DECEMBER 2022

Reduction of

GREENHOUSE GAS EMISSIONS REPORT

Maryland
ENVIRONMENTAL
SERVICE

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Message from the Executive Director

The Maryland Environmental Service (MES) is once again pleased to present this annual report detailing our efforts towards reducing greenhouse gas emissions in the State of Maryland. This report is required by Section 3-103.4(f) of the Natural Resources Article of the Annotated Code of Maryland.

Our mission is to provide operational and technical services that protect and enhance the environment for the benefit of Maryland's citizens. We are a quasi-governmental agency, operating on a fee-for-service basis, with no regulatory oversight outside of our own governance. MES serves clients and partners, meeting or exceeding the environmental regulations required in our operations.

We are proud to support our State, County, and municipal partners in executing projects that promote the mitigation of greenhouse gas emissions. Climate change impacts every Marylander in the form of extreme weather events, changing ecosystems, threats to infrastructure resilience and risks to public health. Mitigating carbon emissions also helps to protect Maryland's 7,719 miles of tidal shoreline from flooding risks.

The carbon emission offset data presented in this report is the culmination of four months' worth of effort by a multi-disciplinary team at MES. Our staff documented carbon offsets from our operations in every group at MES – Environmental Dredging and Restoration, Water and Wastewater, Environmental Operations, and Technical and Environmental Services.

Maryland has the most ambitious climate change mitigation goals in the country, with a greenhouse gas emission target reduction of 60% by 2031 and net zero emissions by 2045. MES is in the process of implementing new projects that will help our State meet its climate change goals. Our initiatives include new solar energy installations at State Parks and landfill gas capture projects.

Through this effort and others mentioned in this report, MES seeks opportunities to meet the environmental challenges of our day with innovative solutions for our partners and clients across the State. MES looks forward to the future with hope and all the ancillary benefits that come from lower carbon emissions and carbon sequestration.

Sincerely,

Charles Glass

Charles C. Glass, Ph.D., P.E.
Executive Director

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1. Introduction to the Maryland Environmental Service

MES was established by the General Assembly in 1970 to assist with the preservation, improvement, and management of the quality of the air, land, water, and natural resources, and to promote the health and welfare of the citizens of the State. Today, we employ over 700 teammates and operate more than 1,000 environmental projects across Maryland and the Mid-Atlantic Region. As a not-for-profit business unit of the State of Maryland, MES delivers diverse environmental management services to enhance and protect the environment through innovative solutions to the region's most complex environmental challenges.

MES is a leader in the environmental management sector in Maryland. MES plans, constructs, and operates projects within our four operating groups:

- Environmental Dredging and Restoration
- Environmental Operations
- Water and Wastewater Services
- Technical and Environmental Services

Detailed descriptions of each operating group are given below.

1.1. Environmental Dredging and Restoration

The Environmental Dredging and Restoration Group (EDR) provides operational and technical services on behalf of our clients in the areas of dredged material management, habitat restoration, hazardous materials management, environmental management systems and compliance, permitting and mitigation services and, wetland and forest services. EDR supports our clients with planning, engineering, construction, environmental and regulatory management, and operations. EDR operates three dredged material containment facilities (DMCF) and the Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island (Poplar Island) on behalf of the Maryland Department of Transportation Maryland Port Administration (MDOT MPA).

The three DMCFs include the Masonville DMCF, located near the Middle Branch of the Patapsco River in Baltimore, the Cox Creek DMCF in Anne Arundel County, and Hart-Miller Island (HMI) DMCF, in Baltimore County near the mouth of Middle River. HMI closed in 2009 to accepting dredged material inflow, but EDR continues to support MDOT MPA with ongoing wildlife habitat restoration.

Poplar Island is a restoration effort located in the Chesapeake Bay in Talbot County and beneficially uses dredged material collected from the approach channels to the Baltimore Harbor to restore lost remote island habitat.

EDR further provides environmental management system support services to MDOT MPA at their marine terminals, including environmental monitoring and reporting, hazardous waste management, groundwater treatment plant operation and maintenance, stormwater best management practices (BMP) maintenance, inspection, and repair services, and lastly assisting with their strategic plan to reduce emissions at the terminals.

Other significant projects executed by EDR, includes the dredging of Lake Linganore in Frederick County in 2021. Approximately 150,000 cubic yards (CY) of sediment was removed from this 209-acre lake. Working along with our partners, EDR managed all aspects of this project, from the alternatives analysis and design to permitting, procurement, and construction. When it was completed, the dredging substantially reversed the effects of sediment build-up in the lake, restored water storage capacity in a vital water source for the County, and improved recreational access for the community. In 2022, EDR continues to support the City of Frederick on projects including Fishing Creek. EDR provides support through investigations regarding the Maryland Department of the Environment's (MDE) Dam Safety requirements and identifying dredging needs associated with sediment build up behind the dam. These projects are critical for assuring the safety of downstream uses and needed storage capacity.

1.2. Environmental Operations

The Environmental Operations (EO) Group primarily serves large jurisdictions, municipalities, and rural counties in Maryland to address their solid waste challenges and recycling needs. MES operates solid waste projects, including landfill operations for Harford County, and four counties in the middle of the Eastern Shore (Caroline, Kent, Queen Anne's, and Talbot). The group also operates materials recovery facilities (MRFs) and yard waste composting facilities in Montgomery and Prince George's Counties.

Our involvement with Harford County includes landfill operations, engineering, services, composting, recycling, litter control, and managing the County's homeowner drop-off facilities.

MES operates a dual stream MRF facility for the Montgomery County Department of Environmental Protection in Derwood, Maryland to recycle both mixed wastepaper and comingled materials, such as glass, metal cans, and plastic containers, picked up from homeowners' residences. A similar effort is performed for Prince George's County's MRF. Single stream recyclables collected from Prince George's County residents are processed at the MRF. Recycling offers significant advantages relative to carbon offsetting, by avoiding the use of virgin materials and using recycled inputs instead to save energy.

This group also operates very successful food waste and leaf and yard waste composting programs, generating two compost products, *Leafgro®* and *Leafgro GOLD®*. *Leafgro GOLD®* compost is produced using food waste as a feedstock at the nationally renowned Prince George's County Organics Composting Facility located in Upper Marlboro, Maryland. Food waste that is diverted from landfill disposal to compost facilities allows for the avoidance of methane emissions from the landfills. This represents a significant opportunity to offset carbon emissions associated with the decomposition of food waste in landfills.

1.3. Water and Wastewater

MES' Water and Wastewater (W/WW) Group operates and maintains numerous municipal, County, and State-owned wastewater treatment plants (WWTP) and drinking water treatment plants (WTP). Privately owned facilities are also operated under contract by this group. The W/WW Program operated 229 facilities across Maryland and the Mid-Atlantic region in fiscal year (FY) 2022. The Engineering Services Division within the W/WW Group also implements capital improvement programs for many of these facilities.

Solids generated from the WWTPs are managed by our Biosolids Management Section staff. Engineering, planning, permitting, regulatory compliance, and operational support is furnished by the biosolids staff. MES recycled 52% of the approximately 3,100 dry tons of solids generated from the WWTPs in 2021 onto agricultural land.

1.4. Technical and Environmental Services

The Technical and Environmental Services (TES) Group provides multi-disciplinary environmental planning, monitoring, environmental systems maintenance, geospatial and engineering, and renewable energy services to our partners. This includes tasks such as:

- Planning
- Permitting
- Inspection Services
- Monitoring
- Regulatory Reporting
- Geographic Information Systems
- Renewable Energy Services

We provide environmental compliance and environmental systems maintenance support to the Maryland Department of Transportation Maryland Aviation Administration (MDOT MAA) at the Baltimore Washington International Thurgood Marshall Airport (BWI). This includes collecting waste deicing fluid at BWI so that it does not runoff into nearby streams. Some of the recovered deicing fluid is recycled rather than disposed, thereby reducing costs to MDOT.

The TES Group maintains a strong presence working on stormwater management projects throughout the State. One such effort is the Prince George's County Clean Water Partnership (CWP). This is an innovative community-based partnership with the goal of retrofitting 8,000 acres of impervious surfaces to help the County meet its obligation to reduce stormwater runoff pollution. MES provides engineering support, compliance certification, and third-party construction inspection services to the CWP.

MES' mandate was updated during the 2009 Maryland General Assembly session to include assisting State and Local governments with renewable energy projects, including solar energy projects. TES staff actively aids our clients with solar projects. One such project completed in FY21 included assisting Hagerstown Community College with soliciting companies to install solar panels at the College.

2. Current Status of Climate Change Mitigation Policies in Maryland

2.1. Greenhouse Gas Emissions Reduction Act Plan

The original Greenhouse Gas Emissions Reduction Act (GGRA) was authorized by the Maryland General Assembly and signed into law by the Governor in 2009. That legislation required a 25% reduction in greenhouse gas emissions by 2020, and a longer-term goal of reducing emissions by 90% (from 2006 baseline levels) by 2050[1]. A recent progress report issued in September 2022 by MDE notes that Maryland had surpassed the 25% goal in 2020, with a reported 30% Greenhouse Gas (GHG) reduction below the baseline 2006 level[2].

