MONTANA FOREST, COMMUNITY AND WORKING LANDSCAPES CLIMATE RESILIENCY PROJECT

APPENDIX B

TECHNICAL APPENDIX

INTRODUCTION

The Technical Appendix (TA) provides a detailed summary of the data inputs, reference sources, and methodologies in quantifying greenhouse gas (GHG) and co-pollutant emissions reductions for the Montana Department of Natural Resources and Conservation (DNRC) implementation grant application. This is in support of implementation grants funding opportunity developed for the U.S. Environmental Protection Agency's (EPA) Climate Pollution Reduction Grant (CPRG) program.

The application contains the following priority reduction measures and estimated greenhouse gas (GHG) emissions reduction in Table 1-1.

Table 1-1: Estimate Greenhouse Gas Reduction Potential and Cost Effectiveness by Measure

Measure No.	Measure	Requested CPRG Funding	Cumulative GHG Emission Reductions		Cost Effectiveness
			(MMT CO_2e)		\$/MT CO_2e
			By 2030	By 2050	2025 - 2030
1	Forest Management and Wildfire Mitigation	$8,215,955	0.037	0.11	$224
2	Expand Healthy Urban and Community Forests	$9,737,193	0.1	0.72	$97
3	Mitigate and Extinguish Coal Seam Fires	$9,816,744	1.6	12	$6
4	Non-point source reductions	$1,000,000	8.24E-05	6.32E-04	$12,129
5	Fertilizer Use Innovation for Improved Soil Health	$1,000,000	0.07	0.57	$13
6	Ranchland Stewardship Program	$10,000,000	0.13	1.13	$80
7	Incentivize Innovation in the Cattle and Beef Industry	$10,000,000	0.37	3.28	$27
TOTAL		**$49,769,892**	**1.9**	**14.6**	**$26**

The Workplan included with the implementation grant application provides a detailed overview of each measure along with supporting information, such as including key implementing agencies, implementation schedules and milestones, geographic scope, metrics for tracking progress, funding, and impacts on low-income and disadvantaged communities. The primary focus of the TA is to describe the methodology in quantifying GHG and co-pollutant reductions for each measure through 2030 and 2050. The calculations quantifying emissions reduction for all measures, along with additional discussion of the methodology, is included as an attachment to the Technical Appendix titled, Attachment 1: Emissions Reduction Calculations Spreadsheet.

1.0 OVERALL APPROACH AND METHODOLOGY

The emissions reduction potential quantified for each priority measure is an extension of the calculations preformed for the Priority Climate Action Plan (PCAP). For the purposes of the PCAP, an overall unitized approach was evaluated for each measure when program-specific inputs were not yet determined. This provided a scalable basis for future reduction and implementation considerations to be used for the implementation grant process. The sectors evaluated within the PCAP exist within a complex and interdependent system where reduction in one sector can change the conditions for evaluating other sectors. This evaluation acknowledges the complexity in those systems but evaluated reduction potential for each measure independently of each other.

2.0 HEALTHY, RESILIENT FORESTS

Measure 1. Expand Forest Management and Wildfire Mitigation

a. Emission Reductions Estimate Method:

Emissions reduction potential for the forest management and wildfire mitigation measure addresses calculations in three parts: 1) Reforestation, 2) Forest Treatment and Management, and 3) Waste Biomass used for Industrial Process Heating. The United States Forest Service (USFS) Forest Vegetation Simulator (VFS) model was used to assess the emissions reduction impact for Parts 1 and 2. The FVS tool determined emissions reduction for Part 1 based on the total number of seedlings planted under specified conditions and timeline. Part 2 accounts for thinning overgrown forest areas to mitigate fire risk. The FVS tool calculated fire risk based on current conditions as well as after thinning treatments occur. Emissions reduction potential are aligned with the quantified reduction in wildfire risk associated with the thinning process. Part 3 assesses the utilization of the waste biomass from Part 2 and assess emissions reduction potential when utilizing the material in an industrial boiler at a nearby wood products facility rather than natural gas. Industry standard emission factors were utilized for these calculations and are referenced throughout the Attachment 1 Calculation Spreadsheet. Additionally, model inputs and other calculation specifics are included in the attachment. Measure-specific activity data and implementation tracking metrics for all measures are included in the Workplan unless stated otherwise in the following sections.

b. Models/Tools Used:

