# U.S. Environmental Protection Agency Climate Pollution Reduction Grant

Town of Windsor Biosolids Treatment and Disposal Project
Draft Technical Appendix
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# 1. Introduction

The Windsor Water District (District) in California owns and operates a 2.2 million gallon per day (MGD) Water Reclamation Facility (WRF) that currently uses sludge ponds for storage and stabilization of the Waste Activated Sludge (WAS) and sludge generated by the Advanced Wastewater Treatment (AWT) clarifiers. The District established specific goals for their future solids management, including eliminating current reliance on outside contractors for biosolids disposal, increasing beneficial use of biosolids, reducing cost and carbon footprint associated with sludge disposal. To achieve these goals, the District completed a Feasibility Study (2021) and a Preliminary design (2022) that established the recommended project. The District selected thickening and dewatering, followed by biodryers and pyrolysis, as the recommended project. The Town of Windsor is engaging with surrounding Sonoma communities to discuss the potential implementation of a regional biosolids biodrying and pyrolysis facility, thus the town is evaluating the design, cost, and greenhouse gas implications of both a regional facility and a facility that is solely dedicated to the Town of Windsor.

The evaluation presented herein includes an operational greenhouse gas (GHG) assessment of current biosolids management for the District. This reference scenario is compared with the operational GHG footprint of potential future biosolids management for the District with the implementation new thickening, dewatering, biodrying and pyrolysis to produce biochar for local use.

# 2. GHG Reduction Estimate Method and Models/Tools Used

The GHG Protocol[1] is a partnership of various entities including businesses, nongovernmental organizations, and governments which aims to develop an internationally accepted GHG accounting and reporting standard. The GHG Protocol has released multiple standards that address how GHG emissions inventories should be prepared at the corporate, project, and product levels. The GHG Protocol approach to calculating GHG emissions was used to determine the GHG emissions of current and proposed future biosolids management strategies.

The GHG Protocol classifies GHG emissions into three scopes, as defined below. For this study, this evaluation includes only scope 1 and scope 2 emissions because they are more directly under the control of District and surrounding Sonoma communities, although the GHG analysis has been organized to accommodate the potential inclusion of scope 3 emissions in the future.

- Scope 1 emissions reflect direct emissions from sources that are owned or controlled by the District (e.g., carbon dioxide, methane, and nitrous oxide emissions from biological treatment), including on-site fossil fuel combustion, emissions from biological treatment processes, and transportation/hauling-related uses of fleet vehicles and fuel.

- Scope 2 emissions are those resulting from electricity, steam, heating, and cooling that is purchased and/or acquired by the District.

[1] ghgprotocol.org

- Scope 3 emissions, or embodied GHG emissions, are all additional indirect emissions that occur in the value chain, including both upstream (e.g., manufacturing) and downstream (e.g., disposal) emissions.
    - Scope 3 emissions also include offsets resulting from the beneficial reuse of materials, such as the GHG emissions benefit of reduced synthetic fertilizer use (and associated production) resulting from land application of biosolids on agricultural sites.

An evaluation boundary must be established for consistent inclusion of inputs and outputs in the evaluation, and transparent communication of comparative results. The boundary of this evaluation includes biosolids-specific activities at the WRF, including onsite storage and treatment, and hauling of biosolids from the WRF to its final destination.

Two operational inventories were created for projected annual average conditions in 2025 through 2050, one assuming continuation of the existing practices (reference case scenario) and one assuming implementation of the proposed biodrying and pyrolysis process at the District WRF. The proposed biodrying and pyrolysis process at the District is described in Table 1.

**Table 1: Current and Proposed Future Biosolids Management for the District and Surrounding Sonoma Communities**

| Community | Current Biosolids Management (Reference Case) | Proposed Future Biosolids Management |
|---|---|---|
| **Town of Windsor** | • Onsite sludge storage in unaerated ponds<br>• Third party dredging, dewatering, and hauling for landfilling every year | • Newly implemented thickening, dewatering, biodrying, and pyrolysis |

The operational inputs and outputs for current and proposed future biosolids management strategies were estimated using the following methods:

- Reference case information, including projected biosolids production, electricity use and/or equipment power ratings and run times, chemical use, and biosolids hauling frequencies/distances, were provided by the District,
- Methane emissions from the District's unaerated onsite storage pounds were estimated using the Water Environment Federation's BEAM*2022 model. BEAM*2022 is a spreadsheet modeling tool that calculates net greenhouse gas emissions from various biosolids management processes, and
- Electricity, natural gas, and chemical use estimates for thickening, dewatering, biodrying and pyrolysis at the District WRF were provided by the project design team and vendor (Bioforcetech Corporation) based on the water content of thickened/dewatered biosolids.

## 3. Measure Implementation Assumptions

Several key assumptions related to the implementation of the proposed regional biodrying and pyrolysis facility have been made for this GHG analysis. These assumptions include the following:

- Projected biosolids production rates in Table 2 were assumed based on information provided by the District. For the years in between 2025 and 2030, 2030 and 2035, and so on, biosolids production rates are estimated using interpolation.

