California Air Resources Board

**Greenhouse Gas Quantification Methodology for the
California Department of Food and Agriculture
State Water Efficiency and Enhancement Program**

**Greenhouse Gas Reduction Fund
FY 2015-16**

March 15, 2016

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Section A. Introduction

The California Air Resources Board (ARB) is responsible for providing the quantification methodology to estimate greenhouse gas (GHG) emission reductions from projects receiving monies from the Greenhouse Gas Reduction Fund (GGRF) for California Climate Investments. For the California Department of Food and Agriculture's (CDFA) State Water Efficiency and Enhancement Program (SWEEP), ARB staff developed this quantification methodology and the accompanying calculator tool for applicants to use to estimate the GHG emission reductions from each proposed project. ARB staff will periodically review each quantification methodology to evaluate its effectiveness and update methodologies to make them more robust, user-friendly, and appropriate to the projects being quantified.

This methodology uses calculations to estimate the reduction of on-farm energy use and associated reduction in GHG emissions based on proposed SWEEP project enhancements. These calculations are based on the current understanding of irrigation practices, irrigation system enhancements, fuel conversions, and GHG emission factors.

Methodology Development

ARB staff followed a set of principles to guide the development of the quantification methodology. These principles ensure that the methodology for SWEEP projects will:

- Apply at the project-level;
- Align with the project types proposed for funding;
- Provide uniform methodologies that can be applied statewide, and be accessible by all applicants;
- Support the analysis of GHG emission reductions from the proposed projects;
- Use existing and proven methods; and
- Use project-level data when available for estimated energy use reductions.

The methodology fits these objectives, and provides a uniform approach to quantify GHG emission reductions in metric tons of carbon dioxide equivalent ($MTCO_2e$).

ARB released a draft FY 2015-16 quantification methodology for public comment in February 2016. Public comments were considered in the development of this Quantification Methodology.

Tools

Applicants must use the ARB GHG Calculator tool, located at http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/quantification.htm, to estimate the GHG emission reductions from their proposed SWEEP projects. GHG emission reductions used in this methodology are calculated as a result of on-farm enhancements that reduce groundwater pumping, improve pump system efficiency, or convert to less carbon-intensive energy sources used to operate pump system.

For projects that reduce water use that results in reduced pump demand, applicants will utilize the United States Department of Agriculture (USDA) National Resource Conservation Service (NRCS) Irrigation Water Savings Calculator tool to estimate water savings from proposed irrigation system enhancements. The water savings estimate determined by the NRCS Irrigation Water Savings Calculator tool is used as an input in the ARB GHG calculator tool.

The NRCS Irrigation Water Savings Calculator tool can be assessed here: https://efotg.sc.egov.usda.gov/references/public/CA/CA_irrigation_water_savings_10-6-14.xls. Instructions for applicants are included in Appendix C.

SWEEP Projects

GHG emission reductions for SWEEP projects are based on the following project types:

1. Pump and motor enhancement and/or replacement
2. Irrigation system enhancement
3. Fuel conversion

Per SWEEP Program Guidelines:

Eligible projects must:
- Reduce greenhouse gas emissions; and
- Reduce water use.

Applicants must provide supporting documentation directly related to actual on-farm water consumption and GHG emissions.

Note: Projects that reduce water consumption but do not reduce GHG emissions are not considered an eligible project.

GHG Emission Reductions Quantification Approach

The following metric will be used for ARB reporting purposes to assess the effectiveness of the project to reduce GHG emissions per dollar of GGRF funds will be reported by the applicant as:

$$\frac{Total\ Project\ GHG\ Reductions\ in\ Metric\ Tons\ of\ CO_2e}{Total\ GGRF\ Funds\ Requested\ (\$)}$$

GGRF Funds Requested is the dollar amount requested through SWEEP. Section B describes the process for estimating the GHG emission reductions for proposed SWEEP projects in FY 2015-16. Additional documentation and reporting requirements are provided in sections C and D

The ARB calculator tool also determines GHG emission reductions per project acre. This metric is used by CDFA as a project selection criteria as outlined in CDFA's solicitation materials.

Program Assistance

CDFA staff, in conjunction with subject matter experts, will review the quantification portions of SWEEP project applications to ensure that the methods described in this document were properly applied to estimate the GHG emission reductions for the proposed project. Applicants should use the following resources for additional questions and comments:
- Questions on this quantification document should be sent to GGRFProgram@arb.ca.gov.
- For more information on ARB's efforts to support implementation of GGRF investments, see: www.arb.ca.gov/auctionproceeds.
- Questions not related to this quantification document but pertaining to SWEEP should be sent to grants@cdfa.ca.gov.