The GGRA was reauthorized in 2016, which set a more ambitious goal of reducing GHG emissions by 40% (from 2006 baseline levels) by the year 2030.[3] That legislation also required MDE to develop a plan that will guide the State on meeting the objectives of the GGRA Reauthorization of 2016. The 2030 GGRA Plan was prepared by MDE in February 2021[4]. The 2030 MDE GGRA Plan proposed a comprehensive set of measures to be implemented that would meet the 2016 GGRA Reauthorization Act mandate to reduce and sequester carbon. This included measures detailing GHG carbon sequestration actions from multiple sectors – electricity generation, transportation, agriculture, forestry, waste management, and residential and commercial buildings.

2.2. Current Greenhouse Gas Emissions Inventory in Maryland

The GGRA of 2016 required MDE to publish an inventory of GHG emissions every three years. To comply with that directive, MDE has summarized estimated GHG emissions for various sectors for the year 2020[5]. A summary of the inventoried emissions is shown in Table 1 below.

The inventory shown below is segregated by different Global Warming Potential (GWP) timeframes. GWP is the magnitude of the gas' warming potential relative to CO_2. The GWP timeframe is a measure of the warming impact of a GHG expressed over a specified time period. The U.S. Environmental Protection Agency (EPA) bases the GWPs for various gases over a 100-year life.

Because the various gases responsible for greenhouse warming could have different lifetimes in the atmosphere these timeframes will exert different global warming impacts. For example, the 100-year GWP of methane (CH_4) is 27 to 30 times that of CO_2. However, the 20-yr GWP of CH_4 is 81 to 83, more potent relative to CO_2.

	2020 (20-yr GWP basis)	2020 (100-yr GWP Basis)
Sector	MMTCO2e	
Electricity Use (Consumption)	18.32938	18.29813
RCI Fuel Use	13.64134	13.47744
Transportation – On Road	24.27294	24.21691
Transportation – Non-Road	5.50515	5.41532
Fossil Fuel Industry	4.58965	2.37536
Industrial Processes and Product Use	7.26743	4.51568
Agriculture	3.07146	1.72267
Waste Management	8.37788	3.95134
Total =	85.05523	73.97285

***Table 1 – State of Maryland GHG Emissions Inventory by Sector in 2020*[5]**

Note that Transportation for On-Road Vehicles (e.g., passenger vehicles), Electricity Consumption, and RCI (Residential/Commercial/Industrial) Fuel Use which is the direct fossil fuel use for space heating in buildings, account for the majority of GHG emissions in the State.

2.3. Climate Solutions Now Act of 2022

Recognizing the need to further accelerate the State's climate change mitigation efforts, the Maryland General Assembly passed the Climate Solutions Now Act of 2022[6]. This is more comprehensive than previous legislation and is the current law mandating the goals for sequestering carbon. Specifically, the Act:

- Mandates that carbon emissions will be reduced by 60%, by 2031 and net zero emissions are to be achieved by 2045.
- Requires MDE to establish "High Performance Building Emissions Standards", for new school construction, State buildings and commercial buildings greater than 25,000 square feet of gross floor space.
- Requires the State government to transition its fleet to electric vehicles (EV) by 2031, and light duty trucks by 2036. The transportation sector is the largest source of GHG emissions in Maryland, accounting for approximately 40% of GHG emissions[7].
- Promotes the use of clean energy for new buildings, by requiring them to be "electric ready" for the installation of solar energy systems.
- Directs MDE to develop specific strategies to address environmental justice concerns from the effects of GHGs and associated pollutants.
- Sets an objective of creating new "green jobs" when achieving the net-zero emissions goal by 2045.

The Act directs MDE to develop a plan by June 30, 2023 that sets the State on a path to reduce GHGs by 60% by 2030 from the baseline 2006 levels. It provides for public input when developing this plan through a series of public workshops. MDE must submit to the

General Assembly the final plan to achieve net zero (carbon neutral) emissions by December 31, 2030.

3. Projects and Carbon Emission Sequestration

3.1. Overview of Efforts – Greenhouse Gas Emissions Reductions

Through our various operating programs, MES has managed to implement numerous projects that investigate carbon emissions reductions techniques, now and/or in the future. Examples of these projects are capturing methane from fugitive landfill gas (LFG) emissions, recycling metals, plastics, and paper at our MRFs, generating biochar from biosolids, and replacing dray trucks and other diesel-powered vehicles employed at the Port of Baltimore.

Examples of projects that are currently providing carbon emission reductions include the solar array at MES, installed in 2008. Projects for future reductions include the generation of biosolids based biochar, which as of the writing of this report is in the planning stages, or ongoing investigations of carbon sequestration in restored wetlands.

Detailed project descriptions by operating program are described in the following sections of this report, along with a summarization on Table 2 below.

Project	Carbon Emissions Avoided mt CO2 eq.	Equivalent Number of Cars Removed per year
Biosolids Land Application	3,924	846
Harford County Recycling	8,034	1,747
Harford Waste Disposal Center Landfill Gas Recovery	13,761	2,965
Headquarters Solar Array	502	108
Headquarters Telecommuting	337	73
Maryland Port Administration Dray Truck Program	1,110	239
Midshore I Landfill Gas Recovery	17,902	3,857
MidShore Regional Recycling Program	7,752	1,670
Montgomery County Materials Recycling Facility	128,428	27,672
Prince George’s County Materials Recycling Facility	90,981	19,604
Prince George’s County Organics Food Waste Composting Facility	11,554	2,490
Totals	**284,285**	**61,271**

Table 2 – Carbon Offsets at a Glance

3.2. Environmental Dredging and Restoration Projects

3.2.1. Dray Truck Replacement Program

MDOT MPA's contribution towards improving air quality in the Baltimore region is to reduce diesel emissions from the Port of Baltimore operations. One such project is the Diesel Equipment Upgrade Program[8], which replaces older vehicles used by companies doing business at MPA with newer, cleaner, and more efficient equipment that reduces emissions of pollutants, including GHGs. The dray trucks targeted by this program are used to transport cargo to and from the port, as well as replace older, inefficient off-road diesel rolling stock. Companies that own the vehicles match the EPA grant funds received by MES on behalf MDOT MPA. For the 2022 program year, a $1.8 million grant from the EPA's Diesel Emissions Reduction Act (DERA) was awarded to MES in September 2021. MES is administering this grant on behalf of MDOT MPA.

In calendar year 2021 a total of 41 vehicles were replaced by this program (38 heavy duty trucks and 3 off-road rolling stock equipment). In order to estimate the improvement in diesel emissions by replacing these vehicles, the EPA's Diesel Emission Quantifier (DEQ) Tool was used[9]. Inputs used for the DEQ tool were obtained from actual usage data for the vehicles that were being replaced. The output from the DEQ tool for annual emissions reductions is given in Table 3. Not only did the program achieve an impressive reduction in air pollutant emissions such as nitrogen oxides (NO_x), fine particulate matter ($PM_{2.5}$), hydrocarbons (HC) and carbon monoxide (CO), but it also reduced GHG emissions by 1,110 mt CO_2 eq.

Parameter	NOx	$PM_{2.5}$	HC	CO	CO_2
	metric tons per year or % reduction				
Baseline for Project (Before Upgrades)	29.05	1.37	2.16	8.26	3,361.61
Amount Reduced After Upgrades	24.77	1.36	2.03	4.71	1,110.26
Percent Reduction After Upgrades	85.30%	99.50%	93.70%	57.00%	33.00%

Table 3 – EPA DEQ Tool Output for MPA 2021 Dray Truck Replacement Program

3.2.2. Investigations of Electric Pick-Up Trucks

The EDR group will be testing the Ford Lightning F-150 Electric Pick-up at Cox Creek DMCF to see how the vehicle performs during the required daily activities at a field site and to test battery life. EDR is taking steps to reduce the emissions associated with and maintenance of the Diesel Emissions Systems in the trucks currently employed at four MDOT MPA facilities.

3.2.3 Masonville Dredged Material Containment Facility

The Masonville DMCF, located in Baltimore City, was identified as a viable placement site to help meet the Dredge Material Management Plan 20-year placement capacity requirement. The facility was originally completed in 2010 but is currently undergoing an expansion to increase site capacity. MES worked diligently with MDOT MPA to identify stakeholders (neighboring communities, nongovernmental organizations (NGOs), businesses, resource management agencies), to educate neighboring communities about the importance of constructing DMCFs, dredging's economic benefit to the State of Maryland, and the science related to dredged sediment from Baltimore Harbor channels. The larger successes of the collaboration with neighboring communities were the Masonville Cove Environmental Education Center, which is a green education center that MDOT MPA constructed for community use and community access to waterfront. Living Classrooms, a local NGO, runs several science-based activities for the public, including local school systems around Baltimore City. Masonville Cove, adjacent to the Masonville DMCF, was restored and became the nation's first Urban Wildlife Refuge Partnership, not only provides a haven in the city for wildlife, but the surrounding community can now come and engage with nature and the waterfront through this access.

