Black Earth 2022 2023 Organic Waste Composting Technical Report

Project Name:	Black Earth 2022 2023 OWC
Offset Project Methodology:	Climate Action Reserve – Organic Waste Composting Project Protocol Version 1.1 (July 29, 2013) with updated factors
Aster Global Project Number:	21021.00/25058.00
Date:	V2: 24 March 2025

Project Proponent:	Technical Consultant:
Name: The One Earth Fund Inc. **Contact:** Gordon Hilbun **Email:** Gordon.Hilbun@oneearth.us	**Name:** Aster Global Environmental Solutions **Contact:** Barbara Toole O'Neil **Email:** btooleoneil@asterglobal.com

Table of Contents

1 Executive Summary

1.1 Technical Statement

Aster Global worked with Black Earth and One Earth Fund to provide technical support/assistance as needed during the development of the project (Black Earth Compost Project). This document details the specific reviews, calculations, and support provided by the Aster Global team.

1.2 Summary

The Black Earth composting project operates multiple turned windrow composting facilities in Massachusetts U.S. A turned windrow compost facility is a large-scale composting operation that processes organic waste; typically, food, soiled paper, and green waste, into nutrient-rich compost. The facilities consist of long, narrow piles called windrows, which are typically placed on a hard-surfaced pad. These windrows are regularly turned using specialized equipment like compost windrow turners to improve oxygen content, distribute moisture, and regulate temperature. The project sources its compostable waste from local residential and commercial facilities. Diverting organic food and paper waste from traditional waste disposal operations (waste to energy plants, landfills) lowers methane emissions which results in net emission reductions that are calculated using the Climate Action Reserve Organic Waste Composting Project Protocol Methodology.

2 Introduction

This section provides an overview of the Black Earth Composting Project, the Climate Action Reserve Organic Waste Composting Project Protocol Methodology, and a summary of the key project activities.

2.1 Project Description

The Black Earth project consists of three composting sites located in Massachusetts, US, and uses the Climate Action Reserve Organic Waste Composting Project Protocol (OWC Methodology). This methodology is utilized by projects that divert food and paper waste from landfills. Composting significantly reduces methane emissions compared to landfill disposal of waste. In landfills, organic matter undergoes anaerobic decomposition, producing large amounts of methane, a potent greenhouse gas. Composting, on the other hand, is an aerobic process that introduces oxygen through regular turning and watering of the compost pile. This aerobic environment prevents the formation of methane-producing microbes, resulting in primarily carbon dioxide emissions instead. The quantification and monitoring procedures to calculate the overall emission reductions are presented in the OWC methodology.

The Black Earth composting facilities located in Manchester, Framingham, and Groton, Massachusetts operate a small fleet of trucks that drive local routes collecting compost, primarily food waste, from commercial and residential locations. The truck routes are tracked via GPS which log the date and time of all compost deliveries and distances traveled. This data along with the truck type and source of the delivery is recorded in a central database managed by the project development team. The compost is deposited daily at one of the three facilities where it is composted in a turned windrow system. Once on-site heavy equipment (Cat loaders, screeners etc.) is used to incorporate and track the management of the windrow systems.

3 Technical Overview

Aster Global supported the project by updating emission factors used by the OWC methodology. These updates included the CH_4 and N_2O turned windrows emission factors, the global warming potential of CH_4, the state specific gas collection factor, and the state specific electricity emission factor. Aster also provided technical assistance to the project development team to create an emission reduction calculation workbook based on the updated emission factors and the equations presented in the OWC Methodology. Calculation and data management support was also provided on monitored parameters such as the total compost weight, truck mileage, onsite electricity usage, and onsite fuel usage.