Section B. Quantification Methodology

This methodology estimates the GHG emission reductions of a proposed SWEEP project based on reduction in on-farm energy use as a result of pump and motor enhancements and replacement, reductions in pump demand from irrigation system enhancements, and the conversion to a less carbon intensive fuel or installation of on-site renewable energy generation. Applicants will use the ARB GHG calculator tool to estimate the total GHG emission reductions from the proposed project over the useful life, as defined in the methodology.

The following is a summary of the steps SWEEP applicants will follow to estimate and report the GHG emission reductions for a proposed project. Detailed instructions for each step are provided on subsequent pages. An example of a proposed SWEEP project quantification is included in Appendix A.

Step 1   **Identify the SWEEP proposed project component(s)**: The applicant must select at least one project component as identified in the 2016 SWEEP "Request for Grant Applications" (i.e., guidelines) or from Table 1 of this document. To achieve energy and water reductions, projects may require multiple project components.

Step 2   **Determine the inputs needed**: The applicant will use Table 2 to determine the required project details needed for input into the calculator tool for the applicable project type selected in Step 1. Links for the ARB GHG calculator tool and USDA NRCS Irrigation Water Savings calculator are available in Section A. Introduction, Tools. Instructions for using the NRCS tool are included in Appendix C.

Step 3   **Estimate GHG emission reductions (use ARB calculator tool)**: The applicant will enter the project details into the ARB GHG calculator tool to calculate the GHG emission reductions over the useful life[1] using the inputs identified in Step 2.

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[1] For purposes of SWEEP projects, the life of a proposed project (useful life) is defined as the number of years recipients are expected to use and maintain their system. The default useful life for these projects is 10 years.

Step 1: Identify the SWEEP Proposed Project Component(s)

Table 1 identifies the most common eligible project components expected to be funded under SWEEP. The applicant must identify at least one project component from this list that defines the proposed project. All projects must achieve energy use reductions and result in water use reductions. To achieve both objectives, projects may require multiple components. The project components identified will inform the sections of the ARB GHG calculator tool required to determine GHG emission reductions. Each calculation is for a single irrigated plot with a dedicated pump. For projects with additional pumps being upgraded or multiple plots, applicants must perform calculations on the additional Inputs Tabs for each pump or individual plot. The cumulative value is displayed as the Total GHG Emission Reductions in the Summary Tab. The irrigated acreage for each table should correspond to the acres served by that dedicated pump.

Table 1. Project Components

Pump and Motor Enhancements
Install a variable frequency drive (VFD) (booster pump or well pump)
Motor replacement or efficiency improvement
Pump replacement or efficiency improvement
Irrigation System Enhancements (for systems utilizing pumps)
Install or modify irrigation system that results in a reduction in system pressure
Install automated irrigation system, scheduling, soil moisture sensors, or other techniques to reduce water use that reduce pump demand
Fuel Conversions and Renewable Energy
Change fuel types to less carbon intensive fuel (in conjunction with water savings measures)
Install renewable energy on-site to offset fuel use

Step 2: Determine the Inputs Needed

Table 2 identifies the data inputs for the ARB GHG calculator tool to estimate the GHG emission reductions for proposed projects by project component.

Table 2. Required Calculator Inputs

All SWEEP Projects
Existing Conditions (prior to any project modification)
- Irrigated Project Area (acres)   - GGRF funds requested ($)   - Pump fuel amount or electricity use (gallons, therms, or kWh)   - Fuel type
Pump and Motor Enhancements
Project Details (both pre-project values and post-project estimates)
- Motor Rated Horsepower (hP)   - Operational hours in a growing season; this parameter is only needed for pre-project scenario for determining baseline energy demand if energy use data is unavailable   - Motor Efficiency (%)   - Pump Efficiency (%)   - System Pressure, in units of feet, determined from the following user inputs: - Pumping depth (ft) – this is groundwater depth for wells   - Discharge pressure from pump (ft)   - Friction losses (ft); if unknown, use a default of 10 ft for well pumps and 5 ft for booster pumps   Note: If pressures are known in units of pounds per square inch (psi), the calculator tool provides a mechanism for conversion to units of feet.   - If a VFD will be installed, specify type and VFD efficiency (%)
Irrigation System Enhancements (for systems utilizing pumps)
Project Details
Water savings, as estimated in USDA NRCS Irrigation Water Savings Calculator, is located in Cell A30 (%). If the project includes system repairs preventing leakage, these values should be captured in the USDA NRCS Irrigation Water Savings Calculator. Please refer to Appendix C for instructions on using the NRCS tool.
Fuel Conversions and Renewable Energy
Proposed Project Details
- New fuel type if converting to a different fuel.   - Capacity of renewable energy installations (kW).   - If converting fuels, enter the change from the drop down menu in the ARB GHG calculator tool.

