support of the Proposed Rule is unwarranted, because the EIP Study does not appear to have been peer reviewed in a manner consistent with EPA's General

Assessment Factors and its Peer Review Policy. In the acknowledgements, two EIP authors are credited with reviewing the EIP study. See EIP Study at p. 1, 2. However, according to EPA's Peer Review Policy, peer review only occurs when "scientifically and technically based work products are evaluated by relevant experts who *were not involved in creating the product* (emphasis added). EPA, *Peer Review and Peer Involvement at the U.S. Environmental Protection Agency*. The two acknowledged reviewers work for EIP and assisted with some of the data analysis for this specific study, and thus were involved in the creation of the final product. EPA's Peer Review Handbook emphasizes that "peer review of scientific and technical work products that support regulations is an important, fundamental step in policy setting and regulatory development processes." *Peer Review Handbook*, at p. 28-9.[1] Any work product that is "important to EPA decision making" and "independently generated," such as this study by EIP, "should be considered as [a] candidate for peer review." *Id.* at 47. Especially when relying on scientific or technical information from an outside organization, EPA "should work with that organization… to promote the use of peer review." *Id.* at 48. The fact that this study was not properly peer reviewed in accordance with EPA's own guidance, calls into question the data quality and credibility of the primary study used by EPA as a justification for the agency's proposed revisions to Subpart HH.

In its Technical Support Memo, EPA acknowledges that the differences between the EIP and Subpart HH reported collection efficiency could be attributed to methodology. Specifically, the Memo states: "The subpart HH calculated collection efficiencies are consistently higher than those determined from the Maryland inventory data. This may indicate that the subpart HH defaults are too high, but it may also indicate that the "potential methane generation capacity" input term for LandGEM (which is analogous to the DOC term used in Equation HH-1) is higher than the actual potential CH_4 generation capacity of the waste being disposed. That is, because the CEs determined from the Maryland data are based on modeled CH_4 generation rather than actual measured CH_4 emissions from the landfills, it is just as likely that the Maryland CEs are biased low as the subpart HH CEs are biased high." *Technical Support Memo* at p.8.

The majority of the Maryland landfills (13 out of 14) in the EPA's comparison are County-owned landfills that generally do not accept significant out-of-state waste tonnages. The Maryland Recycling Act state law enacted in 1988 requires counties to divert compostable waste/organics and recyclable waste from landfill waste streams. Counties with <150,000 people must divert 20 percent and counties with >150,000 people must divert 35 percent. Many Maryland counties also have a focus on voluntary (non-state mandated) organics diversion from landfills. Furthermore, waste incineration currently is a significant method of waste management in Maryland, with two major waste incineration facilities in high population areas (in operation since 1985 and 1995) and two coal power plants. The EIP study appears to fail to account for these considerations. Because of the state-mandated requirements for waste diversion (which has significantly reduced methane-producing waste disposed in Maryland landfills for the past 20-30+ years) coupled with the higher percentage of inert incinerator ash it is <u>more likely</u> that the EIP Maryland collection efficiencies are biased low because the potential methane generation capacity LandGEM input term is too high.

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[1] Notably, there is no mention of any EPA peer review process for the studies relied upon in support of the Proposed Rule on EPA's Peer Review Agenda website. EPA, *Science Inventory: Peer Review Agenda*. This may indicate that EPA does not consider these studies to rise to the level of influential scientific information (ISI), a label which would require EPA to follow specific OMB peer review polices. EPA, *Peer Review Handbook* at 42. However, even if a work product does not rise to the level of ISI, EPA's Peer Review Handbook stresses that such work product "will have greater standing in the scientific community if an independent peer review is completed." *Id.*

Furthermore, as noted above, the EIP study compares actual landfill gas recovery rates to modeled results in order to estimate collection efficiency. Because this approach uses actual landfill gas recovery, this calculation would already account for factors such as gas system operation/downtime. In contrast, Subpart HH collection efficiencies are based solely on the proportion of landfill areas with gas collection and specific cover types (daily, intermediate or final cover) and do not incorporate factors such as gas collection operation and destruction device operation. As such, this would further bias low the EIP Maryland collection efficiencies when compared to Subpart HH collection efficiencies. It should be noted that the Subpart HH methane emission rate calculated by equation HH-8 does account for these through the fRec and fDest terms, which are distinct parameters separate from the Subpart HH collection efficiency factor.

Maryland is a comparatively small state with a comparatively low number of active landfills. There are currently only four (4) federally-regulated landfills in Maryland (the 3 landfills in the EPA's comparison plus the Sandy Hill Landfill). In contrast, there are hundreds of federally-regulated landfills across the U.S. In combination with the waste diversion rates and incinerator ash waste streams, Maryland landfills are not representative of all the landfills that would be subject to EPA's proposed changes across the sector. Furthermore, with the low number of landfills in its comparison, EPA's dataset does not allow for analysis of statistically-significant differences between landfills and, apart from incorporation into a larger dataset, should not be used to justify changes to requirements applicable to landfills across the U.S.

EPA's proposed rule change regarding collection efficiency presumes that performing surface emission monitoring is the sole or primary factor for the differences in collection efficiency between EIP and Subpart HH landfills in Maryland. In its Technical Support Memo, EPA states that it is "clear that landfills that have federally required GCCS appear to have higher CEs than voluntary systems." *Technical Support Memo* at p.8. We agree with the statement in that, on average, landfills with federally-required GCCS would be expected to have higher collection efficiencies than landfills with voluntary collection systems. However, this difference is due to the fact that federally-regulated systems are required to provide comprehensive control, must meet prescriptive timelines for system GCCS expansion, and must limit system downtime to a minimum, and not based on whether or not surface emission monitoring is performed. Landfills with voluntary systems are often designed with different objectives, such as to provide localized odor or migration control and/or to provide gas collection over a limited area of the landfill. Voluntary systems also are not subject to federal requirements to limit system downtime, and may therefore operate on an intermittent basis or with large periods of downtime. These factors are, however, already addressed in the current Subpart HH, equation HH-8 methodology.