To provide safe, convenient, and equitable access for pedestrians and non-motorized vehicles to the Nation's first Urban Wildlife Partnership, the Masonville Cove Connector (MCC) is currently under development. The MCC is planned to be a shared-use path and is expected to be along a segment of Frankfurst Avenue in Baltimore, between Masonville Cove and Hanover Street. Once established, the MCC will join the existing Gwynns Falls Trail and proposed Baybrook Connector, linking Masonville Cove to over 20 miles of walking and biking trails.

3.2.4. Seagirt Loop Channel Feasibility Study

The Baltimore Harbor Anchorages and Channels (BHAC) Modification of Seagirt Loop Channel Feasibility Study (BHAC Study) was initiated in 2020. The purpose of this project is to provide an analysis of the proposed deepening of the Seagirt Loop Channel to accommodate the new large Class IV Post Panamax ships calling on the Port of Baltimore. MES is providing various technical services associated with the required studies in the Environmental Assessment and Feasibility sections of this report. In 2022, the Recommended Plan was approved for review which including deepening the loop to 50' to allow for safe passage of the new large Class IV Post Panamax ships.

MES provided the necessary information to identify any impacts to neighborhoods surrounding the project area and placement of dredged material. MES identified the neighborhoods most impacted by the proposed project using Census data and evaluated project-related air quality/conformity and noise impacts to the community. Results of the air quality/conformity report show that impacts to air quality from implementation of the project would be temporary and minor and would fall below *de minimis* standards. Furthermore, project related emissions as proposed do not exceed the EPA Nonattainment Limits for Criteria Pollutants for Nitrogen Oxides (NOx) emissions threshold of 100 tons per year that would require mitigation and/or offsetting (see Table 4 below).

Criteria Pollutant	Nonattainment Limits (tons per year)	Total Emissions for West Seagirt Branch Channel Dredging Operation (tons per year)		
		2025	2026	2027
NOx	100	78.32	84.99	78.32
VOC	50	2.47	2.69	2.47
CO	100	17.91	19.43	17.91
SOx	100	0.04	0.04	0.04
PM_{10}	100	2.43	2.64	2.43
$PM_{2.5}$	100	2.35	2.56	2.35

Table 4: Summary of Air Emissions from the Recommended Plan in Tons per Year (2025-2027), Seagirt Loop Channel Project

MES, on behalf of MDOT MPA, performed a GHG accounting analysis following United States Army Corps of Engineers (USACE) regulatory standards for the proposed project.

The Council on Environmental Quality 2014 guidance on the consideration of GHGs in National Environmental Policy Act reviews focuses on two key points: 1) the potential effects of the recommended plan on climate change as indicated by its GHG emissions, and 2) the implications of climate change for the environmental effects of the recommended plan. Table 5 provides the annual carbon dioxide (CO_2) emissions by year, in tons related to the recommended plan. The primary GHG emitted from diesel-fueled equipment is CO_2. Although nitrous oxides (N_2O) and methane (CH_4) have significantly higher GWP (298 times CO_2 for N_2O and 25 times CO_2 for CH_4), are emitted at significantly lower rates, resulting in minimal fractional increases in carbon dioxide equivalents (CO_2e) when compared with CO_2 alone.

Estimated Emissions, Metric Tons Per Year			
	2025	2026	2027
CO_2	3,687	3,999	3,687

Table 5: GHG Emissions by Calendar Year (in Metric Tons). Seagirt Loop Channel Project

The study analysis followed best practices described by EPA when calculating GHG emissions related to the project construction schedule, which is anticipated to occur across three years with two mobilizations and demobilizations. The work components and estimated GHG emissions for the project are detailed in Table 6 below. The equipment usage and schedule assume one clamshell dredge will be used to complete the project construction. This is based on prior deepening and widening of the adjacent West Dundalk Channel and on potential capacity constraints at the Cox Creek DMCF. However, there is the potential that two dredges will be utilized during construction. In this case, the overall GHG emission would not change; however, increased productivity could result in a reduced timeline.

Work Component		Tonnes CO_2
Mobilization/Demobilization		**1,247**
Mechanical Dredging and Transport		**10,127**
	Clamshell Dredge	2,155
	Tending Tug	2,425
	Transport Tug	5,207
	Crew boat/Survey boat	340
Total		**11,374**

Table 6: Total Tons of CO_2 Emissions Generated by the Recommended Plan by Construction Component, Seagirt Loop Channel Project

Impacts related to increased vessel callings to the Port were not addressed by the GHG evaluation. The fleet forecast shows an increase in vessels calling to the Port with or without the Recommended Plan. However, improvements to the Seagirt Loop Channel will allow more efficient passage of post-Panamax vessels. Generally, these classes of vessels will be newer and more efficient. *Ship Technology* [10] reports that the newer vessels electronically controlled engine consumes less fuel and lubricant oil on average and includes other features, such as improved rudder and hull design that increase productivity and reduce GHG output. As the Port moves more cargo using post-Panamax vessels, reductions in GHG emissions per ton of cargo is expected due to reduced idling time, a reduced need for tug assist when leaving the terminal, and more efficient vessels; however, overall increases in vessels calling to the Port are anticipated to result in an overall increase in GHG emissions.

When considering long-term cumulative impacts, the recommended plan is part of a large-scale modernization effort at the Port. Fleet forecast projections show an increase in cargo moving through the Port with increased demand and efficiency; however, studies related to both the Seagirt Marine Terminal and the Howard Street Tunnel Improvement Project show reduced GHG emissions per ton of cargo related to modernization of landside equipment and increased reliance on cargo transport by double-stacked rail rather than trucks.

The BHAC Study was shared with the public for review in early February 2022 and a public meeting was held later that month to present the report and receive comments. The report is currently posted on the USACE Baltimore District website[11].

3.2.5. Poplar Island

As climate change increases global temperatures of air and water, polar ice melts, and thermal expansion raises sea levels. Combined with land subsidence in the mid-Atlantic, rising sea level and wave action causes erosion, resulting in the loss of valuable island habitats throughout the Chesapeake Bay. In the last 150 years, it is estimated that 10,500 acres have been lost in the middle eastern portion of Chesapeake Bay alone. Islands and the surrounding habitat are preferentially selected by many migratory birds, as well as other fish and wildlife species, as nesting/production areas. The Poplar Island is an environmental restoration project located in the Chesapeake Bay in Talbot County. The beneficial use project relies on dredged material from the approach channels to the Baltimore Harbor (necessary to keep the Port of Baltimore's commerce flowing) to restore what was once a nearly completely lost remote island habitat within the Chesapeake Bay.

In 2001, Maryland enacted the Dredged Material Management Act of 2001, Maryland Code Annotated, Environment Article §§ 5-1101 through 5-1108. This prioritizes beneficial and innovative reuse of dredge material as the preferred placement options in Maryland.

USACE and MDOT MPA began the project to achieve three goals:

- Restore remote island habitat within the mid-Chesapeake Bay
- Optimize the placement capacity for sediment dredged from shipping channels
- Cause no harm to the environment around the restoration site

The Poplar Island project is a cost share between the federal sponsor, the USACE who funds 75%, and the non-federal sponsor, MDOT MPA, who funds the remaining 25%. In addition, MES, on behalf of MDOT MPA, manages the daily operations and technical and environmental services on site, as well as provides valuable onsite construction services to build portions of the island.

<u>Carbon Sequestration Study</u>

The University of Maryland Center for Environmental Science (UMCES), under contract to MES, conducted a carbon budget and sediment (total suspended sediment or TSS) budget study on Poplar Island from 2013–2014 in Wetland Cell 1B (see Figure 1). The study focused on carbon sequestration and carbon export from a restored marsh. Carbon sequestration is a goal of restored marshes; additionally, the carbon incorporated into the sediment helps increase vertical accretion and combat sea level rise.

The results from the study show that the input of macrophytic fixation at 73,145 kg/year is very large, whereas the input of benthic algal carbon fixation is only about 23,502 kg/year. The export of carbon via tidal flux is about 4,994 kg/year, and about 15,700 kg/year of carbon is sequestered. The carbon fixed by macrophytes is incorporated into the vegetation that persists through the growing season, and through a large part of the winter, and can be exported into the estuary; the carbon fixed by the benthic algae is largely recycled through the marsh and no large accumulations of algae are usually seen.