Step 3: Estimate GHG Emission Reductions Using the ARB GHG Calculator Tool

The applicant should download the calculator tool and enter project specific data to estimate GHG emission reductions. An overview of the calculator tool is provided below.

Read Me Tab

- On the Read Me Tab, enter the Project Name, Project ID from FAAST, and the contact information for person who can answer project specific questions from staff reviewers on the quantification calculations. This file must be submitted with other required documents. Please use the following file naming convention: "[FAAST ID]_[Project Name]" not to exceed 20 characters.

Project Name:	Smith Brothers Farm
Project ID - FAAST:	12-3456789
Contact Name:	John Smith
Contact Phone Number:	916-555-1234
Contact Email:	john@smithbros.com
Date Completed:	12/1/2015

Inputs Tab

- Headers in red indicate a field that requires input by the project applicant. For each project component section, please complete all relevant data. For example, if the project is not making changes to the pump or motor, the existing pump information will still be utilized in determining energy reductions from irrigation system enhancements. If applicants are implementing more than one project or their project impacts more than one pump or well site, the applicant should run the calculator tool for each pump or well site impacted. Definitions are provided in the definitions tab. Inputs must be substantiated in the documentation provided in accordance with Section C. Documentation.

Summary Tab

- The summary tab identifies the annual and useful life GHG emission reductions associated with SWEEP project enhancements. In addition, the total GGRF funds awarded, Total GHG emission reductions per acre, and the reporting metric of the project are summarized.

GHG Emission Reduction Calculations

All equations and calculations are included in the ARB GHG calculator tool as part of this quantification methodology; detailed documentation is included in Appendix B. In general, GHG emissions reductions are calculated using the following approaches:

Pump and Motor Enhancements
$GHG\ Emission\ Reductions =$ $GHG\ Emissions\ of\ Old\ Pump - GHG\ Emissions\ of\ New\ Pump\ (Including\ VFD)$
Irrigation System Enhancements (for systems utilizing pumps)
$GHG\ Emission\ Reductions$ $= GHG\ Emissions\ Reductions\ of\ Pump\ Operation\ for\ Reduction\ in\ Water\ Use$
Fuel Conversions and Renewable Energy
$GHG\ Emission\ Reductions$ $= GHG\ Emissions\ of\ Displaced\ Fuel\ or\ GHG\ Emission\ Reductions\ from\ Less$ $Carbon\ Intensive\ Fuel$

Section C. Documentation

Applicants must report the Net GHG Benefits over the useful life of the project and provide documentation of the calculations and inputs used. The Net GHG Benefits over the useful life are equal to the Total Project GHG Emission Reductions estimated in the ARB GHG calculator tool and found in the "GHG Calculations" Tab.

Applicants are required to provide electronic documentation that is complete and sufficient to allow the calculations to be reviewed and replicated. Paper copies of supporting materials must be available upon request by CDFA or ARB staff.
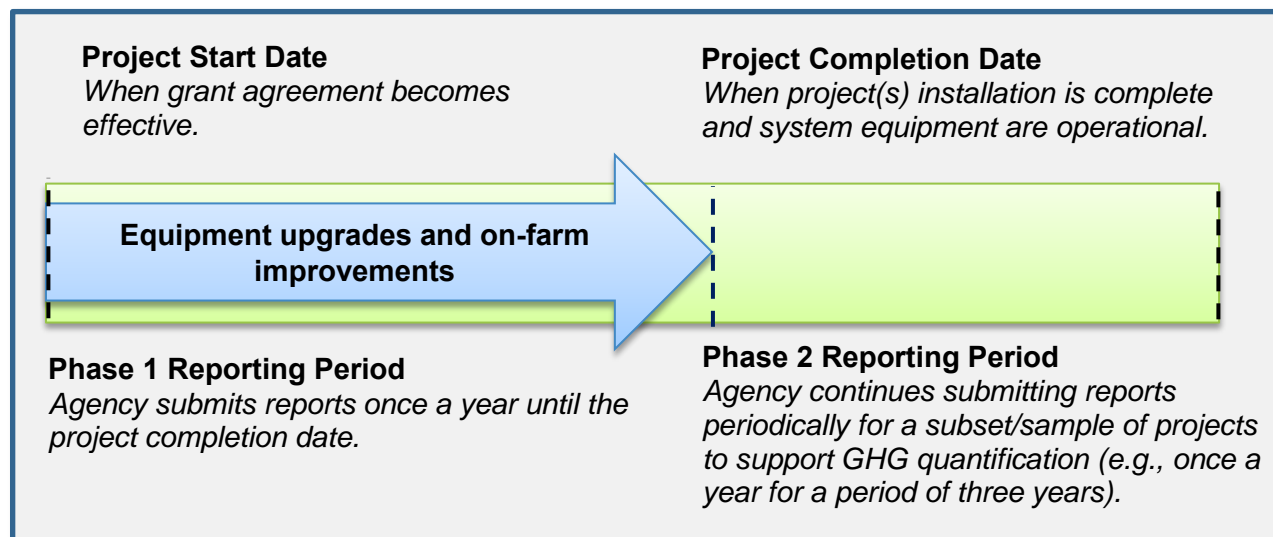
Documentation must include, at a minimum:

- Project application;
- Completed ARB GHG calculator tool file(s);
- Project description, including excerpts or specific references to the location in the main SWEEP application of the project information necessary to complete the applicable portions of the quantification methodology; and
- Project data support, including:
    - Calculator inputs determined in Step 2;
    - Documentation of the project data used to support ARB GHG calculator inputs (i.e., energy use, pump and motor specifications, and water savings estimates (USDA NRCS Irrigation Water Savings Calculator);
    - References to public documents that are the source of the project data.

Section D. Reporting after Funding Award

Accountability and transparency are essential elements for all GGRF California Climate Investment projects. Each administering agency is required to track and report on the benefits of the California Climate Investments funded under their program(s) and each funding recipient has the obligation to provide the necessary data or access to data for their project to support reporting on project outcomes.

In 2015, ARB developed Funding Guidelines for Agencies Administering California Climate Investments (Funding Guidelines).[2] These Funding Guidelines describe the reporting requirements and set the <u>minimum</u> project-level reporting requirements for projects funded by CDFA. Volume III of the Funding Guidelines summarizes the major reporting components that CDFA must report to ARB. Because much of this data will be aggregated by CDFA staff, SWEEP funding recipients will need to provide project data to CDFA to support these reporting requirements.

Table 3 and the figure below show the project phases and when reporting is required.

Project Start Date
When grant agreement becomes effective.

Project Completion Date
When project(s) installation is complete and system equipment are operational.

Equipment upgrades and on-farm improvements

Phase 1 Reporting Period
Agency submits reports once a year until the project completion date.

Phase 2 Reporting Period
Agency continues submitting reports periodically for a subset/sample of projects to support GHG quantification (e.g., once a year for a period of three years).

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[2] California Air Resources Board. Funding Guidelines for Agencies Administering California Climate Investments. December 21, 2015. http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/arb-funding-guidelines-for-ca-climate-investments.pdf.

Table 3. Quantification and Reporting By Project Phase

	Timeframe	Quantification Methodology Section
Project Selection	Covers the period from solicitation to selection of projects and funding awards	All applicants use methods in this QM to **estimate** GHG reductions based on application data.
Phase 1	Covers the period from the beginning of the project until it becomes operational or the initial implementation is completed	Funded projects use methods in this QM, as needed, to update GHG **estimates** based on project changes.
Phase 2	Starts after Phase 1 is complete and a project becomes operational	GHG reductions **achieved** are quantified and reported for a subset of funded projects.

Phase 1 reporting is required for all SWEEP projects. CDFA will collect and submit data to ARB to satisfy Phase 1 reporting requirements. Recipients of SWEEP funding must report any changes that impact GHG emission reduction estimates (i.e., fuel or energy use) to CDFA prior to project completion.

Phase 2 reporting is required for only a subset of SWEEP projects and is intended to document actual project benefits achieved after the project becomes operational. Phase 2 data collection and reporting will not be required for every project. CDFA will be responsible for identifying the subset of individual projects that must complete Phase 2 reporting, identifying who will be responsible for collecting Phase 2 data, and for reporting the required information to ARB. ARB will work with CDFA to address "Phase 2" procedures, including but not limited to:

- The **timelines** for Phase 2 reporting, i.e., when does Phase 2 reporting begin, how long will Phase 2 reporting be needed.
- As applicable, **approaches for determining the subset of projects** that need Phase 2 reporting (i.e., how many **X** projects out of **Y** total projects are required to have Phase 2 reporting).
- **Methods for monitoring or measuring** the necessary data to quantify and document achieved GHG reductions and other select project benefits.
- **Data to be collected**, including data field needed to support quantification of GHG emission benefits.
- Reporting requirements for transmitting the data to ARB or CDFA for program transparency and use in reports.

Once the Phase 2 quantification method and data needs are determined, ARB will develop and post the final ARB approved Phase 2 methodology for use in Phase 2 reporting.

Appendix A. Example Project

The following example is a hypothetical SWEEP proposed project for the purpose of demonstrating how to use the ARB GHG Calculator tool to estimate the proposed project's GHG emission reductions.