**Table 2: Assumed Biosolids Production Rates**

| Community | Biosolids Production Rate, dry tons/day | | | | | |
|---|---|---|---|---|---|---|
| | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
| **Town of Windsor** | 1.77 | 1.94 | 2.11 | 2.27 | 2.44 | 2.61 |

- Current third party hauling distances for landfilling and were assumed to remain constant in the reference case from 2025 to 2050.
- The regional biodrying and pyrolysis facility is assumed to come online in 2030 and all thickened/dewatered biosolids from the District are assumed to be hauled to the regional facility instead of landfills and land application sites.
- Biochar produced at the biodrying and pyrolysis facility is assumed to be picked up by commercial and residential customers for local use, therefore eliminating the need for biochar hauling away from the District WRF.

# 4. GHG Reduction Estimate Assumptions

Several key assumptions were used as part of the method for estimating GHG emission reductions. These assumptions include the following:

- BEAM*2022 estimates of methane emissions from District storage ponds involved the following model inputs:
    - 1,025 kg BOD5 per dry ton of biosolids to the storage lagoons (assumes all influent BOD5 is accumulated in the solids),
    - Lagoons are not aerated,
    - Lagoons have an average depth that is greater than 2 meters.
- The emissions factors in Table 3 were used to equate operational inputs and outputs to associated carbon dioxide equivalents (CO2e).

**Table 3: Assumed Emissions Factors**

| Operational Input/Output | Emissions Factor | Unit | Reference |
|---|---|---|---|
| **Electricity** | 112 | lbs CO2e/MWh | Sonoma Clean Power |
| | 70 | lbs CO2e/MWh | Sonoma Clean Power – EverGreen |
| | 160 | lbs CO2e/MWh | PG&E |

| Operational Input/Output | Emissions Factor | Unit | Reference |
|---|---|---|---|
| | 404 | lbs CO2e/MWh | Healdsburg Electric – Standard Rate |
| | 59 | lbs CO2e/MWh | Healdsburg Electric – Green Rate |
| **Hauling** | 0.36 | lbs CO2e/ton-mile | Average freight truck in the US, Environmental Defense Fund |
| **Natural Gas** | 6.55 | lbs CO2e/MMBTU | US EPA Greenhouse Gas Equivalences Calculator |
| **Methane** | 28 | units CO2e/unit CH4 | 2013 IPCC AR5 Fifth Assessment Report |

# 5. Reference Case Scenario

The reference case scenario assumes that the District continues the existing biosolids management practices (business as usual), which largely consist of minimal onsite treatment and third party hauling to either a landfill or land application site. The reference scenario is further described in Table 4. For cases in which multiple transport/hauling distances could be assumed, the shorter distance was assumed to provide for a more conservative reference scenario.

**Table 4: Refence Scenario**

| Inventory | Town of Windsor |
|---|---|
| **Electricity, kWh/dry ton** | 37.85 (dewatering) |
| **Electricity Provider** | Sonoma Clean Power – Clean Power |
| **Chemical Use, lbs/dry ton** | NA |
| **Chemical Hauling Distance, miles** | NA |
| **Hauled Biosolids Solids Content, %** | 15% |
| **Hauled Biosolids, wet tons/dry ton** | 6.7 |
| **Hauled Biosolids Distance, miles** | 135 |

# 6. Measure-Specific Activity Data

The assumed measure-specific activity is that the regional biodrying and pyrolysis facility comes online in 2030 and that the District directs all thickened/dewatered biosolids to these newly implemented processes. The District is assumed to cease all onsite storage in anaerobic ponds by 2030. Additionally, all biochar produced at the new biodryind and pyrolysis facility is assumed to be used locally with no third party hauling. Updated operational inputs required for biodrying and pyrolysis are provided in Table 5.

**Table 5: Measure-Specific Activity Data**

| Inventory | Town of Windsor |
|---|---|
| **New Biosolids Hauling Distance, miles** | NA |
| **Electricity, kWh/dry ton** | 80 (thickening),<br>882 (sludge storage tank),<br>106 (dewatering),<br>401 (odor control),<br>1,440 (biodrying),<br>406 (pyrolysis) |
| **Electricity Provider** | Sonoma Clean Power – Clean Power |
| **Natural Gas Use, MMBTU/dry ton** | 25 (biodrying) |
| **Chemical Use, lbs/dry ton** | 27.9 (thickening polymer),<br>47.3 (dewatering polymer),<br>31.1 (NaOH for pyrolysis),<br>21.0 (sulfuric acid for wet chemical scrubber) |
| **Chemical Hauling Distance, miles** | 100 (polymer, NaOH, and sulfuric acid) |

# 7. GHG Emissions Reduced

The proposed regional biodrying and pyrolysis facility is expected to result in an overall GHG reduction relative to the reference scenario due to reduced biosolids hauling distances and the elimination of anaerobic storage ponds at the District WRF. Figure 1 shows the estimated annual GHG emission reductions of the regional facility relative to the reference scenario from 2025 to 2050 and Figure 2 shows cumulative GHG reductions. Annual reductions range from 2,652 to 3,572 $mtCO_2e$ per year. The cumulative GHG reduction from 2025 to 2050 is 65,367 $mtCO_2e$. No GHG emissions reductions are estimated for the period of 2025 to 2029 because the regional biosolids facility is not expected to come online until 2030.