3.1 Eligibility & Additionality

As stated in the OWC methodology approximately 2.5% of food waste generated in the U.S. is composted annually, and this is limited mostly to food waste from grocery stores. Therefore, food waste and soiled paper streams from grocery stores are not eligible unless they meet certain requirements in the OWC methodology. The project documentation states that no food waste is sourced from grocery stores, and as such it is not subject to the additional performance-related criteria detailed in the methodology. The OWC methodology also mandates that composting activities must not be legally required by any applicable local, state or federal regulation/mandate/law. The only applicable law identified by the project proponent is enacted by the state of Massachusetts and states that institutions that generate more than 1,000 pounds of food/paper waste per week must not be disposed of by incineration or transfer to a landfill/solid waste disposal facility. As per the project documentation this law does not apply to the project as no single business or institution is generating food waste in the quantities required. Compost collection routes show that it is typical for the collection truck to stop at 50-100 locations to fill the truck before returning to the compost facility. The average per route total compost weight is conservatively estimated to be two short tons, making it highly unlikely that a quarter of the total compost collected would come from one location out of the 50 to 100 stops being made per route. Additionally, all composting facilities have the legally required U.S. SWGP – General Permit for Recycling, Composting or Digestion Operation which have been issued by the Massachusetts Department of Environmental Protection. These permits confirm the site locations and the legal right to operate a composting facility. Additionally, the technical support team pulled the publicly available enforcement histories for each site and found no violations.

3.2 Baseline – Emission Factor Updates

The baseline calculations in the OWC methodology assume that if not for the project activities organic waste would otherwise have been disposed of at a waste incineration plant (WTE) or a landfill. State specific factors, utilized in the baseline calculations, were developed for landfill gas collection fractions, and WTE rates to ensure local waste disposal trends were incorporated correctly, as these parameters vary greatly from state to state and change over time. Table A.3 of the methodology details the data source (U.S. EPA Landfill Methane Outreach Program - LMOP 2012) and necessary data used to calculate the gas collection fractions (GCF) for each state. During the project development the technical support team recreated the state specific GCF's for each state by utilizing the same publicly accessible database for 2021 to ensure any changes in waste management practices were captured in the baseline scenario. Ultimately, there was no change in GCF for Massachusetts, however, if the project is expanded to other states these updated values may be utilized. The same exercise was conducted to update the state specific WTE fractions found in Table

A.4, but updated values published by the data source referenced in the OWC methodology could not be found, so the project baseline calculations use the original values in Table A.4. Baseline equations 5.3 and 5.4 also identify the global warming potential of methane (GWP_{CH4}) as 21 $MTCO_2e/MTCH_4$, which aligns with the IPCC AR4. The project chose to apply the updated IPCC AR5 GWP_{CH4} of 28 to calculate the baseline as its publication aligns with the project start date and activities.

3.3 Project – Emission Factor Updates

The OWC methodology accounts for project emissions from fossil fuel usage, grid electricity, methane from composting, and nitrous oxide from composting. The methane and nitrous oxide emissions factors used to calculate emissions during composting are detailed in Table 5.2 of the methodology. These emissions factors relevant to the project activities (turned windrow composting) were sourced from the 2006 IPCC guidelines for National GHG Inventories. The technical support team conducted a literature review to determine if these values required updating based on more recent studies and publications. During the review six reputable papers and/or publications by the U.S. and Canadian governments were identified as being relevant to methane and nitrous oxide emissions in well managed turned windrows that were composting organic waste. The sources found were the Clean Development Mechanism (CDM), The Waste Reduction Model (U.S. WARM), the California Air Resource Board (CARB), the Canadian Organic Waste Management Methodology Report, and Nordahl et al. The combined CH_4/N_2O emissions factors varied greatly from each other and from the original 2006 IPCC factors used by the OWC methodology (0.05-0.18 $MTCO_2e$/MT Food waste). This variability is expected as compost is inherently heterogeneous with its diverse feedstocks, variation in particle size, uneven decomposition rates, and microbial diversity. If the updated emissions factors are to be representative, the calculations should include all relevant high quality data sources. The new emissions factors (CH_4 – 0.06 $MTCO_{2e}$/MT FW, N_2O – 0.04 $MTCO_2e$/MT FW) employed by the project were derived by averaging all seven data sources; the original IPCC values used by the OWC methodology and the six more recent sources noted above.