Maryland landfills are not representative of landfills across the U.S. and represent a small subset with a low number of federally regulated landfills. Therefore, this data should not be used in isolation from other landfills in the U.S. for comparing Subpart HH collection efficiencies and LandGEM modeling-based collection efficiency. It appears EPA failed to consider key variables in its analysis including differences in waste disposal streams (and associated differences in potential methane generation capacity), calculation methodologies for collection efficiencies based on reported collection volumes, and the significance of federal expansion timelines and downtime limitations over the performance of SEM.

Like its reliance on the California aerial study, the Agency's use of the Maryland study to support a change to the default collection efficiency table in Subpart HH represents an inappropriate change that is based on a small subset of landfills that is likely not representative of the sector, and which will lead to an inaccurate and overreporting of GHG emissions from the sector.

c. Quantification of Emissions from Surface Emissions Exceedances

Based on both the California and Maryland studies, EPA proposes a series of changes to Equations HH-6, HH-7 and HH-8 intended to quantify emissions associated with monitored surface emissions exceedances. For the reasons set forth above, the Landfill Industry Commenters do not believe that the California and Maryland studies are an adequate basis on which to make such changes to Subpart HH. Further, the methodologies set forth in EPA Technical Support Memo do not adequately capture the complexity of the attempted correlation between surface emission exceedances and methane flux. The Technical Support Memo cites two studies, and relies on one study (Heroux, et.al.) which describes an analysis (by Fécil, et. al.) conducted using a dynamic flux chamber covering a surface area of 0.2 m^2 over 20 years ago at one landfill in Canada. *See* Technical Support Memo at p. 9. Looking at Figure 6 in the original paper by Fécil, et. al., one can see in that there are exactly 6 data points defining the relationship between flux and surface concentration above 500 ppm. No justification is provided for extrapolating the relationship between flux and near surface methane concentration observed in 0.2 m^2 area to an area at a typical landfill that may be 4,500 times larger. Further, EPA's Technical Support Memo states "The SMCM are conducted every 30 meters, so each measurement location represents a 900 m^2 area (30 m × 30 m)." *Technical Support Memo* at p. 9. While the spacing between surface emission monitoring walking paths is 30 m, measurements are taken continuously while walking along the path. Further, it is unclear why a square area has been chosen (rather than, for example, a circle) and how the proposed approach would be applied in practice where there may be separate exceedances detected in close proximity to each other. Given that the majority of SEM exceedances occur at cover penetrations or cracks, any associated emissions would be expected to be much more localized and occur over an area much less than 900 m^2. The area of a typical vertical gas well boring (about 0.7 m) would better represent the majority of SEM exceedances.

There are several other studies that EPA should consider in this context, all of which show significant variability in any such attempted correlation and would cast doubt on EPA's reliance on a singular study and limited data set. *See e.g.* Abedini, A. R. 2014. *Integrated approach for accurate quantification of methane generation at municipal solid waste landfills*. Ph.D. thesis, Dept. of Civil Engineering, Univ. of British Columbia; Abichou, T., J. Clark, and J. Chanton. 2011. *Reporting central tendencies of chamber measured surface emission and oxidation*, Waste Manage.(Oxford) 31: 1002–1008. https://doi.org/10.1016/j.wasman.2010.09.014; Fécil, B., M. Héroux, and C. Guy. 2003. *Development of a method for the measurement of net methane emissions from MSW landfills*; In Proc., Sardinia 2003, 9th Int. Landfill Symp. Cagliari, Italy: CISA Publisher; Lando, A. T., H. Nakayama, and T. Shimaoka. 2017 *Application of portable gas detector in point and scanning method to estimate spatial distribution of methane emission in landfill*, Waste Manage. (Oxford) 59: 255–266. https://doi.org/10.1016/j.wasman.2016.10.033; Hettiarachchi, H., Irandoost,E., Hettiaratchi, J. P., and Pokhrel, D. 2023. *A Field-Verified Model to Estimate Landfill Methane Flux Using Surface Methane Concentration Measurements under Calm Wind Conditions*, J. Hazard. Toxic Radioact. Waste: 27 https://doi.org/10.1061/JHTRBP.HZENG-1226.

In addition, the Landfill Industry Commenters offer specific comments on the proposed equation terms as follows:

- dM Leak duration: EPA offers no justification for assuming that the duration of surface emissions exceedances extend back to the prior monitoring event. This assumption significantly overestimates the resulting GHG emissions.

- 0.0000284 Correlation factor: support for this value and its application is lacking as noted in the observations noted above.

- EPA offers no basis for multiplying the new surface emission measurement term [0.0000284 x dm x Sm] by the oxidation factor OX in HH-6, and why a similar application is not provided in HH-7 and HH-8.

The Agency's reliance on six data points from one study at one Canadian landfill that is 20 years old to support a substantive change to the emission calculation equations is inappropriate and inconsistent with data quality and peer review procedures. It is also not representative of the sector and will lead to an inaccurate and overreporting of GHG emissions from the sector. It would also impose confusing and burdensome data collection and reporting requirements to public and private landfill owners and operators. Based on all of the above, the Landfill Industry Commenters believe that it would be premature at this time to amend Subpart HH to account for surface emissions exceedances in the manner set forth in the Proposed Rule.

d. <u>Multivariate Analysis and DOC and k Values</u>

EPA relied on two technical papers authored by RTI entitled *Multivariate analysis of data reported to the EPA's Greenhouse Gas Reporting Program (GHGRP), Subpart HH (Municipal Solid Waste Landfills) to optimize DOC and k values* (June 11, 2019), and *Comparison of U.S. Inventory Waste Model Decay Rate (k) Values to Other UNFCCC Annex 1 Country Defaults and Country-specific Waste Models* (June 18, 2019), both of which are available in the rulemaking docket, as support for revisions to the DOC and k values in Subpart HH of the GHGRP. The two RTI memos do not appear to comply with General Assessment Factors, especially factors (5) evaluation and review and (1) soundness.