UMCES generated three main conclusions from this carbon-fixation study:

1. In Poplar Island marshes, the nitrogen supply drives extremely high rates of carbon fixation, and high rates of decomposition and remineralization.
2. Even though the wetland cells are open to tidal flow, the perimeter dikes help retain above-ground biomass (wrack) and support accretion.
3. As marshes age, nitrogen supply declines and:
    a. Production shifts to roots/rhizomes
    b. Decomposition slows and carbon burial increases
    c. Dike removal should not occur until this nitrogen decline occurs

In 2022, MES, on behalf of MDOT MPA, contracted with the University of South Carolina to develop a Coastal Wetland Equilibrium Model. This model is using the vegetation data provided by UMCES along with local sea level rise (SLR) projections. This data is being used to evaluate the resiliency of the restored marshes at Poplar Island against different rates of SLR, evaluate multiple low marsh/high marsh ratio scenarios, and evaluate current carbon sequestration rates of the marshes. A report of the analysis results is expected to be finalized in 2023.

Figure 1 – Poplar island

Methane Study

Methane (CH_4) is a carbon compound that acts as a powerful GHG when released into the atmosphere. Methane's effectiveness in trapping heat in the atmosphere is 25 times that of carbon dioxide (CO_2) when examined over 100 years, making it influential to global warming. Wetland ecosystems have a vital role in the carbon cycle, removing carbon from the atmosphere and sequestering it within the substrate. Wetlands also can emit methane, through the anaerobic decomposition of organic material that occurs within saturated soils.

There is a salinity gradient throughout estuaries that ranges from a tidal freshwater marsh to an oligohaline marsh and then to salt marsh, depending on the proximity to the influx of oceanic saltwater. The variability of salinity in wetlands coupled with changing soil temperature, plant diversity and abundance, and saltwater intrusion and precipitation events, can result in different marshes throughout the estuary acting as carbon sinks or sources.

Methane emissions have been quantified in natural marshes varying in salinity but there is a lack of information regarding methane emissions in restored marshes. The goal for the pilot methane study was to examine methane generation in the Poplar Island marshes to determine if there is a trend related to marsh maturation. UMCES examined the oldest marsh, Wetland Cell 3D, a middle-aged marsh, Wetland Cell 1B, and the newest marsh, Wetland Cell 5AB. UMCES concluded that the rates of methane flux within this cell are low, and not considered major in terms of net carbon exchange in Wetland Cell 5AB. The high sulfate concentrations within the soil at the time of planting may inhibit methanogenesis.

In 2022, Wetland Cell 1A methane measurements were compared with measurements taken in a natural marsh, Monie Bay. Poplar Island high marsh methane fluxes were much lower compared to Monie Bay. The low marsh fluxes were similar, except for one outlier in July at Poplar Island that was much higher than Monie Bay. As with all wetlands, any methane flux would offset some of the carbon buried; however, the fluxes at Poplar Island remain relatively small and the marshes of the site continue to act to reduce GHG overall.

3.3. Technical and Environmental Services Projects

3.3.1. Solar Energy

According to the U.S. Energy Information Administration (EIA), most of the increase in new U.S. electricity generation in the U.S. is forecast to come entirely from wind and solar installations[12]. Renewable sources of energy are expected to supply 22% of U.S. electricity generating capacity in 2022. Solar energy is the largest source of new generating capacity and accounts for approximately 46% of all additions in 2022 (see Figure 2 below)[13]. Solar energy projects represent a novel way of producing electricity without generating direct emissions (and hence is considered a low carbon intensive process).

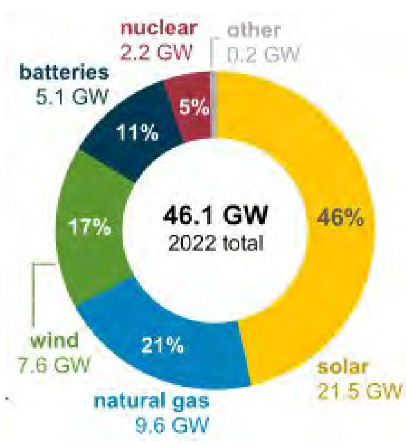

Figure 2 – Planned U.S. Utility Scale Electric Generating Capacity Additions 2022[13]

The TES Group plans and builds solar installations as part of their portfolio of renewable energy projects. These clean energy projects are executed in partnership with other State agencies, such as the Maryland Energy Administration (MEA).

3.4. Water and Wastewater Program Projects

3.4.1. Biosolids Management - Land Application

One of the consequences of operating a municipal WWTP is the generation of a solid byproduct called sludge. A basic principle of wastewater treatment is to remove the solids that are in the influent wastewater. A flow diagram showing a typical WWTP configuration is given in Figure 3 below. While these sludge solids contain pollutants and biological pathogens, they are also comprised of valuable nutrients like nitrogen and phosphorus that are beneficial to plant growth, like other fertilizers. There are numerous technologies and management strategies that can be employed to handle this solid by-product. The removed solids can be disposed of (i.e., into a landfill) or recycled by beneficially reusing the material for its nutrient content and soil conditioning properties. When a WWTP chooses to use the latter management method, they must treat the solids to meet EPA standards for pathogen reduction/treatment and monitor for pollutants like heavy metals. A sludge that meets the EPA regulations for beneficial reuse is called biosolids.

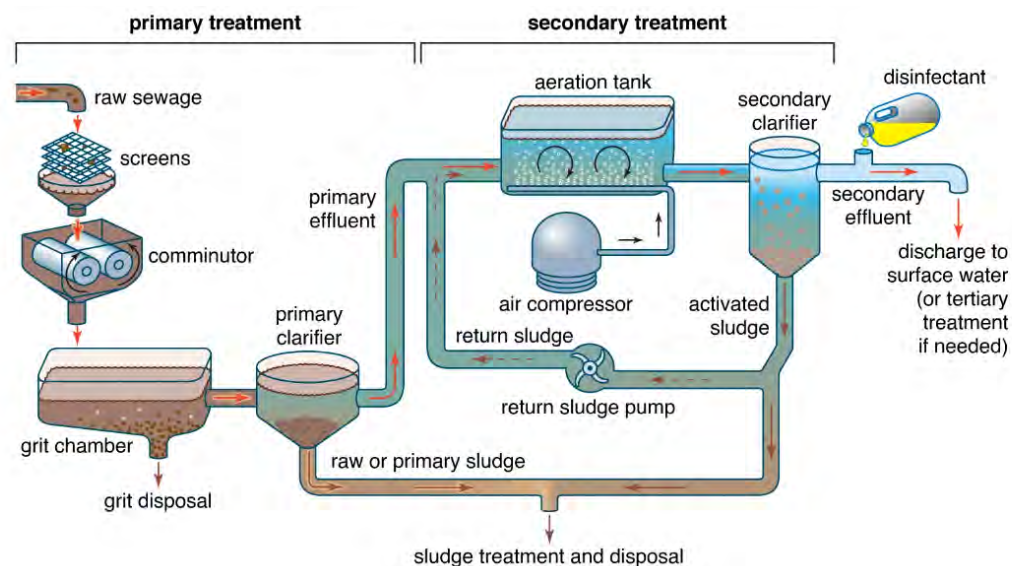

Figure 3 – Typical WWTP Flow Configuration

In calendar year 2021, MES' WWTPs generated 3,063 dry tons of solids, with 52% being beneficially reused by land applying onto farmland. The farmers who received these biosolids reaped the benefits of the nitrogen and phosphorus in the material that were land applied to their fields, thus offsetting their fertilizer costs.

The land application of biosolids offers some opportunities to reduce GHG emissions, mainly for carbon sequestration in the soil and the displacement of fossil fuels used to manufacture chemical fertilizers[14]. Current standard practice for estimating GHG emissions (carbon footprint) for biosolids management methods is the use of the Biosolids Emissions Assessment Model (BEAM). The model was developed in 2009 by the Canadian Council of Ministries of the Environment for evaluating the carbon footprint of various biosolids management methods. The BEAM model uses actual data inputs, when available, for each biosolids processing treatment and end use unit process step and calculates a total carbon footprint. Using this model, a utility can plan their treatment and end use practices to achieve a more carbon friendly footprint by comparing operating scenarios.

To determine the carbon emissions avoided by MES' current practice of land applying 52% of the biosolids from MES' WWTPs, two scenarios were modeled by BEAM. The first was set as a baseline that calculated the theoretical carbon footprint assuming that all of MES' biosolids were landfilled. The second scenario calculated the carbon footprint of MES' actual practice of land applying 52% of the biosolids and landfilling the other 48%. The difference between the two practices (baseline landfilling carbon emissions minus land application carbon emissions) was determined to be the actual carbon emissions avoided due to land application. The results of the two BEAM model results are shown in Table 7.