The Forest Vegetation Simulator (FVS) is a forest growth simulation model that simulates forest vegetation change in response to natural succession, disturbances, and management. The tool is developed by the USFS and is used by natural resource managers and researchers as an empirical growth model based on the Forest Inventory and Analysis (FIA) plots.

c. Measure Implementation Assumptions:

The following key assumptions about measure implementation were used to quantify emissions reductions for this measure:

- Implementation measure uptake
    - The measure supports existing programs within Montana DNRC. Funds would be utilized within the first year of the grant period.
- Implementation milestones
    - Part 1: 500,000 seedlings annually (2,500,000 over 5-years) See Attachment 1 for distribution of planting geography and seedling type
    - Part 2: 1,600 acres treated annually (8,000 acres of 5-years)
    - Part 3: 44,000 tons of slash combusted over 5-years
- Measure lifetime

- Emissions reduction associated with Parts 1 and 2 have a measure lifetime beyond 2050. Part 3 only assess through the program period (2025 – 2030).

- Capital cost and operation and maintenance cost assumptions
    - Costs associated with measure implementation are well documented through existing programs that implement these same practices. They direct program goals and milestones. The costs are based on the discussion within the workplan and budget.

d. Emission Reduction Estimate Assumptions:

The following key assumptions about emission reductions were used to quantify emission reductions for this measure:

- Emission rates, factors, model inputs
    - Part 1 and 2 emission rates, factors and model assumptions are based on the FVS modeling tool and specific model inputs are included in Attachment 1.
    - Part 3 quantifies "avoided emissions" by calculating the emissions from natural gas that are avoided by substituting with heat energy from biomass when combusted in an industrial boiler. This evaluates emissions associated with the combustion of both fuel types and assess the difference in operating scenarios. References for emission factors, material heating values, and other inputs are included in Attachment 1.

e. Reference Case Scenario:

The reference case scenario accounts for the following:

- Part 1: No reforestation occurs so no carbon sequestration is available from the proposed seedlings
- Part 2: Thinning and forest treatment does not occur, so wildfire rise is higher and impacts due to wildfire are greater
- Part 3: Facility boiler operation continues to be combusted using natural gas

Measure 2. Expand Healthy Urban and Community Forests

a. Emission Reductions Estimate Method:

Montana DNRC inventories existing urban trees using the TreeKeeper tool. The existing inventory accounts for 25% of community urban forest coverage. TreeKeeper utilizes the iTree Eco model to quantify emissions reduction potential. iTree Eco only quantifies reduction potential based on a portion of the total forest coverage, so the model was initially processed utilizing the existing 25% urban tree inventory. The results were then scaled to apply program coverage to 100% of community forest to quantify total reduction potential.

b. Models/Tools Used:

TreeKeeper urban forest management system to establish baseline conditions for existing urban forests. iTree Eco is connected to TreeKeeper and was used to forecast pollution reduction from program implementation.

c. Measure Implementation Assumptions:

The following key assumptions about measure implementation were used to quantify emissions reductions for this measure:

- Implementation measure uptake

  - The measure supports existing urban forestry programs within Montana DNRC. Funds would be utilized within the first year of the grant period.

- Implementation milestones
  - Add 20,000 trees per year over 5-years (100,000 trees total)
  - Total program implementation is the equivalent of canopy increasing by 1 - 3%
  - Program implementation can be tailored to community needs: Number of trees requested or to meet a carbon reduction goal
- Measure lifetime
  - Emissions reduction have a measure lifetime beyond 2050
- Capital cost and operation and maintenance cost assumptions
  - Costs associated with measure implementation are well documented through existing programs that implement these same practices. They direct program goals and milestones. The costs are based on the discussion within the workplan and budget.

d. Emission Reduction Estimate Assumptions:

The following key assumptions about emission reductions were used to quantify emission reductions for this measure:

- Emission rates, factors, model inputs
  - Emission rates, factors and model assumptions are based on the iTree Eco modeling tool and specific model inputs are included in Attachment 1.

e. Reference Case Scenario:

The reference case scenario accounts for the following:

- The reference case accounts for no urban forest planting and growth occurs through the program, so no carbon sequestration is available from the proposed urban tree plantings

f. Emissions Reduced:

- In a national report (McPherson, 2002), every dollar spent on managing urban and community forests is matched by nearly two dollars in environmental services and increased property values in return. Montana is expected to exceed this. According to Montana DNRC's cost-benefits scenario (DNRC 2017), for every $1 invested in public trees, Montanans receive $4.41 in benefits. Trees are one of the only assets that appreciate over time if grown in proper conditions. These grant funds would undoubtedly increase overall urban forest benefits for an even higher return on investment by 2050 and beyond.