First, the evaluation and review factor (5) "refers to the extent of independent verification, validation and peer review of the information." *General Assessment Factors*, at p. 8. Neither RTI memo provides any mention nor certification of an independent peer review. According to EPA's Peer Review Policy, "peer review of all scientific and technical information that is intended to inform or support Agency decisions is encouraged and expected." EPA. *Peer Review and Peer Involvement at the U.S. Environmental Protection Agency*, (Jan. 2006). Furthermore, "any work product that is "important to EPA decision making" and "independently generated," such as these analyses conducted by RTI, "should be considered as [a] candidate for peer review." *Peer Review Handbook* at p. 42. The fact that these memos, which function as the technical basis for the DOC and k value changes, were not independently peer reviewed, undermines the quality and credibility of this scientific information.

Second, RTI's June 18, 2019 memo does not satisfy the (1) soundness factor in EPA's General Assessment Factors. Soundness is described by EPA as the "extent to which the scientific and technical procedures, measures, methods or models employed to generate the information are reasonable for, and consistent with, the intended application." *General Assessment Factors*, at p. 4; RTI's memo relies on the k values reported by other Annex I countries to determine the new k values for U.S. landfills. Although the other countries are claimed to have similar climates to the U.S., there are multiple significant differences between the U.S. and these countries which make reliance on their k values unreasonable, such as different laws, waste management practices, and the U.S.'s vast geography with varying climates. These differences are not discussed or accounted for in RTI's literature review. Furthermore, the other countries' k values rely on the IPCC 2006 model, which is an international model that is designed for a wide range of countries, not for specific U.S. landfill site conditions. The assumption that the 2006 IPCC model bulk waste k values yield more realistic estimates of landfill gas generation from U.S. landfills has not been justified by the EPA. Furthermore, EPA's proposed k value for moderate climates (0.111) is 2.2 times the IPCC value for temperate climates in this precipitation range (0.05), and their value for wet climates (0.142) is about 60% higher than IPCC's bulk MSW k value for wet temperate climates (0.09).

RTI developed the k values proposed by the EPA by performing a multivariate analysis to minimize the difference between the reported values from Equations HH-7 and HH-1. EPA's analysis optimized k and DOC simultaneously to adjust the results from HH-1 to more closely align with the "observed" HH-7. This approach is concerning as follows:

- The "observed" value of HH-7 is an estimate that is approximate and is not an "observation". Adjusting the k and DOC values to minimize the difference between HH-1 and HH-7 values will produce error to the extent that the HH-7 estimates do not reflect actual collection efficiency.

- Optimizing k and DOC values simultaneously can lead to extreme and unrealistic values because an error in one value causes an offsetting error in the other to yield the same LFG generation estimate. This error occurs in the RTI study because DOC and k values are not constrained to realistic values, but are allowed to vary across a 40-fold range, so that DOC and k pairs are unlikely to accurately reflect the waste composition and decay rates at many of the study sites. The extremely wide observed range of "optimized" k values (e.g., 0.001 to 0.400 for dry climates) produce so much uncertainty in the estimated average value as to render it practically meaningless.

- The changes to estimated LFG generation from proposed new k and DOC values are 2.5 to 3 times higher than the existing values, and will produce large increases in LFG generation and emissions estimates for open sites. Because the k values are not supported by a valid, peer-reviewed study by a waste sector expert, they appear to be chosen not based on science but on the desired effect. EPA has indicated a belief that methane emissions from landfill have been underestimated based on aerial studies indicating higher methane emissions may be present. Putting aside for the moment questions of the accuracy, uncertainty, and limitations of quantifying methane emissions from landfills using remote sensing, the solution to a potential underestimation of landfill methane emissions is not assuring that LFG generation is overestimated in emissions models.

For these reasons, the method employed by RTI to generate the new U.S. k values is "not reasonable for and consistent with the intended application," of such information in U.S. landfills. *General Assessment* Factors at p. 4. The Landfill Industry Commenters provided comment on the proposed DOC and k values in the October 2022 comment letter attached hereto, and continue to disagree with certain of these proposed values set forth herein. In particular, we again request that the Agency reconsider the work done by the Environmental Research and Education Foundations ("EREF") with respect to DOC values. The Environmental Research & Education Foundation (2019), *Analysis of Waste Streams Entering MSW Landfills: Estimating DOC Values & the Impact of Non-MSW Materials*, (available at www.erefdn.org). In addition to those comments, we support and ask EPA to consider the review conducted by Morton Barlaz, as set forth in his comment to the Proposed Rule.