A 100 acre farm in the Central Valley utilizes a high pressure solid set sprinkler system to irrigate vegetable crops. The farmer sources irrigation water primarily from an on-site groundwater well that employs an older, inefficient vertical turbine pump rated at 100 horsepower (hP) used in conjunction with a diesel motor. A pump test reported a pump test efficiency of 70%. The motor efficiency is listed by the manufacturer as 75% Through CDFA's SWEEP grant program, the farmer proposes to convert the existing high pressure irrigation system to a low pressure micro-drip irrigation system. The farmer also proposes to replace the inefficient diesel motor/pump system with a new and more efficient electric motor/pump system rated at 80 hP with a VFD controller. In addition, the farmer proposes to install 20 kilowatt (kW) solar panels to provide renewable electricity to supplement a portion of the power to the electric pump system. Below are the steps that the applicant would perform to estimate the proposed project GHG emission reductions utilizing the ARB GHG calculator tool.

Step 1. Identify the SWEEP Proposed Project Type(s)

The first step is to identify applicable project components that will reduce both GHG emissions and water usage. CDFA has identified applicable project components in the SWEEP guidelines. In addition, Table 1 of this document provides a list of the most common eligible project components expected to be funded under SWEEP. The applicant must identify at least one project component from the list of applicable project components that defines the proposed project. All projects must both achieve energy use reductions to achieve GHG emission reductions and water use reductions. To achieve both objectives, many projects will include multiple components. The project components identified will inform the sections of the ARB GHG calculator tool required to determine GHG emission reductions. Each calculation is for a single irrigated plot with a dedicated pump. For projects with multiple plots, applicants must perform calculations for each individual plot and submit each run as well as a cumulative value for net GHG emission reductions.

In the above example, the project applicant identified irrigation system conversion that reduced system pressure and reduce water usage, motor/pump system replacement to improve system efficiency, VFD controller installation, and solar PV installation to provide renewable energy.

Steps 2 & 3. Determine the Inputs Needed and Estimate GHG Emission Reductions (using ARB Calculator Tool)

The applicant determines all of the required inputs from Table 2 for the ARB GHG calculator to estimate GHG emission reductions. The next step for the applicant is to review the "Read Me Tab" of the ARB calculator tool and to enter the project identifier

information. Below is an example of the required project identifier information that is entered by an applicant.

Project Name:	Smith Brothers Farm
Project ID - FAAST:	12-3456789
Contact Name:	John Smith
Contact Phone Number:	916-555-1234
Contact Email:	john@smithbros.com
Date Completed:	12/1/2015

Next, the applicant enters in the identified proposed project information for both pre-project and post-project cases into the ARB GHG calculator located in the "Inputs Tab". The red headers under the "Input Data" column are project descriptors and indicate the fields (highlighted in yellow) that the applicant enters into the applicable pre-project and post-project columns. Below are sample inputs for the ARB GHG calculator from the example proposed project.

General Project Information
The "General Project Information" section is required for every applicant. Each project descriptor must have the associated project input.

General Project Information	
Input Data	**Pre-Project**
Irrigated Project Area (acres)	100
Funds requested ($)	$ 100,000
Pump fuel or electricity use (gallons, scf, kWh)	5,000
Fuel type	Diesel
Fuel Emissions Factor	0.013818137
Life of Project (yrs)	10

Pump and Motor Enhancement and Replacement
This section is required for proposed projects that incorporate improvements to the irrigation pump system. If pressures are not known in units of feet, please utilize the green "Pressure Conversion" tab to convert pressure into units of feet.

Pump and Motor Enhancement and Replacement - This Section required for all applicants		
Input Data	**Pre-Project**	**Post-Project**
Motor Rated Horsepower (hP)	100	80
Operational Hours (hr) (if Known) - If unknown, leave cell blank		
Motor Efficiency (%)	75%	85%
Pump Efficiency (%)	70%	85%
System Pressure (ft)	User may override system pressure if known	User may override system pressure if known.
Pumping depth (ft)	350	350
Discharge pressure (ft)	100	50
Friction losses (ft)	10	10
Are you installing a VFD?	N/A	VFD Well Pump
VFD Efficiency (%)		95%

Irrigation System Enhancement (for systems utilizing pumps)

This section is required for irrigation system modifications and improvements that result in water savings. Water savings results are determined from the USDA NRCS Irrigation Water Savings calculator as described in the CDFA SWEEP Guidelines, accessible http://efotg.sc.egov.usda.gov/references/public/CA/CA_irrigation_water_savings_9-

08.xls. The USDA NRCS Irrigation Water Savings estimate in <u>Percentage (%)</u> is the value used for this calculator. Estimated water savings from leakage repair is calculated as part of the NRSC tool. For instructions on the NRCS tool, please refer to Appendix C.

Irrigation System Enhancement (for systems utilizing pumps)		
Input Data	Pre-Project	Post-Project
Water savings (from NRCS) (%)	N/A	20%

Fuel Conversions and Renewable Energy

This section is required for pump system fuel conversions and renewable energy installations. Below are sample inputs (post-project) for the example SWEEP proposed project.