	Current Actual Practice (Land Application 52 %)				**Baseline Practice (Landfilling 100%)**			
Unit Treatment Process or End Use Practice	**Scope 1 Emissions**	**Scope 2 Emissions**	**Scope 3 Emissions**	**Total Emissions**	**Scope 1 Emissions**	**Scope 2 Emissions**	**Scope 3 Emissions**	**Total Emissions**
Conditioning/Thickening	0	4	0	4	0	4	0	4
Dewatering	0	9	125	134	0	9	125	134
Alkaline Stabilization	0	8	232	239	NA	NA	NA	NA
Landfill Disposal	3,602	0	0	3,602	7,434	0	0	7,434
Land Application	-68	0	-257	-325	NA	NA	NA	NA
Transportation	152	NA	NA	152	157	NA	NA	157
Total Carbon Footprint (mt CO2 eq)	**3,685**	**20**	**100**	**3,805**	**7,591**	**13**	**125**	**7,729**

Table 7 – Biosolids Carbon Footprint Modeling Results

It can be seen from Table 7 that land application of MES' biosolids avoids a total of 3,924 mt CO_2 eq in carbon emissions when comparing the total emissions of the two practices. This is largely attributable to avoidance of landfill methane emissions, sequestering carbon in the soil during land application, and avoiding the use of chemical fertilizers at the farm where the material is land applied.

3.5. Environmental Operations Projects

3.5.1. Materials Recovery Facilities

The EO Group operates two MRFs for the two largest jurisdictions in Maryland (Montgomery and Prince George's Counties). The Montgomery County MRF is a dual stream recycling facility which MES has been operating since 1999. Montgomery County residents separate their recyclables into two separate categories, paper/cardboard, and glass/plastic/metals. Separating the recyclables into two separate streams results in less contaminated end products that can be marketed for resale.

The Prince George's County MRF is a single stream system located in Capital Heights, Maryland that provides recycling services for material collected from approximately 300,000 homes in the County.

An analysis of carbon emissions avoided by these two recycling facilities is presented below.

3.5.1.1. Prince George's County – Carbon Emissions Modeling

A summary of recycled commodities managed at the Prince George's County MRF is presented in Table 8 below. These recycled tonnages were input into the EPA's Waste Reduction Model (WARM) Tool[15]. This model calculates GHG emissions, energy, and economic impacts for baseline and alternative waste management practices. It uses emissions factors for each type of material that is recycled. For this MRF, it was assumed that the baseline case would be landfilling of these materials, with the model calculating emissions impacts for the materials being recycled instead of landfilled. There is a positive, net benefit from recycling in terms of GHG emissions levels. This is mostly achieved by less methane generation at landfills, and avoidance of manufacturing new products using virgin raw materials[16]

There is a significant impact on GHG emissions as a result of the recycling effort in Prince George's County. It was estimated that a total of 90,981 mt CO_2 eq was avoided because of the operation of this facility in FY22. These carbon emissions avoided are equivalent to removing 19,604 gasoline powered cars from the roadways every year[20].

Commodity	**Tons Recycled in FY 22**	**Carbon Emissions Avoided (mt CO_2 eq)**
Mixed Paper	10,708	40,437
Cardboard (OCC)	11,315	40,530
Plastic	3,533	3,341
Aluminum	408	3,732
Steel *	970	1,891
Mixed Metal (scrap)	238	1,050
Glass to Market	N/A	0
Totals =	**27,172**	**90,981**

Table 8 – Carbon Emissions Modeling, Prince George's County MRF
(- this was modeled as structural steel in the WARM tool inputs)*

3.5.1.2. Montgomery County – Carbon Emissions Modeling

Montgomery County MRF recycling data for FY22 is shown in Table 9. That facility recycled a total of 52,700 tons in FY 22. The EPA's WARM model was run to determine the GHGs avoided due to recycling at this facility. The baseline case here was to assume that the solid waste accepted at the MRF would normally have been combusted at the Covanta Resource Recovery Facility (Waste-to-Energy) located in Dickerson, Maryland. The WARM model estimates emissions from the combustion of municipal solid waste (MSW) at Waste-to-Energy facilities.

The Montgomery County MRF resulted in a total of 128,428 mt CO_2 eq avoided in FY22. This was equivalent to removing 27,672 passenger vehicles from the roads each year.

Commodity	**Tons Recycled in FY 22**	**Carbon Emissions Avoided (mt CO_2 eq)**
Mixed Paper	22,174	68,161
Cardboard (OCC)	17,007	45,297
Plastic	2,736	6,073
Aluminum	490	4,489
Steel *	787	1,534
Mixed Metal (scrap)	N/A	0
Glass to Market	9,506	2,874
Totals =	**52,700**	**128,428**

Table 9 – Carbon Emissions Modeling, Montgomery County MRF
(- this was modeled as structural steel in the WARM tool inputs)*

3.5.2. MidShore Regional Recycling Program

The Midshore Regional Recycling Program (MRRP) is a cooperative partnership between four counties on the Eastern Shore, collectively referred to as the Midshore counties (Caroline, Kent, Queen Anne's, and Talbot Counties), that was established in 1993. The heart of the MRRP is a residential recycling drop-off program that allows Midshore residents to deposit their separated paper, cardboard, plastic, metal cans, and glass at one of thirty-five separate locations throughout the region. These source-separated recyclables are collected, transported, marketed, and sold by MES on behalf of the Midshore counties.

In FY22, MES collected 3,214 tons of recycled materials via the MRRP as detailed in Table 10 below. This resulted in an estimated 8,618 mt CO_2 eq avoided which is the equivalent of reducing the CO_2 emissions from the consumption of 970,000 gallons of gasoline.

Commodity	**Tons Recycled in FY 22**	**Carbon Emissions Avoided (mt CO_2 eq)**
Mixed Plastic/Metal*	559	1,803
Mixed Paper	739	2,791
Cardboard	1,052	3,768
Glass	864	256
Totals =	**3,214**	**8,618**

Table 10 – Carbon Emissions Avoided via MRRP Recycling
(- modeled as mixed recyclables in the WARM tool inputs)*

3.5.3. Harford County Integrated Solid Waste Management

MES has been providing solid waste services for Harford County since 2015. We deliver an integrated set of services to County residents – landfill (disposal) operations, recycling, and composting. Our scope of work includes:

- Operation of the County's Landfill in Street, Maryland
- Homeowner drop-off center at the Landfill
- Engineering and Procurement
- Yard Waste Composting
- Single Stream Recycling Services
- Litter Control and Adopt-a-Road Programs
- Recycling Public Education and Outreach

Curbside recycling and material brought to the homeowner's drop-off site at the landfill is transported to a transfer station at the landfill and ultimately to a commercial recycling facility in Baltimore County. The County's recycling program managed 2,114 tons of material in FY22 (See Table 11).

Some of the recycled material tonnages were input into the EPA's WARM model to determine the carbon avoidance for the recycling program. A total of 8,034 mt CO_2 eq. emissions were avoided as a result of Harford County's recycling program, which is the equivalent of reducing the CO_2 emissions from the consumption of 904,000 gallons of gasoline.

Material	**Tons**	**Carbon Emissions Avoided (**mt CO_2 eq)[10]
Agriculture Plastic	2.05	2
Tires	33.27	13
Durable Medical Equipment	2.78	NA
Hazardous Waste	5.58	NA
Recycled Bulky Donation	12.77	NA
Recycling Auto Batteries	19.04	NA
Recycling Electronics	31.81	26
Recycling-Food Scraps	2.29	2
Recycling Gas Cylinder	1.29	NA
Lithium Ion Batteries	3.58	NA
Recycling Front End Scrap Metal	1,326.48	5852
Recycling Oyster Shells	0.27	NA
Recycling Textile	10.05	NA
Recycling Single Stream	663.75	2140
Totals =	**2,115.01**	**8034**

Table 11 – Carbon Emissions Avoided by Recycling – Harford County Solid Waste

3.5.4. Landfills and Greenhouse Gas Reduction Activities

3.5.4.1. Overview of Landfill Gas Recovery Projects

MES owns and operates the Old Easton, Midshore I and Midshore II landfills located on Maryland's Eastern Shore. The Midshore I and Midshore II landfills were constructed pursuant to the Midshore Waste Disposal Agreement, a regional collaboration with MES between Caroline, Kent, Queen Anne's, and Talbot Counties that provides an 80-year solid-waste solution for these counties. The title to the Old Easton Landfill was transferred from the Town of Easton to MES as part of the original Midshore Agreement. In addition, MES operates the Harford Waste Disposal Center (HWDC) in Harford County, Maryland and the W.R. Grace Landfill in Baltimore, Maryland.

MSW landfills are the third-largest source of anthropogenic methane emissions in the United States, accounting for approximately 14.5% of these emissions in 2020[17]. Promoting LFG recovery projects to generate energy represents a significant step towards mitigating GHG emissions.

In order to estimate LFG emissions, the EPA's LFG Emissions Model (LandGEM) tool was used[18] .This tool estimates emission rates for CH_4, CO_2, and nonmethane organic compounds (NMOCs) that results from the degradation of solid waste in the landfill. LandGEM can be used to estimate these emissions as part of a landfill's commitment to determine the applicability of the Clean Air Act regulations for MSW landfills.