2. Proposed Collaboration with Solid Waste Industry for Climate Solutions

In July 2007, the Solid Waste Industry for Climate Solutions ("SWICS") released its first white paper entitled *Current MSW Industry Position and State-of-the-Practice on LFG Collection Efficiency, Methane Oxidation, and Carbon Sequestration in Landfills* ("SWICS White Paper"). The White Paper was updated in 2009 (version 2.1) to incorporate additional studies and data, and again in 2012 (version 2.2) to include methane oxidation results from evaluations of cover soils at 90 landfills. As a general matter, the SWICS White Paper can be considered the most comprehensive compilations of peer-reviewed data and studies relating to a broad range of municipal solid waste landfills, for the express purpose of creating a methodology that would result in more accurate inventories of methane from landfills. Unlike the Duren and EIP studies set forth above, the SWICS studies do not suffer from a lack of representativeness – SWICS presents the municipal solid waste industry state-of-the-practice on LFG collection efficiency, methane oxidation, carbon sequestration, LFG generation modeling, and methane destruction efficiency in LFG control devices as they occur at landfills based upon reviewed literature. Literature was reviewed to:

- Compile and critically analyze published information on LFG collection efficiencies;
- Compile and critically analyze published information on methane oxidation;
- Evaluate carbon storage factors (CSFs) reported for MSW and individual components thereof;
- Establish the best practice methodology for modeling methane generation in landfills;
- Compile and critically analyze published information on methane destruction efficiencies for LFG-fired flares, engines, and turbines.

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EPA relied on the SWICS 2012 Addendum in considering revisions to methane oxidation fractions identified within Subpart HH in the *2013 Revisions to the Greenhouse Gas Reporting Rule and Final Confidentiality Determinations for New or Substantially Revised Data Elements*, 78 Fed. Reg. 71904-71981 (November 29, 2013). *See e.g., Review of Methane Flux and Soil Oxidation Data* (Docket No. EPA-HQ-OAR-2012-0943-0015).

The SWICS White Paper is again undergoing a revision (to version 3.0), which will address several of the same data quality objectives and variables that the Agency seeks to address in the Proposed Rule. This includes a move toward a more quantified basis for GCCS collection efficiency assessment, as well as an integration of prior versions of SWICS and a revisit on the current state-of-the-practice on collection efficiencies, oxidation, carbon storage, methane generation in landfills, and destruction efficiencies. The intent of SWICS 3.0 will be to serve as a protocol under SBTi for landfill emissions reporting, for both sites with and without a GCCS. The Landfill Industry Commenters expect that the SWICS revision will be complete in 2023, and we are eager to collaborate with EPA for review and discussion of the data and methodologies considered therein. We ask EPA to delay finalization of the proposed revisions to the Subpart HH within the Proposed Rule pending completion of this process.

Subpart B - Energy Consumption

Proposed Subpart B of the Proposed Rule would require affected facilities to report purchased metered electricity and metered thermal energy products, and develop a written Metered Energy Monitoring Plan ("MEMP") for purchased electricity and thermal energy products. The MEMP must include detailed recordkeeping practices that include, among others, identifiers of each meter and delivery service provider, copies of billing statements, certifications of accuracy for each meter, processes and methods for collecting data, procedures and methods for quality assurance, maintenance and repair of all monitoring systems, conformance of electricity meters to consensus accuracy specifications, and periodic audits of the accuracy of meters for purchased thermal products.

The Landfill Industry Commenters object to the inclusion of Proposed Subpart B within the GHGRP at Part 98, governing energy consumption, on the basis that the information that would be collected under proposed subpart is outside EPA's authority under 114 of the Clean Air Act, would be excessively burdensome, and would produce data of little value to the overall goals of the GHGRP.

Section 114 of the Clean Air Act confers broad authority on EPA to collect information for the following purposes:

> *For the purpose (i) of developing or assisting in the development of any implementation plan under section 7410 or section 7411(d) of this title, any standard of performance under section 7411 of this title, any emission standard under section 7412 of this title,,[1] or any regulation of solid waste combustion under section 7429 of this title, or any regulation under section 7429 of this title (relating to solid waste combustion), (ii) of determining whether any person is in violation of any such standard or any requirement of such a plan, or (iii) carrying out any provision of this chapter (except a provision of subchapter II with respect to a manufacturer of new motor vehicles or new motor vehicle engines)*

Clearly, data relating to purchased energy products will not be used to assist EPA in the development of an implementation plan under Section 110 of the Clean Air Act (governing plans for the implementation, maintenance and enforcement of National Ambient Air Quality Standards), or standards under Sections 111, 112, or 129 of the Clean Air Act (governing direct emissions from categories of stationary sources), or in determining whether a person is in violation of such a standard or requirement. In the preamble to the proposed rule, the Agency acknowledges that energy consumption data would not reflect direct emissions associated with reporters' operations, but would instead represent indirect or Scope 2 emissions. The Agency claims that such information is necessary to gain an improved understanding of the energy intensity of specific facilities or sectors, and to better inform its understanding of energy needs and the indirect GHG emissions associated with certain sectors. *See* 88

Fed. Reg. at 32885. The Agency also asserts that this purpose is consistent with Section 114 of the Clean Air Act, which allows EPA to use its information request authority for "carrying out any provision of this chapter." 88 Fed. Reg. at 32887. EPA further claims that reading Section 114 narrowly to preclude such usage would "hinder the EPA's ability to implement" a variety of duties under the Clean Air Act that extend to regulatory and non-regulatory programs, and would "subvert Congressional intent." *Id*.

The Landfill Industry Commenters disagree with the Agency's broad interpretation of Section 114, and that disallowing Subpart B would somehow subvert Congressional intent. In the preamble for the original rule, EPA noted that the joint explanatory statement accompanying the FY 2008 Consolidated Appropriations Act directed EPA to "*include in its rule reporting of emissions resulting from upstream production and downstream sources, to the extent that the Administrator deems it appropriate*." 74 Fed. Reg. at 56264. The proposed Subpart B explicitly "*does not require the reporting of either direct or indirect greenhouse gas emissions.*" 88 Fed. Reg. at 32924.