Measure 3. Mitigate and Extinguish Coal Seam Fires

a. Emission Reductions Estimate Method:

Montana DNRC inventories existing coal seam fires along with Montana Department of Environmental Quality (MDEQ) and county extension offices. The basis for determining emission reduction potential is based on the published article "Quantifying greenhouse gas emissions from coal fires using airborne and ground-based methods." Engel et al. 2011. The magnitude of the contribution of combustion gases from coal fires to the environment is highly uncertain because adequate data and methods for assessing emissions are lacking. Engel et al. demonstrates the ability to estimate CO_2 and CH_4 emissions for the Welch Ranch coal fire in the Powder River Basin, Wyoming, using two independent methods for heat flux calculated from aerial thermal infrared imaging and direct, ground-based measurements. The two methods provide complimentary results for cross-reference. The results of the study are utilized to quantify emissions for this measure because the Powder River Basin is representative of coal seam regions in Montana, including variables that can impact combustion such as the type and quality of regional coal, climate, groundwater saturation, and terrain. This provides a representative coal seam fire to be utilized as a surrogate for this analysis. Therefore, the air pollutant emissions assessed from the study represent emissions for each coal seam fire addressed by this implementation measure. These emissions include gases transported to the surface via two mechanisms: (a) diffusion/convection through overburden (soil-diffuse emissions), and (b) advection through vents and fractures (vent emissions).

b. Models/Tools Used:

Engel et al. used a combination of aerial and ground-based measurement tools and are further detailed in the 2011 paper and Attachment 1.

c. Measure Implementation Assumptions:

The following key assumptions about measure implementation were used to quantify emissions reductions for this measure:

- Implementation measure uptake
  - The measure supports existing programs within Montana DNRC and county extension offices. Funds would be utilized within the first year of the grant period.
- Implementation milestones
  - Identify and extinguish 40 coal seam fires each year for 5-years
  - Extinguish 200 coal seam fires over the 5-year period
- Measure lifetime
  - Emissions reduction have a measure lifetime beyond 2050 under the assumption that a treated area will not ignite again
- Capital cost and operation and maintenance cost assumptions
  - Costs associated with measure implementation are well documented through existing programs that implement these same practices. They direct program goals and milestones. The costs are based on the discussion within the workplan and budget.

d. Emission Reduction Estimate Assumptions:

The following key assumptions about emission reductions were used to quantify emission reductions for this measure:

- Emission rates, factors, model inputs
  - Emission rates are based on the monitored and measured emissions published in Engel et al. 2011. This fire is considered representative of all 200 fires treated through the measure

e. Reference Case Scenario:

The reference case scenario accounts for the following:

- Th case considers all the 200 coal seam fires to be treated through this program instead continue burning beyond 2050 due to no intervention and treatment.

3.0 INNOVATIVE AGRICULTURE & WORKING LANDS

Measure 4: Reduce Nonpoint Sources of Pollution and Associated Algal Blooms

a. Emission Reductions Estimate Method:

Montana DEQ collects nitrogen and phosphorus data when treating algal blooms in water bodies. This data, along with quantification methodology from Smith 1982 and Beaulieu et al. 2019, were utilized to quantify emissions reduction

b. Models/Tools Used:

The evaluation utilized the research of Smith 1982 and Beaulieu 2019. The calculation methodology is included in Attachment 1.

c. Measure Implementation Assumptions:

The following key assumptions about measure implementation were used to quantify emissions reductions for this measure:

- Implementation measure uptake
  - The measure supports existing programs within Montana DEQ. However, the first year would require program administration, set up and outreach. Funds would be utilized within the years 2-5 year of the grant period to directly reduce carbon emissions.
- Implementation milestones
  - Treat 2 impacted water bodies per year
  - 6-total water bodies treated throughout the 5-year program period
- Measure lifetime
  - Emissions reduction have a measure lifetime beyond 2050 under the assumption that a nontreated area will continue to emit again
- Capital cost and operation and maintenance cost assumptions
  - Costs associated with measure implementation are well documented through existing programs that implement these same practices. They direct program goals and milestones. The costs are based on the discussion within the workplan and budget.

d. Emission Reduction Estimate Assumptions:

The following key assumptions about emission reductions were used to quantify emission reductions for this measure:

- Emission rates, factors, model inputs

- Emission rates are based on the calculations listed in Smith 1982 and Beaulieu 2019. They are included in Attachment 1.

e. Reference Case Scenario:

The reference case scenario accounts for the following:

- The reference case considers all 6-water bodies would be treated through the program and would continue to emit through 20150.