3.5.4.2. Old Easton Landfill – Easton, Talbot County, Maryland

Old Easton Landfill is located adjacent to the Midshore I landfill. Waste acceptance occurred at this facility from the 1960s through 1991, with an estimated 548,000 short tons landfilled. The relatively minor amount of LFG that is generated at the landfill is passively vented, which resulted in estimated emissions of 287 $mtCH_4$ and 789 $mtCO_2$ eq in 2021

In August 2022, MES issued a request for proposals (RFP) to lease the rights for solar energy installation/generation at the closed Old Easton Landfill and/or areas atop or adjacent to the interim-closed fill area of Midshore I landfill. No viable proposals have been received to date.

3.5.4.3. Midshore I Landfill – Easton, Talbot County, Maryland

The Midshore I Landfill ceased accepting waste in 2010 with a total waste-in-place (WIP) of 2,032,481 tons (3,684,695 CY). It subsequently underwent an expansion of its central LFG collection and control system and was covered with an exposed geomembrane cap in 2016. The landfill was issued interim closure approval by MDE in 2017.

LFG is collected via a network of approximately 67 wells. Gas is conveyed to a central flare station consisting of three candlestick flares and, between 2017 and 2020, was also delivered to a nearby gas-to-energy facility operated by Easton Utilities Commission as a beneficial reuse. LFG that is collected and destroyed by the flares or combusted to produce electricity is quantified for net GHG reductions/removals under the Verified Carbon Standard by a contracted third-party, Blue Source Canada ULC. During the 2021 reporting period, the gas captured and destroyed at the Midshore I landfill resulted in net GHG reduction/removals totaling 17,902 mt CO_2 eq., which is equivalent to the CO_2 emissions from 2,255 homes' energy use for one year.

In November 2021, an agreement expired between MES and a local utility company for MES to supply LFG generated at the Midshore I Landfill to the utility for electricity generation. In lieu of flaring the LFG collected at Midshore I, which destroys the potent greenhouse gas methane, MES researched energy alternatives that were compatible with the declining quality (heating or energy value) of the LFG. Through this research it was determined that a technology that had taken hold in the shale patch for remote power generation, namely the combustion of poor and variable quality gas via Stirling engines, could be applied to the solid waste industry. MES submitted a grant application through MEA's Open Energy Program in FY22 and received a funding award. Design, procurement, and pilot testing of the unit, a 5.6 kW Qnergy Stirling engine, occurred during the second half of calendar year 2022. If successful, MES will purchase the engine and tie the electricity generated back into the grid, not only generating Renewable Energy Credits (RECs), but also offsetting electricity that would have otherwise been purchased.

3.5.4.4. Midshore II Landfill – Ridgely, Caroline County, Maryland

The Midshore II landfill began accepting waste in 2010 and will continue to do so through 2030. At the end of 2021, the landfill had a total WIP of 1,415,227 tons (2,398,527 CY). LFG is collected via a series of horizontal wells that have been constructed in two of the three constructed cells at the facility and is passively vented via five candlestick flares. MES has retained an A/E firm to design a central gas collection and control system for the facility. It is anticipated that the design for this facility will be completed by the end of calendar year 2022. Construction of the gas collection and control system is expected in or after 2023 and may be in conjunction with a beneficial reuse technology.

In September 2022, MES issued a request for information (RFI) or the beneficial reuse of LFG at the Midshore II landfill. Numerous respondents provided submissions to the RFI indicating an interest to beneficially reuse the gas for either the production of renewable natural gas or electricity. MES expects to issue an RFP based on these RFI responses in early 2023. Once operational, and given the current WIP, the LFG collection and control system is expected to produce at least 41,360 mt CO_2 eq GHG reductions/removals per year through 2030, according to the design engineering firm, which is equal to removing 8,912 gasoline-powered passenger vehicles from the road per year.

3.5.4.5. Harford Waste Disposal Center – Street, Harford County, Maryland

The HWDC began accepting waste circa 1957 and, through 2021, has a total waste-in-place of 1,900,357 short tons. LFG at the facility is collected via a network of vertical gas collection wells and controlled by a central, enclosed flare. In 2021, the gas collection and control collected 48,605,056 standard cubic feet of LFG. The methane destruction efficiency of the system was calculated to be 99%. Using the 2021 annual quantity of methane recovered, 556 metric tonnes, a methane destruction efficiency of 99%, and a methane GWP of 25, the flaring of LFG at the facility in 2021 resulted in roughly 13,761 mt CO_2 eq avoided from methane destruction. Increasing the LFG system's capture efficiency in the years to come may yield higher net GHG reductions/removals.

3.5.4.6. W. R. Grace Landfill, Baltimore City, Maryland

MES operates the industrial waste landfill at this location on behalf of W.R. Grace. Approximately 17,000 – 25,000 short tons of industrial waste comprised of silica filter cake material are landfilled per year. This material has a high inorganic content, and thus probably generates an insignificant amount of LFG. Thus, LFG is not collected at this facility by, or on behalf of, W.R. Grace.

3.5.5. Environmental Operations – Steam and Cogen Plant Activities

The EO Group operates boiler plants at the Maryland State Correctional Institution at Hagerstown (Washington County), the Central Maryland Correctional Facility in Eldersburg (Carroll County), and the Jessup Correctional Institution in Jessup (Anne Arundel County). Steam produced by those boilers provides heat for cooking, laundry operations, and heat for the prison complex.

In addition to the boiler plant operations noted above, MES operates a biomass-fueled combined heat and power system (cogeneration plant) at the Eastern Correctional Institution (ECI) in Westover (Somerset County). The four-megawatt (MW) capacity plant utilizes debarked wood chips as its primary fuel source for two high-pressure boilers. In FY22, the facility consumed 53,975 tons of wood to produce 13,750 MWh of energy and an equivalent quantity of RECs. The RECs are registered and sold on Pennsylvania-New Jersey-Maryland Interconnection's Generation Attribute Tracking Systems trading platform. In total, the plant generated 66% of the electricity and 100% of the thermal needs for ECI in FY22 and fulfilled their primary responsibility of maintaining electrical power to the prison without interruption.

In August 2019, MES entered a 10-year Gas Service Agreement with Chesapeake Utilities to utilize natural gas as a bridge fuel at ECI. Subsequently, Chesapeake Utilities Corporation completed the Del-Mar Energy Pathway Project that added a natural gas transmission pipeline on the lower Delmarva Peninsula. A seven-mile leg of this new transmission pipeline extended service from Salisbury, MD to Westover, MD and was supported by the MES-operated ECI cogeneration plant - one of the two large anchor customers who supported this portion of the project through long-term gas transportation contracts.

In FY 22, MES contracted and oversaw the construction of a new 2,810-foot underground distribution pipeline to deliver natural gas from the Chesapeake Utilities transmission main to the ECI cogeneration plant. The new distribution line was horizontally drilled to avoid surface features, such as drainage ditches, as well as numerous subsurface utilities at the site. Once operational, it is expected to flow more than 700 million cubic feet of natural gas annually to the Cogeneration Facility.

The remaining task associated with the cogeneration plant's conversion is retrofitting the existing boilers. MES has completed the design and bid phases of the boiler conversion project and is scheduled to begin the construction phase in FY23. Once the boiler conversion project is complete, natural gas will supplant wood chips, which have been used at the facility for the last 34 years, as the primary boiler fuel. It is anticipated that the conversion of the boilers to the relatively cleaner burning natural gas will reduce the cogeneration plant's greenhouse gas emissions by roughly 19,000 mt CO_2 eq per year.

3.5.6. Food Waste Composting - Prince George's County Organics Composting Facility

In 2018, the EPA estimated that a total of 63.1 million tons of food waste was generated in the United States by all sectors. This represented 21.6% of all MSW generated in the U.S.[19]. This food waste when disposed into a landfill is a readily degradable source of methane emissions. An alternative to landfill disposal of food waste is to compost the material, thereby generating a marketable product. The resulting compost offers several benefits with respect to GHG mitigation: When applied as a soil conditioner, it sequesters carbon in the soil. Food waste derived compost also adds nutrients to the soil, thus offsetting the purchase of commercial fertilizers.

MES operates a very successful food waste composting facility for Prince George's County in Upper Marlboro, Maryland. The Prince George's Organics Composting Facility features an innovative Gore™ cover system. This cover is waterproof and breathable yet minimizes odor emissions from the compost piles. It allows the use of positive aeration to create an optimized composting environment to degrade the food waste. And it optimizes energy since the compost piles are covered and retain heat better than an uncovered windrow. A picture of the food waste composting system is shown in Figure 4.

Figure 4 – Prince George's County Food Waste Composting

The compost produced at the site is marketed as a branded product, Leafgro GOLD®. In FY22 MES sold 35,040 CY of Leafgro GOLD®.