The preamble for the original rule goes on to note that numerous other programs were already in place to collect relevant information:

> *As described in Sections I.C and D of this preamble as well as in the comment response sections, there are several existing programs at the Federal, regional and State levels that also collect valuable information to inform and implement policies necessary to address climate change. Many of these programs are focused on cost-effectively reducing GHG emissions through improvements in energy efficiency and by other means.*

74 Fed. Reg. at 56264.

The Agency has not provided any supporting information to demonstrate that these existing programs are inadequate or no longer available, and instead relies on vague generalizations about its need for the information that would be reported under Subpart B, and fails to show any direct linkage to the standards or programs EPA carries out or intends to carry out under the Clean Air Act. Further, EPA seems to erroneously conclude that such information is readily available or otherwise would not impose a heavy burden on reporters. We disagree; the MEMP provisions and reporting requirements impose obligations that are neither necessary or appropriate for reporters of direct emissions, and represents information that could be sourced elsewhere, including from the power generating facilities that report direct emissions associated with the produced energy.

The new requirement for a Metered Energy Monitoring Plan (MEMP) adds layers of complexity to a heretofore simple process of doing business. A facility that requires electricity enters into an agreement to purchase electricity from a utility or other provider; and pays for that electricity based on its usage as recorded by a meter that is supplied by the provider of that electricity. Under the proposed Subpart B, a facility would be required to perform the following additional tasks:

- Develop and maintain, a MEMP;

- Determine whether its meter complies with the requirements of Subpart B, and document same using either a certification from the manufacturer or the provider, or documentation that such certification could not be obtained;
- Describe the processes associated with "*procedures and methods that are used for quality assurance, maintenance, and repair*" of the meter;
- Revise the MEMP "*as needed to reflect changes in production processes, monitoring instrumentation, and quality assurance procedures; or to improve procedures for the maintenance and repair of monitoring systems to reduce the frequency of monitoring equipment downtime*"; and
- Request a replacement meter if the installed meter does not meet the quality assurance requirements of Subpart B.

See 88 Fed. Reg. 32924. These obligations impose a significant additional burden on the facility to document and develop information about a meter that the facility, in most cases, had no role in selecting or installing and has no expertise in its function. For these reasons, the Landfill Industry Commenters do not support the finalization of Subpart B in the Proposed Rule.

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We very much appreciate the Agency's consideration of these comments. Should you have any questions about this letter, please contact Anne Germain, COO & SVP of Regulatory Affairs for NWRA, at agermain@wasterecycling.org. You may also contact Richard Yep, Interim Executive Director for SWANA, at ryep@swana.org.

Very truly yours,

Darrell K. Smith
President & CEO
National Waste & Recycling Association

Richard Yep
Interim Executive Director
Solid Waste Association of North America

Tab A

October 6, 2022

Submitted electronically to: *https://www.regulations.gov*

Ms. Jennifer Bohman
U.S. Environmental Protection Agency
EPA Docket Center
Air and Radiation Docket
Mail Code 28221T
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Re: Comments on Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule; Docket ID No. EPA-HQ-OAR-2019-0424

Dear Ms. Bohman:

The National Waste & Recycling Association (NWRA) and Solid Waste Association of North America (SWANA) are pleased to submit comments to the Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule; Docket ID No. EPA-HQ-OAR-2019-0424.

The NWRA and SWANA represent companies, municipalities, and professionals in the solid waste industry. The NWRA is a not-for-profit trade association representing private solid waste and recycling collection, processing, and management companies that operate in all fifty states. SWANA is a not-for-profit professional association in the solid waste management field with more than 10,000 members from both the private and public sectors across North America. Our members strive to deliver collection, composting, recycling, and disposal services that are protective of the environment in a safe, science-based, and technologically advanced manner. It is important that regulatory policy enables us to continue to deliver these essential services.

DOC Values

Facilities reporting to Subpart HH of the GHGRP may use one of three options noted below to characterize their waste streams. EPA has proposed a rule to revise degradable organic carbon (DOC) values for landfills for these options (as shown).

1) Bulk Waste Option– assumes single stream of mixed solid waste
2) Modified Bulk MSW Option– facilities can characterize waste into 3 streams: construction & demolition debris (C&D), inerts, municipal solid waste (MSW) (which excludes the prior 2 streams).
3) Waste Composition Option – facilities can characterize waste into a variety of categories where each category has a specific DOC value assigned based in IPCC recommended values.

As referred to in the proposed rule, EREF published a report on DOC values and estimated values using multiple state-based composition studies. A comparison of the current DOC, proposed DOC, and EREF values for the Bulk and Modified Bulk MSW options are shown below.

Comparison of Current/Proposed EPA and EREF DOC Values

Option	Current EPA	Proposed EPA	EREF
Bulk Waste	0.20	0.17	0.161 *(Range: 0.118 - 0.180)*
Modified Bulk MSW	0.31	0.27	0.184 *(Range: 0.142 - 0.209)*

As shown above, the proposed bulk waste DOC value of 0.17 falls within the range of values computed by EREF, suggesting that independent research using a different approach supports EPA's multivariate analysis. For the modified bulk method, EPA's proposed DOC value for MSW has been reduced by approximately 10% from 0.31 to 0.27. However, the proposed value is approximately 47% higher than EREF's estimate of 0.18. Further, the proposed value is outside the range of EREF's values, suggesting that there is a discrepancy between the approaches used by the EPA and EREF to compute these values.

A memorandum[1] dated June 18, 2019 (that only recently was shared) stated the discrepancy lies in the interpretation of the "inerts" waste stream. EREF's approach considers the waste accepted at a facility in three discrete streams:

- Bulk MSW, which contains inerts such as plastic bottles, metal and glass (aligning to the standard MSW definition used by EPA's *Advancing Sustainable Materials Management: Facts and Figures* reports);
- Bulk C&D, which may contain inerts such as concrete and tile; and
- Inerts (e.g., inert special wastes).