3.4 Measurements & Monitoring

In order to support the baseline and project emission calculations the project development team monitored several key parameters, including compost weight, on-site diesel usage, truck routes/distance, and on-site electricity usage. The raw data provided by the project was sorted by site and totaled on a monthly basis. The Groton compost facility was the only location with electricity usage, and a customer history report provided monthly electricity usage in kWh for the reporting periods. As required by the methodology the electricity project emissions are calculated by multiplying the electricity usage by the appropriate U.S. EPA eGrid emission factor, which for Massachusetts is subregion NEWE.

All three facilities used on site equipment (Cat loaders, screeners, etc.) to move, pretreat, and manage the compost windrows. These on-site project emissions were calculated by multiplying the total diesel used by each site by the diesel specific emission factor located in Appendix A of the methodology. Total monthly diesel usage for the Manchester site was tracked by invoices that were provided to the technical support team for review and input into the calculation spreadsheets. The Groton on-site diesel supporting documentation was provided by the diesel supplier in a yearly transaction summary invoice. The equipment used on-site at the Framingham site shares an underground diesel tank with the truck fleet, so the total on-site diesel consumption was conservatively estimated using the equipment types and hour logs. Data sheets for each of the three on-site haulers/screeners were obtained through the manufacturer's websites based on the model numbers provided by the project development team. The project also provided maintenance logs which documented the numbers of hours on each machine at time of service. These logs showed regular maintenance and upkeep of the machines and also provided an estimate of each machine's total run time for the year. In order to ensure a conservative estimate for diesel usage, it was assumed that each machine was running at its maximum rated power for every hour of use throughout the year. The Framingham location is the smallest of the three sites and handles approximately half to three quarters of the total compost as the other sites; however, the estimated on-site diesel usage at the Framingham site was higher than both of the larger sites. This supports the assertion that the estimated on-site diesel usage calculated for the Framingham site was conservative and would not lead to an overestimation of emission reductions.

The project development team uses online route management software to plan and track compost pick up routes/locations. The route maps show the path of each truck and each compost pickup location. The trucks are tracked via GPS to monitor any deviations from the planned route and are used to track the total distance traveled on each route. The technical support team compiled the total mileage for each site from the raw data download from the software platform. The date, end location (composting facility) and total mileage were recorded in the system for every route. Two truck types were used to collect compost, and the average miles per gallon for each truck was obtained from each trucks spec sheet. The data management system tracks the mileage for each route but does not specify which truck type completed the route. In order to ensure a conservative estimate all calculations were performed assuming the route was completed by the less fuel efficient truck (lower MPG). This miles per gallon value was then multiplied by the total mileage for each monitoring period to calculate the total diesel usage in gallons. As with the on-site diesel usage calculations, the total diesel used for compost collection in each period is then multiplied by the appropriate emission factor in Appendix A of the methodology to determine the project emissions.

The total weight of compost collected on each route can vary given the season, number of stops on the route, and the types of facility being collected from. Weight slips that showed total truck weight pre and post compost pick up were supplied for each reporting period to determine the average weight for each route/delivery. The average compost weight in 2022 was 2.793 short tons per route, and 3.231 short tons per route in 2023. The project development team chose to assume that each route collected 2 short tons of compost to maintain conservativeness in the emission reduction assertions. As described in the previous paragraph each route is tracked in the project data management system, so the total compost tonnage for each year is calculated by multiplying the total number of routes by the highly conservative 2 short tons of compost per route.

3.5 Technical Results/Conclusions

This report describes the activities completed by the technical support team to assist the Black Earth Composting project in calculating an accurate and conservative emissions reduction for each monitoring period. The technical review team concludes that emission reduction values presented in Table 2 of the project description document were calculated using the methods outlined in the OWC methodology and are supported by high quality data collection and accompanying conservative estimates needed to ensure the claimed emission reductions are not overstated. The tables and equations below summarize the key project parameters, equations, and resulting emission reductions.