Measure 5: Fertilizer Use Innovation for Improved Soil Health Industry

a. Emission Reductions Estimate Method:

Montana State University (MSU) has researched nitrogen fertilizer (N) use efficiency across 8 Montana rainfed winter wheat fields over last 8 years. The results have demonstrated that by using On-Field Precision Experimentation (OFPE), farmers can substantially decrease full-field nitrogen application amounts, increase farmer profits, and decrease nitrogen loss to environment by site-specific application of the fertilizer (Hegedus 2023a). OFPE allows agricultural producers to quantify the exact N amounts to apply to each field, which is important because all fields, even adjacent ones, have different optimum N rates (rates that maximize profit and at same time minimize pollution). Therefore, this methodology allows for field specific quantification as a target for all farmers, or more specifically, for all fields. Innovation of variable rate N application fertilizing equipment, driven by GPS, can aid in applying optimum site-specific rates. MSU research has shown 10 - 60% decreases in full-field N amounts using the OFPE framework (Hegedus (2023b).

While developed in dryland winter-wheat systems of Montana, the methods outlined in Hegedus 2023a are applicable to other crops and systems when similar procedures are used to generate information for increasing agronomic input efficiency with simultaneous consideration for profitability. This optimized fertilizer application methodology has been proven successful in winter wheat along with other cereal crops such as spring wheat, barley, and durum.

b. Models/Tools Used:

The evaluation utilized the research of Hegedus et al paired with the direct and indirect emissions calculation methodology used in the U.S. EPA State Inventory Tool (SIT) AgModule. The calculations are included in Attachment 1.

c. Measure Implementation Assumptions:

The following key assumptions about measure implementation were used to quantify emissions reductions for this measure:

- Implementation measure uptake
  - The measure supports existing programs within Montana Department of Agriculture and additional partners through the state. Funds would be utilized within the first year of the grant period.
- Implementation milestones
  - Implement variable rate fertilizer (VRF) techniques on 100,000 acres of land used for producing cereal crops per year.
  - Implementation over 500,000 acres over the 5-year period
- Measure lifetime

  - Emissions reduction have a measure lifetime through 2050 under the assumption that the agricultural producer continues VRF application methods on same number of acres through 2050.
- Capital cost and operation and maintenance cost assumptions
  - Costs associated with measure implementation are well documented through industry standards and existing governmental and private programs that implement these same practices. The costs are based on the discussion within the workplan and budget.

d. Emission Reduction Estimate Assumptions:

The following key assumptions about emission reductions were used to quantify emission reductions for this measure:

- Emission rates, factors, model inputs
  - While research has shown a 10% - 60% decrease in emissions, this evaluation uses a uniform 35% average reduction potential. The baseline fertilizer application is based on Montana wheat farmers typically apply one uniform N fertilizer application, typically around 75 lbs N ac−1 in spring (March–April) (Hegedus 2023b).
  - The calculations utilize the EPA SIT Ag Module Methodology, Ag Soils-Plan-Fertilizer Sheet and assumes all reduction is in synthetic fertilizer usage

e. Reference Case Scenario:

The reference case scenario accounts for the following:

- The reference case considers that all the targeted acreage will continue to use traditional fertilizer techniques at rates that exclude the 35% reduction potential. This is considered to occur through 2050.

Measure 6. Ranchland Stewardship Program

a. Emission Reductions Estimate Method:

The ranchland stewardship measure utilizes the research of "Grazing Management, Forage Production and Soil Carbon Dynamics by Mark E. Ritchie (Ritchie 2020) to inform carbon sequestration potential through informed grazing and soil carbon dynamics. It accounts for GHG emission reduction through soil carbon sequestration due to enhanced grazing practices.

b. Models/Tools Used:

The evaluation utilized the research of Ritchie 2020 which is based on soil and vegetation sampling from (9) ranches within Cascade, Park, and Sweetgrass counties of Montana. Sample sites are reference test points of the SNAPGRAZE model for assessing grazing and soil carbon dynamics.

c. Measure Implementation Assumptions:

The following key assumptions about measure implementation were used to quantify emissions reductions for this measure:

- Implementation measure uptake
  - The measure would require an initial year of program administration, set-up, and outreach. Therefore, emission reductions are considered for years 2 – 5 of the grants
- Implementation milestones

- Implement the measure on 25,000 acres of land each year of the program
- Implementation of 100,000 acres over the 5-year grant period

- Measure lifetime
  - Emissions reduction have a measure lifetime through 2050 under the assumption that the agricultural application methods on same number of acres through 2050.
  - Current carbon sequestration contracts in area account for 40-years of sequestration indicating that 2025-2050 is within program bounds.
- Capital cost and operation and maintenance cost assumptions
  - Costs associated with measure implementation are well documented through industry standards and existing governmental and private programs that implement these same practices. The costs are based on the discussion within the workplan and budget.

d. Emission Reduction Estimate Assumptions:

The following key assumptions about emission reductions were used to quantify emission reductions for this measure:

- Emission rates, factors, model inputs
  - Accounting for a change in soil carbon density per year (DSOCy) at 0.5 metric tons CO_2 sequestered per acre based on Ritchie 2020.
  - Assumes soil uptake at the rate each year following program methodology and requirements

e. Reference Case Scenario:

The reference case scenario accounts for the following:

- The reference case considers that all the targeted acreage will continue to use common grazing practices so none of the land area will sequester carbon through 2050.

Measure 7. Incentivize Innovation in the Cattle & Beef Industry

a. Emission Reductions Estimate Method:

Emissions reduction potential for this measure addresses calculations in three parts: 1) Methane gas capture technology or feed efficiency improvements, 2) Renewable Energy Systems, and 3) Organic fertilizer production. More specific on each calculation is included in the Attachment 1 Calculation Spreadsheet. Solar PV applications are considered for Part 2, however additional sources of renewable energy generation could be considered for the program such as ground source heat pumps. Organic fertilizer production for Part 3 is considered to be digestate production rather than composting of manure due to lower carbon intensity.

b. Models/Tools Used:

Emissions reduction is based on the U.S. EPA Avoided Emissions and Generation Tool (AVERT) for renewable energy applications. Otherwise, it references the published articles of “Inclusion of Asparagopsis armata in lactating dairy cows’ diet reduces enteric methane emission by over 50 percent” Roque et al 2019 for Part 1 and “Greenhouse gas emissions from inorganic and organic fertilizer production and use: A review of emission factors and their variability” Walling et al 2020 for Part 3.

c. Measure Implementation Assumptions:

The following key assumptions about measure implementation were used to quantify emissions reductions for this measure:

- Implementation measure uptake
    - The measure would require outreach and development for Part 1. Therefore, emissions reduction is calculated for Program Years 2 – 5 for Part 1 and Program Years 1 – 5 for Parts 2 and 3.
- Implementation milestones
    - Part 1: 25,000 animals under innovative feed systems each year (100,000 animals over 5-years)
    - Part 2: 0.2 MW solar PV installed annually (1 MW installed over 5-years)
    - Part 3: 45,000 tons of manure processed per year (based on animals under innovative feeding systems) (225,000 tons of manure process over 5-years)
- Measure lifetime
    - Emissions reduction associated with Parts 1 and 2 have a measure lifetime beyond 2050. This assumes the agricultural producer continues application methods at same amount through 2050. Also, solar PV is considered to have a service life of 25+ years
    - Part 3 assess program reduction over 15-years due to the potential service life of equipment associated with digestate production
- Capital cost and operation and maintenance cost assumptions
    - Costs associated with measure implementation are well documented through existing programs that implement these same practices. They direct program goals and milestones. The costs are based on the discussion within the workplan and budget.

d. Emission Reduction Estimate Assumptions:

The following key assumptions about emission reductions were used to quantify emission reductions for this measure:

- Emission rates, factors, model inputs
    - Part 1 uses a 50% annual reduction rate for cattle due to Roque et al 2020
    - Part 2 utilized the factors and emission rates built into the AVERT tool
    - Part 3 references the extensive aggregation of emission factors included in Walling et al. 2020.

e. Reference Case Scenario:

The reference case scenario accounts for the following:

- Part 1: No reduction in existing feedlot cattle
- Part 2: Electricity offset by proposed solar PV project continues to receive electricity from the grid
- Part 3: Manure is not processed at all and decomposes resulting in GHGs emitted to the atmosphere

REFERENCES

See Attachment 1 for list of references.