Fuel Conversions and Renewable Energy		
Input Data		Post-Project
Renewable energy capacity (kW)		20
New fuel type		Electricity
Fuel Emissions Factor		0.000378576
Fuel conversion		Diesel to Electricity
Conversion Factor		0.300992604

The applicant can select the "GHG Calculations" Tab to view the estimated project GHG emission reductions.

Submit Documentation

To complete the quantification process, the applicant must submit an electronic copy of the calculator (in .xls, .xlsm, or .xlsx) and all of the required documentation as noted in Section C. The summary documentation that provides the GHG emission reductions from the project can be found in the "Summary" tab of the calculator.

For this example, the Annual GHG Emission Reductions (MTCO$_2$e) is equal to the difference between GHG emissions pre-project and the GHG emissions post-project, accounting for the installation of on-site renewable energy. Total GHG Emission Reductions (MTCO$_2$e) is the annual reductions multiplied by the expected useful life of the installed equipment using a default value, as defined by CDFA, of 10 years. The applicant in this example would report the Net GHG Benefits over the Useful Life as 753.80 MTCO$_2$e.

The SWEEP Funds Requested ($) is equal to the total GGRF funds requested. In this example, the amount is $100,000. The total GHG emission reductions (MTCO$_2$e) per GGRF funds represent the benefits over Useful Life per dollar requested.   For this example this value would be 0.0075 MTCO$_2$e per GGRF $.

Results	GHG Emissions (MTCO2e)	Description
GHG Benefits per Growing Season	75.25	Annual GHG Emission Reductions (MTCO2e/yr)
Net GHG Benefits over Useful Life	752.46	Total GHG Emission Reductions (MTCO2e)
GHG Benefits per Acre	7.52	Total GHG Emission Reductions (MTCO2e) per Acre
Total GGRF Funds Requested ($)	100,000.00	Total SWEEP funds requested
Total GHG Emission Reductions per Total GGRF Funds Requested ($)	0.0075	Total Reductions per SWEEP funds requested

Appendix B.   GHG Emission Reduction Calculations

Equations for Irrigation System Pressure Changes

(Eq. 1.a) Pre-Project Head (for use in Eq. 3.c and Eq. 4.a)

$$TDH_{pre\ project} = H_{pumping\ elevation\ pre\ project} + H_{discharge\ pressure\ pre\ project} + H_{friction\ loss\ pre\ project}$$

(Eq. 1.b) Post-Project Head (for use in Eq. 4.a)

$$TDH_{post\ project} = H_{pumping\ elevation\ post\ project} + H_{discharge\ pressure\ post\ project} + H_{friction\ loss\ post\ project}$$

Where:
- $TDH_{project}$ = total dynamic head or system pressure requirement (ft), pre and post project
- $H_{pumping\ elevation}$ = elevation head, the vertical distance which the water must be pumped (ft), pre and post project
- $H_{discharge\ pressure}$ = pressure head, is the maximum operating pressure of the water system converted from psi to feet of head (ft), pre and post project
- $H_{friction\ loss}$ = friction head loss, is the loss of pressure due to the flow of water through pipe and fittings (ft), pre and post project. Default friction losses are estimated at 10 ft.

Equations for Motor and Pump Efficiency Improvements

(Eq. 2.a) Pre-Project Efficiency (for use in Eq. 4.a)

$$\eta_{pre\ project} = \eta_{pump\ pre\ project} \ x \ \eta_{motor\ pre\ project} \ x \ \eta_{VFD\ pre\ project}$$

(Eq. 2.b) Post-Project Efficiency (for use in Eq. 4.a)

$$\eta_{post\ project} = \eta_{pump\ post\ project} \ x \ \eta_{motor\ post\ project} \ x \ \eta_{VFD\ post\ project}$$

(Eq. 3.a) GHG Emission from Existing Pump for Non-Electric Pumps

$$GHG_{pre\ project} = Fuel\ Use\ x\ EF_{fuel\ pre\ project}$$

(Eq. 3.b) GHG Emission from Existing Pump for Electric Pumps with actual use data

$$GHG_{pre\ project} = Electricity\ Use\ x\ EF_{electricity}$$

(Eq. 3.c) GHG Emission from Existing Pump for Electric Pumps (if actual use data is unavailable)

$$GHG_{pre\ project} = HP_{pre\ project}\ x\ \eta_{pre\ project}\ x\ Operational\ Hours_{pre\ project}\ x\ 0.746\ x\ EF_{electricity}$$

Where:
- $\eta_{project}$ = overall pumping plant efficiency (%), pre and post project