The EPA's WARM model was used to determine the carbon emissions avoided as a result of producing Leafgro GOLD®. Landfill disposal of the food waste was the chosen "business as usual" baseline scenario case modeled in WARM. The facility accepted 17,017 tons of food waste in FY22. The model estimated that 11,554 mt CO_2 eq emissions were avoided by composting the food waste versus landfilling, which is equal to removing 2,490 gasoline-powered passenger vehicles from the road per year.

3.6. Initiatives at Headquarters

3.6.1. Solar Array at Headquarters

The solar array at MES Headquarters consists of a ground mounted solar array located at the rear of the headquarters building and a solar array canopy located over portions of the front parking lot of the building. The solar array located at the rear of the building was installed in 2008. It consists of photovoltaic (PV) solar panels rated at approximate 269 kW and a thin film solar panel system rated at 34 kW located on the roof of the building. The parking lot solar canopy was installed in 2016 and is rated at approximate 296 kW. There are 1,488 panels (300 kw) in the ground mounted/roof mounted solar installation, and 930 solar modules for the canopy project. These projects were constructed and owned using private funds from Constellation Energy Group Inc. MES then executed a Power Purchase Agreement (PPA) with Constellation. The term of the PPA for both solar units is 15 years.

Performance data from our solar arrays for the three-year period of 2019 through 2021 is presented in Table 12. The EPA's on-line Greenhouse Gas Equivalencies Calculator[20] can estimate the carbon emissions avoided for various mitigation strategies, in this case, from generating clean, solar energy. The 707,776-kwh produced by MES' solar panels in 2021 is equivalent to 502 mt CO_2 eq. emissions avoided. This is also equal to removing 108 gasoline powered vehicles from the roads for one year.

Figure 5 – Aerial View of Solar Installation at MES Headquarters

Calendar Year	Electricity Produced (kwh)	CO_2 Emissions Offset Due to Solar Arrays (mt CO_2 eq)
2019	644,352	454
2020	666,100	445
2021	707,776	502
Totals =	**2,018,228**	**1,401**

Table 12 – MES Headquarters Solar Array Performance

3.6.2. Telecommuting Impact on Greenhouse Gas Emissions

The COVID-19 pandemic forced major changes in the lifestyles of U.S. workers. A shift in work habits included the option for employees to work at home (telecommute) versus driving to the worksite every day. MES has instituted a hybrid remote work at home policy for agency Headquarters staff since 2020. In addition to addressing public health impacts, this also allows for an ecofriendly savings in terms of fuel use due to avoided driving. In order to document the number of miles of commute driving avoided by MES staff from performing remote work, a survey was conducted in October 2022 to ask MES Headquarters staff about their work commutes (number of days worked from home, average round trip commute distance, etc.). The result was documentation of the total miles avoided per year due to telecommuting.

A total of 167 staff members responded to the survey. This represents most of the staff working at MES Headquarters. Several assumptions were made to calculate the number of miles driven that were avoided due to telecommuting. It was assumed that a five-day workweek is in place, and that passenger vehicles such as cars and light trucks were driven. The survey also assumed that the work year was 50 weeks in length, to account for leave time. It also does not include those MES staff who work in field assignments, since they were usually required to report to a worksite each day.

Using these assumptions, the survey calculated the total number of miles of vehicle use avoided per year by implementing the teleworking policy was 841,340 miles per year. Using an average EPA fuel efficiency of 22 miles per gallon (mpg) this results in the avoidance of 37,902 gallons of fuel consumed per year. Using a value of 0.009 mt CO_2 eq. avoided per gallon of fuel used, a total of 337 mt CO_2 eq emissions per year were avoided because of the teleworking policy. This is equivalent to removing 73 passenger cars per year from the roadways.

4. Future Opportunities Towards Achieving Net Zero Emissions

There are numerous planned projects at MES which will result in additional avoided carbon emissions. These actions will help the State achieve their climate change mitigation goals. Detailed summaries of these projects are presented below.

4.1. Electric Vehicles and Charging Infrastructure

Electric vehicles do not emit tailpipe emissions, and thus have a favorable impact on carbon emissions avoidance, even after accounting for the upstream electricity generated by the utility used for vehicle charging.

At present, MES has purchased one new EV, a Chevy Bolt, and has plans to buy more vehicles. This EV will emit 320 g CO_2 eq less per mile driven as compared to a gasoline powered vehicle[21]. Assuming a conservative usage of 10,000 miles driven per year, this vehicle will avoid 3.5 mt CO_2 eq of carbon emissions per year. In FY22, MES staff logged approximately a total of 2,100,000 miles in passenger vehicles and light trucks usage. Applying this to the scenario where the entire vehicle fleet is electrified, and assuming the same 320 g per mile carbon emissions avoidance, this equates to 740 mt CO_2 eq of avoided emissions per year. This number is an approximate value, and the calculation would have to be refined using data for the specific makes and models of the replacement EVs to be purchased.

There are however some challenges to consider when deploying an EV program. One is the lack of charging infrastructure. For example, installing EV chargers at MES Headquarters (or at any site) would involve negotiations with the local utility, permits, and associated construction costs. In order to circumvent this problem, MES is considering the purchase of solar based vehicle charging stations. One such unit is manufactured by BEAM Global, a San Diego-based clean tech company that produces infrastructure products for electrification of transportation. These charging stations operate using overhead, canopy type solar powered panels installed above a carport. The EV parks under the solar panels while it is charging. As the unit is self-powered this avoids the use of a hard-wired electric supply from the utility grid. The BEAM EV charging station is also easily transportable, thus allowing its use at other sites. A typical charging station installation is shown in Figure 6.

An advantage of deploying solar power for EV charging is avoiding the use of electricity from the utility grid, and hence, not incurring the upstream carbon emissions penalty that the utility would generate. For example, using the utility emissions data for the area where MES is located would negate incurring an additional 90 g CO_2 eq less per mile because no utility electric supply would be used. For the Chevy Bolt vehicle example, this would result in an additional 0.90 mt CO_2 eq per year avoided. MES has applied for a grant from the MEA under their Open Energy Grant program to purchase the solar powered EV charger.

At the request of the Maryland Department of Natural Resources (DNR), MES is also currently working on projects to upgrade the electrical infrastructure at several State parks. As part of that work scope, they have requested that we plan to include upgrading the electrical infrastructure to accommodate EV charging.

4.2. Solar Projects

MES has several solar projects planned for commissioning. These solar arrays mostly target State Parks operated by DNR. Another effort is a study that MES is performing for MEA to identify landfill candidate sites for solar panels. MEA and MES are also in the process of examining the potential siting of solar panels for three local jurisdictions and a University of Maryland site.

4.2.1. Department of Natural Resources Solar Projects

A total of fifteen rooftop solar arrays are planned to be installed by MES at five State Parks. This effort was the result of a previous siting study conducted by MES. An RFP was issued, and we received bids for several sites. MES is currently working on obtaining price quotes for those sites that did not receive any interest during the RFP process. These solar panels will be installed in 2023. A listing of the rooftop solar arrays that will be installed is given in Table 9 below.

Figure 6 –Solar Based EV Charging Stations (courtesy of BEAM Global Inc.)

It can be seen from Table 13 that the solar arrays will meet the electrical power needs for most of the buildings where the arrays are planned to be installed. The estimated total amount of electricity that will be generated for all fifteen installations combined is 446,197 kwh per year. This avoids the emissions of 316 mt CO_2 eq per year, comparable to removing 68 passenger vehicles from the State's roadways every year.

4.2.2. Maryland Landfill Solar Assessment

MES is concluding a study for MEA to identify landfills throughout the State that are optimal for siting solar energy panels. MES assessed landfills, rubble fills, brownfields, and similar sites for solar development potential. Fifty-five landfill sites in the State were identified as being possible candidates for solar sites. The study will identify total net suitable acreage available for solar development. At MEA's request, the deployment will address environmental justice issues by identifying the number of low and moderate-income population for each site's utility territory. MES will provide MEA with an implantation plan defining final scope, approach, subcontractor selection, engagement of stakeholders, key milestones, and other provisions. The study is planned to be completed in FY23.

Park Name	Building Name	Solar Capacity (kw)	Generation Target (kwh/yr.)	Solar Generation as % of Building's Annual Electricity Use
Assateague State Park	Carpentry Shop	46.1	66,061	105
	Dormitory	12.1	16,272	105
	Day Use Building 1	13.5	18,168	22
	Day Use Building 3	24.5	32,948	105
Fair Hill NRMA	Para-Mutual Building	10.3	13,449	105
	Horse Barn #2	15.0	19,637	100
	Walls Hall	51.8	72,671	105
Merkle Wildlife Sanctuary	Visitors Center	23.3	29,903	44
	MCC House	11.0	14,148	62
Sandy Point State Park	Park Office	20.8	27,487	105
	South Beach Concession	28.1	37,128	52
	South Beach Bathhouse	11.7	15,418	105
	South Beach Comfort Station #2	12.3	16,262	105
Deep Creek State Park	Cold Storage Building	17.7	22,056	105
	Discovery Center	38.0	44,589	101
	Total Planned Electricity Generation=		**446,197**	

Table 13 – Planned Solar Panel Installations – DNR Parks

4.2.3. Other Solar Siting Projects

MES is also working with MEA on other solar siting projects for various jurisdictions in the State. Siting plans for some of these projects have been completed, and some will be finalized in FY23. These projects are:

- **Prince George's County**- Solar siting and resiliency study for a county nursing and rehab center.