While EREF's approach excluded inerts from C&D and special waste (as these are not considered to be MSW), it does not exclude inerts from MSW waste itself. As such, EREF's approach estimated the composition-based DOC values for bulk MSW (i.e., DOC as a percent of total MSW) consistently with the accepted approach for bulk C&D (i.e., DOC as a fraction of total C&D).[2] This approach is also consistent with the realities of landfill operations, as inerts from C&D and special wastes (aka non-MSW inerts) can be easily distinguished by landfill personnel via visual inspection of loads at the scale house. Thus, this definition of inerts aligns with industry practice and the types of data collected and tracked on site at the majority of landfills in the U.S.

However, as highlighted in the referenced memorandum,[1] EPA's definition of inerts would include all inerts in the waste stream, including MSW inerts such as plastic, metal and glass. Incoming MSW to a landfill is generally counted by the truckload without further segregation making any estimates of the fraction of MSW inerts impractical. The only way to reliably estimate inerts is through a waste audit. Thus, to comply with this definition would require a landfill owner to conduct a waste characterization study so that the fraction of inerts can be estimated. This effectively renders the Modified Bulk MSW option useless since a waste characterization study (required to adjust bulk MSW for MSW inerts) would instead allow a landfill owner to use the Waste Composition approach to compute DOC.

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[1] Memorandum from Jeff Coburn, RTI International, to Rachel Schmeltz, EPA, *Modified Bulk MSW Option Update, June 18, 2019*, available in the docket for this rulemaking, Docket Id. No. EPA–HQ–OAR–2019–0424.

[2] This bulk MSW approach is consistent with the approach used by both EREF and RTI International to estimate the DOC for C&D waste—that is the DOC for C&D waste is inclusive of C&D inerts and exclusive of any other inerts (e.g., MSW, special waste). The justification for EPA's incongruous methods for MSW vs C&D is not provided in the memorandum.

To better understand how landfill owners interpret the Modified Bulk MSW option, two evaluations were performed examining the reported fraction of the three waste types reported under the method: MSW, C&D, and inerts. Specifically, this evaluation looked at how often facilities are reporting 100% bulk MSW (and thus no inerts/other materials) and the reported fraction of inerts for those using Modified Bulk MSW option.

Analysis of the publicly available Subpart HH reporting data indicates that nearly one-quarter of facilities using the Modified Bulk MSW option report no inerts (i.e., report 100% bulk MSW) and 85% of facilities reporting inerts in addition to bulk MSW are reporting very low levels (<5% inerts). Given that the average fraction of inerts in MSW 37.7% (based on EREF analysis) and 37-38% based on the data presented in the memorandum,[1] this strongly suggests that:

- EPA is receiving information inconsistent with the assumption that the MSW stream in the Modified Bulk MSW option reflects only organic MSW, and
- It is inappropriate to apply a DOC value of 0.31 (or the proposed 0.27) to the bulk MSW data reported under the Modified Bulk MSW option.

Therefore, continued use of a DOC value for bulk MSW that is exclusive of MSW inerts does not align with landfill operational limitations and the perceived intent of establishing a Modified Bulk MSW option in the first place: achieving a more accurate estimate of GHG emissions (relative to the Bulk Waste option) by allowing owners to report site-specific conditions without the substantial cost and time of implementing the Waste Composition option. Instead, the Modified Bulk MSW approach should allow the MSW Landfill to use the same Bulk MSW DOC of 0.17 as the Bulk MSW approach.

<u>k values</u>

EPA proposes to revise the default k values under Subpart HH in response to public comments received for previous Inventory reports. The RTI International (RTI) memorandum dated June 11, 2019 presents the derivation of the proposed new k values for Bulk MSW and Modified Bulk MSW. The memorandum states that EPA is considering changes to the existing k values due to public comments about U.S. k values being lower than k values used in other Annex I countries in similar climates. Given that with few exceptions, the k values reported by other countries relied almost exclusively on the IPCC model, comparisons should not include those countries. The assumption that the 2006 IPCC model provides more realistic estimates of landfill (LFG) generation from U.S. landfills is not justified for a number of reasons:

1. The IPCC model has been available since 2006, so the fact that IPCC has higher k values is not new information which justifies a review.
2. IPCC is an international model not designed for U.S. waste composition and site conditions, but for a range of very different countries, including less developed nations that produce a much higher percentage of food waste than the U.S., and therefore should have much higher bulk waste k values.
3. Material-specific k values listed in IPCC are highly uncertain and have inconsistent ratios between material types when the ratios are compared across different climate zones.
4. IPCC reports higher k values for "tropical" climates than for temperate climates in the same moisture category (wet or dry). The tropical climate zone is not applicable for the vast majority of U.S. sites, but more importantly, it is inappropriate for sanitary landfills that produce their own heat and are largely independent of ambient temperature to have k values that are higher in hotter climates. If anything, higher ambient temperatures may produce lower k values at a given precipitation level due to higher

evaporation rates that dry out the waste. IPCC's higher k values for warmer climates conflicts with their own assertion that evaporation should be considered when evaluating moisture levels in landfills.

RTI suggests that the European Union's more aggressive goals of waste diversion "may be a driver as to why, when compared to the U.S., the k values applied by these countries are higher." We suggest that the EPA assign regulatory k values that reflect data that the industry has been collecting for decades rather than basing it on a motivation to promote waste diversion. We also note that EPA's proposed k values are actually significantly higher than IPCC's k values.