EMISSION SUMMARY			
YEAR	Baseline Emissions Eqn 5.2-5.4 (tCO_2e)	Project Emissions Eqn 5.8-5.11 (tCO_2e)	Emission Reductions Eqn 5.1 (tCO_2e)
2022	4,210.61	1,345.78	2,864.83
2023	4,369.76	1,396.74	2,973.02

KEY PROJECT PARAMETERS				
YEAR	Total Food Waste (t)	Total Soiled Paper (t)	Diesel (gal)	Electricity (kWh)
2022	7,203.19	379.12	56,886	41.73
2023	7,475.46	393.45	59,056	42.88

FIXED PARAMETERS & EMISSION FACTORS	
EF_CH4 (tCO2e/t Waste)	0.06
EF_N2O (tCO2e/t Waste)	0.04
Diesel (kgCO2/gal)	10.15
Electricity (lb/MWh)	536.42
% soiled paper	5%
Gas Collection Factor - Mass (GCs)	1.00
Waste Incineration Rate - Mass (WTEs)	0.37
Decay Rate (k) - Food Waste	0.185
Decay Rate (k) - Soiled Paper	0.06
Global Warming Potential - CH4	28

Emission Reduction Equation 5.1

Equation 5.1. Calculating GHG Emission Reductions

$$ER = BE - PE$$

Where,

			Units
ER	=	Total emission reductions for the reporting period	$MTCO_2e$
BE	=	Total baseline emissions for the reporting period, from all SSRs in the GHG Assessment Boundary (as calculated in Section 5.1)	$MTCO_2e$
PE	=	Total project emissions for the reporting period, from all SSRs in the GHG Assessment Boundary (as calculated in Section 5.2)	$MTCO_2e$

Baseline Emissions - Equation 5.3

Equation 5.3. Baseline Methane Emissions from Eligible Food Waste, by Waste Stream

$$BE_{FW,S} = 0.9 \times W_{FW,S} \times (1 - WTE_S) \times 128 \times \rho \times FE_{FW,S} \times 21$$

Where,

			Units
$BE_{FW,S}$	=	Baseline methane emissions from the food waste component of eligible waste stream 'S' that is composted during the reporting period	$MTCO_2e$
0.9	=	Model correction factor to account for model and waste composition uncertainties related to waste composition and waste characteristics[22]	fraction
$W_{FW,S}$	=	Aggregated weight of eligible food waste (measured on a wet basis) from eligible waste stream 'S' that is composted by the project during the reporting period. See Section 5.1.1 for guidance on determining the weight of eligible food waste	MT food waste (wet weight)
WTE_S	=	Fraction of waste from eligible waste stream 'S' that would have been incinerated at a Waste to Energy plant in lieu of being landfilled. This fraction is equal to the state-specific fraction of total generated waste that is incinerated. Referenced by waste origination State from Table A.4 in Appendix A	fraction
128	=	Methane potential of food waste (measured on a wet basis) from eligible waste stream 'S'. Projects must use this value for all food waste streams[23]	m^3CH_4/MT food waste (wet weight)
ρ	=	Density of methane, equal to **0.000674**	$MTCH_4/m^3$
$FE_{FW,S}$	=	Fraction of methane generated from eligible waste stream 'S' that is emitted to the atmosphere over a ten year time horizon, as calculated using the First Order Decay function. The fraction emitted to the atmosphere is a function of the decay rates of food waste, the landfill gas collection assumptions (see Box 5.1), and the amount of methane generated that is oxidized in the cover soil	fraction
21	=	Global warming potential of methane	$MTCO_2e$ / $MTCH_4$

Equation 5.3. (Continued)

$$FE_{FW,S} = \sum_{x=1}^{10} \left[e^{-k_{FW,S}(x-1)} \times \left(1 - e^{-k_{FW,S}}\right) \times \left(1 - (GC_S \times LCE_x)\right) \right] \times (1 - 0.1)$$