- **Baltimore City**- Solar siting for 25 city-owned buildings to determine best candidates for solar.
- **Caroline County-** Geologic study and solar siting for a carport solar canopy installation at a County Department of Public Works site.
- **UMCES Appalachian Laboratory**- Solar siting for potential rooftop solar array and/or carport in Frostburg, MD.

In addition to the above, MES has been asked by DNR to incorporate solar projects whenever possible into capital improvement plans when upgrading their WWTPs and WTPs. These would most likely be done at State Parks and other DNR facilities.

4.3. Geothermal Energy

Geothermal technology extracts the heat found within the earth's subsurface. This heat can be used directly for heating and cooling, or in some cases converted into electricity. Geothermal energy currently accounts for 0.4% of net electricity generation in the United States [22]. A typical application of a geothermal energy system is for electrical power generation (see Figure 7 below). Geothermal fields produce only about one-sixth of the carbon dioxide that a relatively clean natural-gas-fueled power plant produces, and very little if any, of the nitrous oxide or sulfur-bearing gases[23.]

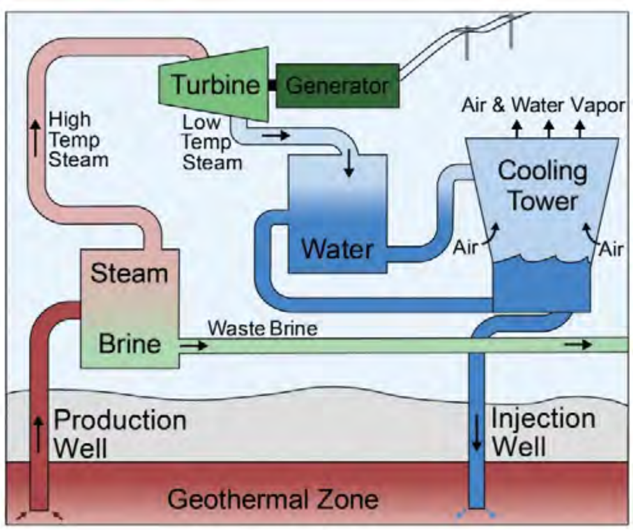

Figure 7 – Typical Application for Electrical Power Generation [22]

House Bill 1007 passed during the 2021 Maryland General Assembly Session requiring MEA to conduct a study on geothermal heating and cooling systems and establish a Geothermal Energy Workgroup [24.] MES is currently conducting this study for MEA. The study's scope evaluates the current status of geothermal heating and cooling systems in Maryland, as well as the potential impact of expanding and incentivizing the use of geothermal heating and cooling systems in the State. The study is expected to be completed in 2023.

4.4. Biochar

Pyrolysis is a process by which organic solids undergo thermal degradation in the absence of oxygen into smaller volatile molecules. Solid wastes and other biomass (e.g., woody wastes) are usually the feedstocks for the pyrolysis process. The pyrolysis process is conducted in the temperature range of 500 to 900^{o}C. Depending on the temperature, the products of pyrolysis are (1) a liquid, or bio-oil, (2) a solid called biochar, and (3) a syngas, which is composed of combustible gases such as CO, H_2, (hydrogen) and light hydrocarbons. A schematic of a typical pyrolysis process is shown in Figure 8.

The solid product, called biochar, has many beneficial properties. Biochar is a charcoal like, stable carbon rich material. This char can be used as a soil conditioner and sequester carbon, thus acting as a carbon sink. Since the biochar carbon is stable and not biodegradable, this fixed carbon remains in the soil for hundreds of years. Creating biochar reduces CO_2 in the atmosphere because the process takes the theoretically carbon-neutral process of naturally decaying organic matter and turns it carbon-negative scenario of material which doesn't return to the atmosphere for hundreds of years[25].

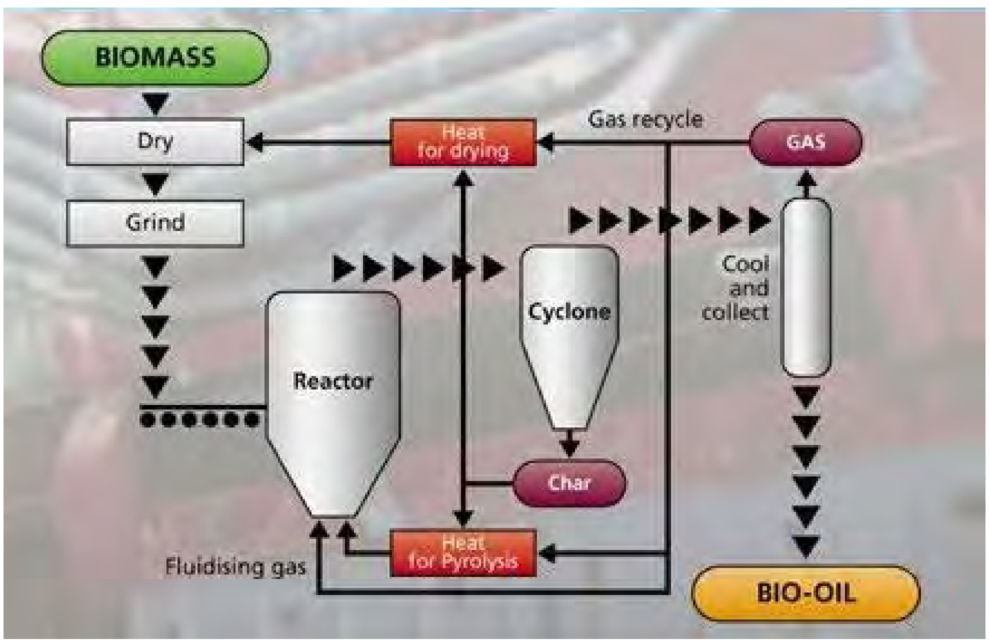

Figure 8 – Schematic of a Typical Pyrolysis Process

MES has proposed a capital improvement program for one of our wastewater treatment facilities, the Dorsey Run Advanced WWTP in Anne Arundel County. Funding has been requested by MES from the Maryland Department of Budget and Management to design and construct a pyrolysis facility at Dorsey with the objective of treating the WWTP's sludge to meet the EPA's Class A standards (thereby destroying all the pathogens in the sludge) and producing biochar for beneficial reuse. When this technology is applied to sludge treatment, it has the added extra benefit of also destroying emerging chemical pollutants, such as Per- and Polyfluoroalkyl Substances. Some providers of this technology have also developed other products from biochar, such as carbon black and consumer grade charcoal.

Pending the funding request, the pyrolysis project at Dorsey is slated to begin design in FY24, and construction and operation in FY25.

5. Conclusions

The State of Maryland has set ambitious new goals for mitigating the effects of climate change. MES is positioned to help the State meet these challenges through its current operations and upcoming projects. MES' EO Group continues to actively reduce GHG emissions though recycling operations at the MRFs and our LFG capture projects. The food waste composting facility in Prince George's County, which MES operates, produces a soil conditioner that is in high demand (Leafgro® and Leafgro GOLD®) *and,* also achieves the goal of avoiding methane emissions by diverting this waste from landfills.

Solar energy is the fastest growing source of electrical generation in the United States. The TES Group is working with MEA to establish solar installations for State agencies and other jurisdictions. The installation of fifteen solar panels at five State Parks are expected to generate a total of 446,197 kwh per year of electricity.

The Dray Truck Replacement Program is removing older, polluting diesel vehicles that are in operation at the Port of Baltimore. A total of 41 vehicles were replaced in 2021, reducing carbon emissions by 1,110 mt CO2 eq per year. This program also impacts public health by improving air quality in the Baltimore region by reducing emissions of other pollutants such as NO_x ,CO, and hydrocarbons.

The W/WW Group has a land application program that recycles biosolids onto agricultural land. By land applying biosolids back into the soil, carbon is sequestered, and the use of commercial fertilizer is avoided, thereby reducing GHGs. The production of biochar from biosolids has a very promising future as well. Biochar material is composed of stable carbon that does not readily degrade and can be considered a "carbon negative" technology. This biochar can be used as a soil conditioner that improves soil health.

MES will continue to work supporting projects that promote the mitigation of greenhouse gas emissions to protect Maryland's environment, and provide a safe and clean MidAtlantic region for generations to come.

6. Appendix

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