In both the June 11 and June 18 memoranda, RTI suggested that its research provided the basis for the existing k values (0.02, 0.038, and 0.057), and cites only RTI 2003 and 2004 studies as references. However, RTI did not develop these k values. They were developed by SCS Engineers under contract to EPA for their Landfill Methane Outreach Program (LMOP). In 2004, EPA's LMOP requested SCS to provide a set of k values for U.S. landfills in different climate zones that reflected the average of values being applied by SCS in LFG models they had been preparing over several years to assist LMOP with their LFG-to-energy outreach work.

SCS modeled landfill gas generation using field data from sites with gas collection and control systems (GCCS). The modeled numbers were empirically calibrated using historical LFG flow data and an independent estimate of collection efficiency. The average of k values derived from the calibrated models were then used to assign the "default" k values provided to LMOP. This was later replicated in Table HH-1 of the GHG Reporting Rule. The existing k values have now been used for 12 years of GHG emissions reporting and has consistently resulted in reasonable estimates for U.S. landfills.

We strongly disagree that we need to turn to other countries for guidance. Because of its greater reliance on landfills than European countries, the U.S. has the most advanced LFG collection and control infrastructure in the world and the most robust LFG-to-energy industry, which has led to the U.S. developing expertise in LFG modeling that is unmatched in other countries.

Once EPA decided to update the k values, they proceeded to apply a questionable methodology for updating the values. EPA/RTI performed a multivariate analysis to minimize the difference between the reported values from Equations HH-7 and HH-1. EPA's analysis optimized k and DOC simultaneously to adjust the results from HH-1 to more closely align with the "observed" HH-7. This approach is concerning as follows:

A. The "observed" value of HH-7 is an estimate that is approximate and is not an "observation". Adjusting the k and DOC values to minimize the difference between HH-1 and HH-7 values will produce error to the extent that the HH-7 estimates do not reflect actual collection efficiency (CE).
B. Optimizing k and DOC values simultaneously can lead to extreme and unrealistic values because an error in one value causes an offsetting error in the other to yield the same LFG generation estimate. The extremely wide observed range of "optimized" k values (e.g., 0.001 to 0.400 for dry climates) produce so much uncertainty in the estimated average value as to render it practically meaningless.
C. The changes to estimated LFG generation from proposed new k and DOC values listed in Table 6 of the June 11, 2019 RTI memo are extremely large, particularly for open dry sites. These large increases in emissions estimates for open sites imply that prior estimates were underreporting emissions to such a large extent that the underestimates should be easily demonstrated. However, EPA has not presented evidence that LFG generation has been underestimated at any specific sites, much less across the country at many sites so as to indicate a consistent pattern of underestimation.

In sum, the overall approach used by RTI to develop revised k values for the EPA is deeply flawed and will produce unrealistic estimates of LFG generation when applied to individual sites. Each of these points are discussed further below.

A. HH-7 is not an observed result.

Collection efficiency (CE) calculated using HH-7 is subject to significant errors because the presence of wells and cover type alone do not fully account for CE variations. Because EPA elected not to allow the range of CE values for a particular cover type recommended by SWICS, there is no adjustment to produce more realistic estimates reflecting site specific factors such as well density and operational efficiency. Some sites with HH-7 calculated CE estimates of approximately 60% but have field measured LFG collection rates and emissions monitoring indicating that CE is likely closer to 90%. Other sites reporting CE estimates over 80% with low LFG recovery rates indicate that they were likely collecting less than 60% due to operational problems that restricted LFG recovery. If errors in CE estimates calculated using HH-7 can commonly reach 50% (+ or -), then model k and DOC values calibrated based on the reported collection efficiencies can be similarly biased.

B. Extreme ranges for k and DOC produces unrealistic k values.

The analysis allowed both k and DOC to vary across extreme and unrealistic ranges producing unrealistic results. Because the k and DOC values were not constrained to realistic values, the results ranged widely. The range of k values observed in the RTI study (e.g., 0.001 to 0.400 for dry sites) demonstrates that this method produces extreme values and is unreliable. The average of k values that vary across a 400-fold range is not a statistically meaningful number and cannot be the basis for regulating U.S. landfills.

We do not share EPA's faith in RTI's method of using multivariate analysis to solve for k. A much more reliable method for solving for k would be to do so on a site by site basis, by first assigning realistic Lo values reflecting waste composition, and using independent collection efficiency estimates that reflect more site-specific information than the simplistic method used in HH-7 similar to how SCS Engineers developed the k values for LMOP in 2004 that were later adopted by the EPA.

EPA's proposed new k values were never demonstrated by RTI to produce realistic LFG generation estimates for individual sites. On the other hand, thousands of U.S. landfills have been reporting GHG emissions for the past 12 years using the existing k values, while the only criticism offered by the EPA to justify changes are public comments that the U.S. had lower k values than the IPCC and other countries.

Further, EPA's multivariate analysis utilized an eligibility criteria that eliminated any facilities that did not report for all years 2011-2017. Landfill gas emissions are most variable at the beginning and end of operations when reporting is just beginning or ending. These landfills are more likely to have been eliminated by the eligibility criteria that was utilized. Therefore, the results may not be a true reflection of what occurs at landfills. Only 27% of landfills reporting to the GHGRP met the eligibility criteria.

EPA took this smaller cohort of landfills and further reduced it by removing outliers that were outside the acceptable range, removing another 56 landfills which accounted for over 25% of the moderate precipitation facilities. Even with the reduced number of landfills, the observed range for the optimized decay value varied by over two orders of magnitude.

C. Combined with the minor changes to DOC, the proposed new k values produce estimates of LFG generation that are up to 130% higher than before.