- η_{pump} = pump efficiency (%), pre and post project
- η_{motor} = motor efficiency (%), pre and post project
- η_{VFD} = efficiency of variable frequency drive (%), pre and post project, if a VFD is not a part of the scenario, use a value of 1
- $GHG_{pre\ project}$ = GHG emissions from existing pump ($MTCO_2e$)
- Fuel use = pre project fuel use (gallons or scf)
- $EF_{fuel\ pre\ project}$ = Emission factor of pre project fuel ($MTCO_2e$ per gallon or scf)
- Electricity use = pre project electricity use (kWh)
- $EF_{electricity}$ = emission factor from electricity (0.000306 $MTCO_2e$/kWh)[3]
- $HP_{pre\ project}$ = Pre project rated motor horsepower
- Operational Hours $_{baseline}$ = baseline irrigation hours based on plant requirements, area, and flow rate (hrs)
- 0.746 = conversion from HP to kilowatts

Equations for GHG Emissions from Post Project Pump Demand and Fuel Conversions

(Eq. 4.a) GHG Emissions from Post Project Pump Demand

$$GHG_{pump} = ((1 - Water\ Savings_{NRCS}))\ x\ \frac{TDH_{post\ project}}{TDH_{pre\ project}}\ x\ \frac{\eta_{pre\ project}}{\eta_{post\ project}}\ x\ GHG_{pre\ project}$$

(Eq. 4.b) GHG Emissions Adjustment for fuel conversions

$$GHG_{pump,adj} = GHG_{pump}\ x\ \frac{EER\ Adjusted\ Carbon\ Intensity_{New\ fuel}}{EER\ Adjusted\ Carbon\ Intensity_{Old\ fuel}}$$

Where:
- GHG_{pump} = GHG emissions from pump changes ($MTCO_2e$)
- Water Savings$_{NRCS}$ = Water savings from USDA NRCS Irrigation Water Savings Calculator (%), as found in output Cell A30.
- $GHG_{pump,adj}$ = GHG emissions from pump changes accounting for fuel conversions ($MTCO_2e$)
- EER Adjusted Carbon Intensity = Energy Economy Ratio lifecycle emission factor for fuel with an adjustment to reflect for the relative efficiency of a specific fuel used in a motor (g/MJ)[4]

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[3] For the purposes of GGRF quantification methodologies, ARB developed a California grid electricity emission factor based on total in-state and imported electricity emissions ($MTCO_2e$) divided by total consumption in MWh. Emissions from ARB GHG inventory (2013), available online at: http://www.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_by_sector_00-12_sum_2014-03-24.pdf. Consumption data from CEC Energy Almanac (2013), available online at: http://energyalmanac.ca.gov/electricity/electricity_generation.html

[4] EER adjusted CI values. Source: California Air Resources Board, CAGREET 1.8b versus 2.0 CI Comparison Table, April 1, 2015

Equations for GHG Emissions from VFD Installation and System Pressure Reductions

(Eq. 5.a) GHG Emission Reductions from VFD Installation (for Electric Pumps) with no changes in pressure demand from irrigation system changes

$$GHG_{VFD} = Energy\ Savings_{VFD}\ x\ HP_{post\ project}\ x\ EF_{electricity}$$

(Eq. 5.b) GHG Emission Reductions from VFD Installation (for Electric Pumps) accounting for reduced pressure demand from irrigation system changes

$$GHG_{VFD} = Energy\ Savings_{VFD}\ x\ HP_{post\ project}\ x\ (1 - Water\ Savings_{NRCS})\ x\ (1 -$$

$$\frac{(TDH_{pre\ project} - TDH_{post\ project})}{TDH_{pre\ project}}\ x\ EF_{electricity})$$

Where:
- GHG_{VFD} = GHG emissions reductions from VFD installation ($MTCO_2e$)
- Energy Savings$_{VFD}$ = Energy savings for VFD installations (from DEER) (kWh/hp)
- $HP_{post\ project}$ = Post project rated motor horsepower

Equation for GHG Emissions Reductions from Installation of Renewable Energy

(Eq. 6) GHG Emission Reductions from pump (use GHG$_{pump,adj}$ if applicable)

$$GHG_{Renew} = Capacity\ x\ Capacity\ Factor_{solar}\ x\ 8{,}766\ x\ EF_{electricity}$$

Where:
- Capacity = Capacity of renewable energy installation (kW)
- Capacity Factor = Statewide average of renewable performance, 18[5]%
- 8,766 = Hours per year of renewable energy generation potential (hr)
- GHG_{Renew} = GHG emissions reductions from on-site renewable energy ($MTCO_2e$)

Equation for GHG Emissions Reductions from SWEEP Project Implementation

(Eq. 7) GHG Emission Reductions from pump (use GHG$_{pump,adj}$ if applicable)

$$GHG_{post\ project} = GHG_{pre\ project} - GHG_{pump} + GHG_{VFD} + GHG_{Renew}$$