Where,

			Units
e	=	Mathematical constant, approximately equal to 2.71828	
$k_{FW,S}$	=	Decay rate for eligible food waste stream 'S'. The decay rate is a function of the climatological characteristics of the region where the waste is landfilled. Referenced from Table A.2 by waste origination county climate category, which is referenced from Figure A.2	yr^{-1}
x	=	Placeholder for the iterative calculation. The FOD equation calculates emissions out over a period of ten years (x = 1 to 10) following the year in which the waste is initially diverted to the compost operation. The ten year calculation is summed and applied to the total baseline emissions for the current reporting period	
GC_S	=	Gas collection factor for eligible waste stream 'S'. The gas collection factor is equal to the fraction of waste disposed at landfills utilizing gas collection for the state from which the waste stream 'S' originates. Referenced by state from Table A.3 in Appendix A	fraction
LCE_x	=	Fraction of methane that would be captured and destroyed by LFG collection systems in the year x, starting with the year that the waste is diverted to the project (x =1) and ending with year x = 10. All projects shall use a value of '**0.0**' for the first two years of calculated waste decay (x=1 to 2), a value of '**0.5**' for the third year (x=3), a value of '**0.75**' for years 4 to 7 (x=4 to 7), and a value of '**0.95**' for the remaining years of decay until the end of the calculation period (x =8 to 10). See Box 5.1 for a discussion of LCE assumptions[24]	fraction
0.1	=	Factor for the oxidation of methane by cover soil bacteria[25]	fraction

Project Emissions - Equation 5.8

Equation 5.8. Total Project Emissions

$$PE = PE_{CO_2} + PE_{CH_4,C} + PE_{N_2O,C}$$

Where,

			Units
PE	=	Total project emissions for the reporting period, from all SSRs within the GHG Assessment Boundary	$MTCO_2e$
PE_{CO2}	=	Project carbon dioxide emissions for the reporting period from fossil fuel and grid electricity sources included in the GHG Assessment Boundary (SSR 6, 7)	$MTCO_2e$
$PE_{CH4,C}$	=	Project methane emissions for the reporting period from the composting of eligible waste (SSR 7)	$MTCO_2e$
$PE_{N2O,C}$	=	Project nitrous oxide emissions for the reporting period from the composting of eligible waste (SSR 7)	$MTCO_2e$

Report Submitted to:	The One Earth Fund Inc. Gordon Hilbun Gordon.Hilbun@oneearth.us
Report Submitted by:	Aster Global Environmental Solutions, Inc. Corporate Office 3800 Clermont St. NW North Lawrence, OH 44666
Lead/Project Manager Name and Signature	 Barbara Toole O’Neil Lead/Project Manager – Aster Global
Date:	24 March 2025

DF/BTO/JM/CM/25058.00 Black Earth Compost Technical Report V2
One Earth Find SP: PF: 03/24/2025F

4 Qualifications

This section provides a brief overview of the qualifications and expertise of Aster Global and the team's qualifications to provide Technical Support on the Black Earth Composting Project.

4.1 Technical Team – Roles and Responsibilities

Team Member	Role
Barbara Toole O'Neil	Lead/Project Manager
Drake Fisher	Team Member

4.2 Qualifications

Aster Global is accredited by the ANSI National Accreditation Board (ANAB) under ISO/IEC 17029: 2019 Conformity Assessment—General Principles and Requirements for Validation and Verification bodies; however, for the purposes of the work with Black Earth Composting Project no validation or verification was completed as our role was to provide technical support on the project development. As such, this work does not fall under Aster Global's ANAB accreditation.

The technical staff that supported the project are experienced engineers and auditors who have worked on a wide range of methodologies across various sectors.

Barbara Toole O'Neil, MS ChemE, QEP. is an experienced Principal Scientist and Lead Verifier, managing environmental and energy projects. She is a chemical engineer who has focused on climate services for the last 10 years including offset project validation/verification from large industrial processes to ecosystems services sectors. In addition to Aster Global work, she is currently a member of the Hearing Board of the Bay Area Air Quality Management District.

Drake Fisher, BS Mech Eng. has worked on verifications and validations across multiple sectoral scopes for VCS, ACR, CAR, GHG Protocol, and the Canadian GHG Reporting Program. Drake has provided technical support on the development of two VCS Methodologies and is now part of the methodology assessment team for a VCS methodology. Prior to working at Aster Global he worked for six years as a new product development engineer for Stanley Black & Decker, and Pentair Inc. This work included overseeing a small design team, conducting Finite Element Analysis for part stress/airflow optimization, and reviewing manufacturing processes to ensure parts and assemblies met all design criteria.