The large increases in calculated LFG generation listed in Table 6 of the June 11, 2019 RTI memo are unacceptable considering the lack of evidence of problems with historical estimates and the lack of prior indication that such impactful changes to the methodology would be forthcoming. Note that the lower percent changes in the estimates listed in Table 7 are blended values with offsetting changes that are less representative of the impacts that individual landfills will experience when reporting GHG emissions using the new k values in HH-1 and HH-6.

We are especially concerned with the effects these changes will have on arid climate landfills. Using the proposed k and DOC values for arid climate site will substantially increase the methane emission estimates under Equation HH-6 and create a huge discrepancy between HH-6 and HH-8. Based on our review of the proposed values for a series of arid climate landfills, the resulting methane emissions under HH-6 would be well outside of the range of likelihood for these landfills, especially when landfill gas recovery rates and surface emissions monitoring data are reviewed. The difference between HH-6 and HH-8 values will increase for most landfills using the proposed k and DOC value, more pronounced for the arid and moderate precipitation sites, and we are very concerned how that will be used in future regulatory or policy decisions regarding landfills as well as how landfill opponents will try capitalize on the discrepancy.

Last, while EPA cites that the k values can be a factor of 2 or 3 from the average recommended by IPCC as part of the reason for reconsidering k values, the observed range in EPA's report varied by a factor of 400. This suggests that these revised numbers are not supported by this analysis.

EPA suggests that "[t]he nationwide impact of these changes will likely be limited…because…[a]bout 71 percent of subpart HH facilities in RY2020 used equation HH-8 to estimate their methane emissions and the proposed revisions would not impact the emissions reported for these facilities. Thus, the proposed revisions would impact only the emissions from landfills without GCS and landfills with GCS that elect to report emissions using equation HH-6, which is a smaller fraction (about 35 to 40 percent) of the total methane emissions reported subpart HH." While the total impact on the reported greenhouse gas emissions may not be significant, this change could result in significant changes to individual landfills. Therefore, we believe it is important to utilize a method that is supported by data and science.

Further, EPA appears to have relied solely on the report by RTI to propose the revised k-values disregarding more recent analysis developed by EPA itself. In 2021, EPA's Office of Research and Development published an article in PLOS ONE[3] suggesting ranges for k values for each precipitation class that fall below the proposed changes. Like the RTI study, this study utilized data from the GHGRP but used a different methodology. This study focused on closed landfills, by assuming that collection approximated generation. However, even this methodology has flaws. The assumption that k values are static over the life of the landfill ignores the potential for reduced values that would likely occur when a landfill is capped and drying out. Further, if emissions were in fact generated from those closed sites, this would equate to higher generation rates. Higher generation rates for closed landfills suggests that the k values should be even lower than this study proposes.

[3] Jain P, Wally J, Townsend TG, Krause M, Tolaymat T (2021) Greenhouse gas reporting data improves understanding of regional climate impact on landfill methane production and collection. PLoS ONE 16(2): e0246334. https://doi.org/10.1371/journal.pone.0246334

Given all the problems outlined in the forgoing, the proposed changes to k values cannot be supported by EPA's analysis. Therefore, we strongly encourage EPA to maintain the current k values.

Reporting requirements

EPA is also proposing "to require MSW landfills to report data on the landfill CH_4 emissions that are destroyed versus sent to landfill gas energy projects." Further, we understand that this will be done by reporting the relative percentage of gas sent to energy projects versus being, "destroyed." With the availability of data collected by the Landfill Methane Outreach Program (LMOP), we see this request as not only duplicative, but capable of providing data with less reliability than data already collected by the EPA. Further, we are uncertain of the definition of "landfill gas to energy projects," as there are multiple beneficial use projects that destroy landfill gas to produce power as well as other beneficial uses (transportation fuels, leachate evaporation, boilers, etc.). We recommend that rather than requiring new reporting requirements that EPA instead rely on LMOP data.

Retroactive years

The proposed rule will have a significant impact to all landfills, and it is not transparent on how previous years reporting will be impacted. Industry needs the opportunity to review EPA's strategy on how these revisions will impact previous year's submittals before any rule changes are finalized as revising previous reports places an unnecessary workload burden on the EPA and the regulated community. In addition to the burden of recalculating prior years emissions, retroactive revisions will create a great deal of confusion for stakeholders that rely on the GHG reports and raise questions about the validity of prior reporting efforts.

Furthermore, the emissions from the GHG Reporting Rule are used for other programs such as the US GHG Inventory and it is unclear in the proposal how EPA will implement such changes to align with different programs.

Therefore, we recommend EPA apply rule changes prospectively and not retroactively to prior year's reporting.

Costs

EPA calculated a burden of only $3297 for MSW landfills. We believe these costs are low for the changes proposed. Significant effort is required to reconfigure recordkeeping processes and xml coding for reporting. There may also be cases where new measurement locations must be installed to collect data for proposed new reporting elements.

Table 7—Total Incremental Burden by Subpart				
Subpart	Labor costs	Initial year	Subsequent years	Capital and O&M
HH—Municipal Solid Waste Landfills	3,297	3,297		

Conclusion

We appreciate the opportunity to provide this feedback. To summarize, we recommend the following:

- EPA should change the DOC values for Bulk MSW as proposed.

- EPA should change the DOC values for Modified Bulk MSW to 0.17
- EPA should maintain the existing k values
- EPA should not include new reporting requirements
- EPA should apply any final rule changes prospectively (after effective date of final rulemaking)

Thank you for your consideration of our request, and we look forward to continuing to partner with the EPA to ensure the safe and effective management of waste streams containing PFAS. Should you have any questions about this letter, please contact Anne Germain, COO & SVP of Regulatory Affairs for NWRA, at agermain@wasterecycling.org. You may also contact Jesse Maxwell, Senior Manager, Advocacy & Safety for SWANA, at jmaxwell@swana.org.

Very truly yours,

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