Where:
- GHG $_{post\ project}$ = GHG emissions reductions from the SWEEP project improvements compared to the previous irrigation system ($MTCO_2e$)

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[5] CEC (2013). Cost-Effectiveness of Rooftop Photovoltaic Systems for Consideration in California's Building Energy Efficiency Standards. Available online at:
http://www.energy.ca.gov/2013publications/CEC-400-2013-005/CEC-400-2013-005-D.pdf

Appendix C.   NRCS Tool Instructions

USDA NRCS Irrigation Water Savings Calculator Instructions

The NRCS Irrigation Water Savings Calculator (NRCS Calculator) allows applicants to input specific information related to their current on-farm irrigation system to obtain baseline water use estimates. Similarly, applicants can input specific data related to proposed irrigation system enhancements to obtain projected water savings estimates. The NRCS Irrigation Water Savings Calculator can be accessed here: https://efotg.sc.egov.usda.gov/references/public/CA/CA_irrigation_water_savings_10-6-14.xls

The following instructions are included to assist the applicant with completing the NRCS Calculator (i.e., Microsoft Excel file) to obtain the annual water savings percentage to be used in ARB's GHG Calculator tool. If the project includes more than one irrigation practice, follow steps 1-11 to run the NRCS calculator tool for each unique practice. Instructions on how to combine multiple practices is included in Step 12.

1. Open the calculator tool through this link: https://efotg.sc.egov.usda.gov/references/public/CA/CA_irrigation_water_savings_10-6-14.xls

2. Enter project applicant name and date at the top of the NRCS Calculator.

3. Scroll down and enter in the project acreage, located at the bottom of the NRCS Calculator, affected by the proposed CDFA SWEEP project.

4. Select the predominant soil type affected by the proposed CDFA SWEEP project. If the applicant is unsure of the predominant soil type, applicants can determine the soil type as identified by the SoilWeb: http://casoilresource.lawr.ucdavis.edu/gmap/

5. Select the crop currently planted in the acreage affected by the proposed CDFA SWEEP project.
   - For double cropping, multiple crops, or crops grown in rotation: select one principle crop and run the NRCS Calculator only once. *Do not follow the instructions in the blue box in the NRCS Calculator tool.*

6. Select the appropriate baseline, township, and range of the proposed CDFA SWEEP project. Applicants can determine the township and range of their project by using the Land Survey Information System interactive map: http://www.geocommunicator.gov/blmMap/MapLSIS.jsp

7. Select the appropriate practice that captures the proposed irrigation system improvement and the baseline (i.e., current) on-farm irrigation practice used on the proposed project acreage. For example, if the current irrigation practice is surface irrigation and the project will replace leaking pipes, the applicant would select "SURFACE IRRIGATION (Replace a leaky pipeline with a pipeline)" from the "Practice" scroll box.

8. Select the proposed irrigation water management (IWM) plan. If there is not an IWM plan used, or the applicant will not make changes to the existing IWM plan, select "No IWM plan" from the "Water Management" scroll box. Use the following definitions to determine the level of IWM for the project.

IWM Level	Tools Involved	Potential Water Savings
No IWM	no soil moisture equipment, no flow meter	None
Level 1	soil moisture equipment	5% water savings over no IWM
Level 2	soil moisture + flow meter	10% water savings over no IWM
Level 3	soil moisture + flow meter + volumetric management using soil/flow/ET information	15% water savings over no IWM

9. Save the file as "project name_NRCS" as this file may be required for submission to CDFA. For projects with multiple irrigation practices, save each unique practice "project name_NRCS_practice".

10. Record the following values:

   a. "Estimated before practice water use" in ac-in/ac from cell C23
   b. "Estimated after practice water use" in ac-in/ac from cell C25
   c. "Annual Water Savings Estimate" in ac-in/ac from cell A28

   These values may be required for use in the CDFA grant application to verify baseline and project water use.

11. Record the annual water savings estimate percentage (%) located in cell A30. This percentage is the value to be input into the "Water savings (from NRCS) (%) cell located in the ARB GHG Calculator, "Inputs" tab, cell C33.

12. *(Optional)* For projects that include more than one irrigation practice in the same field in a given growing season, the NRCS calculator tool must be run for each unique practice. For each calculator run, multiply the annual water savings estimate percentage (%) from Step 11 by the number of acres which the practice will be used. Add each of these multiplied values and divide by total project acreage. The resulting value will be used in the ARB GHG calculator.

   For example, for three unique practices used on a total 50 acres:

Practice	Acreage	Annual Water Savings Estimate (%)	Multiplied Value
Replacing surface pipe	20	4%	80
Replace surface irrigation with trickle	20	27%	540
Replace wheel lines on center pivots	10	9%	90
Reported Value (%) (Sum Divided by Total Acreage)			14.2