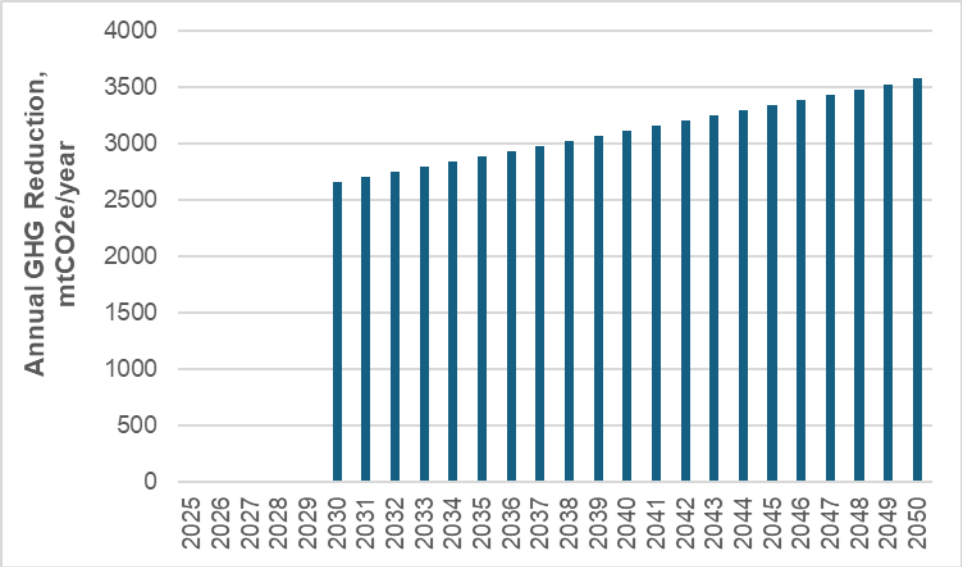


**Figure 1: Estimated Annual GHG Reduction with the Regional Biodrying and Pyrolysis Facility Relative to the Reference Scenario**

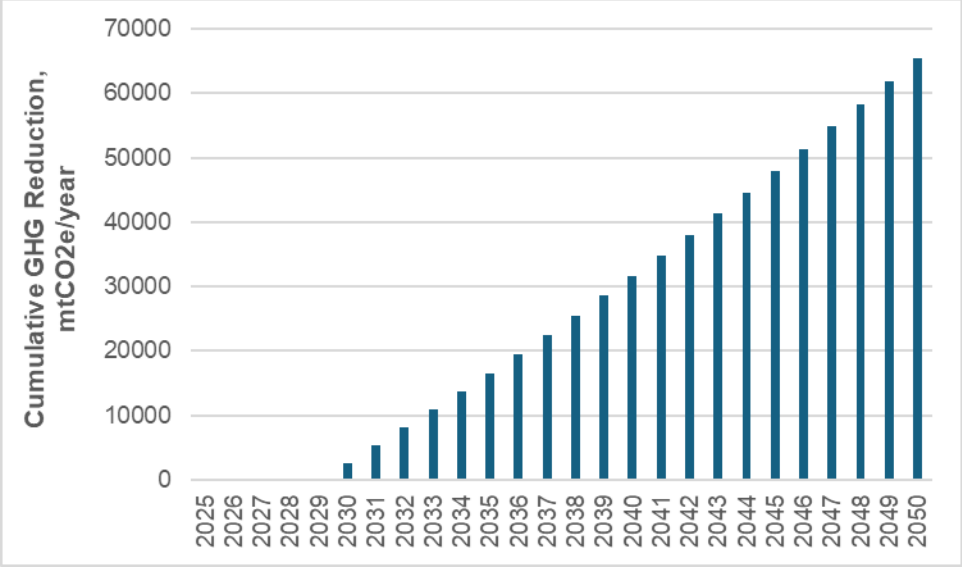


**Figure 2: Estimated Cumulative GHG Reduction with the Regional Biodrying and Pyrolysis Facility Relative to the Reference Scenario**

# Appendix A: GHG Emission Reduction Calculations

The attached calculations include a “References Values” tab for constants, a “Town of Windsor Ref Scenario” tab for the calculations and results of the reference scenario, a “Biodrying and Pyrolysis” tab for the calculations and results of the proposed measure scenario, and a final “Annual and Cumulative Reduction” tab to show estimated GHG reductions over time.