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 2016-17

DRAFT
November 18, 2016

Note:
This Draft FY 2016-17 Quantification Methodology is subject to change in response to public comments. Public comments may be submitted via email to GGRFProgram@arb.ca.gov through December 9, 2016.

Table of Contents

Section A. Introduction

The goal of California Climate Investments is to reduce greenhouse gas (GHG) emissions and further the purposes of the Global Warming Solutions Act of 2006, known as Assembly Bill (AB) 32. The California Air Resources Board (ARB) is responsible for providing the quantification methodology to estimate the GHG emission reductions and other benefits from projects receiving monies from the Greenhouse Gas Reduction Fund (GGRF). ARB develops these methodologies based on the project types eligible for funding by each administering agency as reflected in the program Expenditure Records available at: https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/expenditurerecords.htm. ARB staff 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.

For the California Department of Food and Agriculture (CDFA) State Water Efficiency and Enhancement Program (SWEEP), ARB staff developed this quantification methodology and SWEEP GHG Calculator Tool to provide methods for estimating GHG emission reductions of each proposed project (Section B), provide instructions for documenting and supporting the estimate (Section C), and outline the process for tracking and reporting GHG and other benefits once a project is funded (Section D).

This methodology uses calculations to estimate the GHG emission reductions from on-farm pump and motor enhancement and/or replacement, irrigation system enhancement, and fuel conversion associated with implementation of SWEEP projects. These calculations are based on the current understanding of irrigation practices, irrigation system enhancements, fuel conversions, and GHG emission factors. Projects will report the total project GHG emission reductions estimated using this methodology as well as the total project GHG emission reductions per dollar of GGRF funds requested.

SWEEP Project Types

ARB developed three project types that meet the objectives of the SWEEP and for which there are methods to quantify GHG emission reductions. Each project requesting GGRF funding must include at least one of the following project components for FY 2016-17:

- Pump and motor enhancement and/or replacement
- Irrigation system enhancement
- Fuel conversion

Per SWEEP Program Guidelines:

Eligible projects must:
- Reduce GHG 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.

Section B of this quantification methodology details the methods to use based on the project component(s) proposed.

Methodology Development

ARB and CDFA developed this quantification methodology consistent with the guiding implementation principles of California Climate Investments, including ensuring transparency and accountability.[1] ARB and CDFA developed this quantification methodology through a public process to be used to estimate the outcomes of proposed projects, inform project selection, and track results of funded projects. The implementing principles ensure that the methodology would:

- Apply at the project-level;
- Provide uniform methods to be applied statewide, and be accessible by all applicants;
- Use existing and proven tools and methods;
- Use project-level data, where available and appropriate; and
- Result in GHG emission-reduction estimates that are conservative and supported by empirical literature.

ARB reviewed peer-reviewed literature and tools, and consulted with experts, as needed, to determine methods appropriate for the SWEEP project types. ARB also consulted with CDFA to determine project-level inputs available. The methods were developed to provide estimates that are as accurate as possible with data readily available at the project level.

Tools

This quantification methodology and the SWEEP GHG Calculator Tool rely on project-specific outputs from the following tools:

United States Department of Agriculture (USDA) National Resource Conservation Service (NRCS) Irrigation Water Savings Calculator tool. For projects that reduce water use that results in reduced pump demand, applicants will use this 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 SWEEP GHG calculator tool. The tool is used statewide, publicly available, subject to regular updates to incorporate new information, is free of charge, and available to anyone with internet access. The tool can be accessed

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[1] As described in Volume 1 of the California Air Resources Board's Funding Guidelines for Agencies Administering California Climate Investments. December 21, 2015. www.arb.ca.gov/cci-fundingguidelines.

at: http://efotg.sc.egov.usda.gov/references/public/CA/CA_irrigation_water_savings_10-6-14.xls. Instructions for applicants are included in Appendix C.

Applicants must use this quantification methodology, in conjunction with the accompanying SWEEP GHG Calculator Tool, to estimate the GHG emission reductions of the proposed project. The SWEEP GHG Calculator Tool can be downloaded from: www.arb.ca.gov/cci-quantification.

Major Updates

ARB updated this quantification methodology from the previous version.[2] The major changes include:
- General changes to document formatting and GGRF program language.
- Removal of VFD efficiency from calculations.
- Changes to reflect updates to the NRCS Water Savings Tool.
- Updates to instructions and examples, where applicable.

ARB also updated the accompanying SWEEP GHG Calculator Tool from the previous version.[3] The major changes include:
- Change in inputs for motor and pump efficiency to overall pumping efficiency.
- Change in the output metric for GHG emissions per acre from a per-pump basis to a per-total-acreage basis.
- Change in the cost-effectiveness metric from a per-pump basis to a total-project-cost basis.
- Update to only require applicants to input total project cost once.
- Additional cell on the Input sheet to include a ranch/field name.
- Removal of a limit to increase groundwater depth post-project.
- Removed of project life as an input field.

Program Assistance

ARB and CDFA staff will review the quantification portions of the 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: https://www.arb.ca.gov/auctionproceeds.
- Questions pertaining to the SWEEP should be sent to grants@cdfa.ca.gov.

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[2] Greenhouse Gas Quantification Methodology for the California Department of Food and Agriculture State Water Efficiency and Enhancement Program FY 2015-16. Released March 15, 2016.
[3] Greenhouse Gas Emission Reduction Calculator (Version 2) for the California Department of Food and Agriculture State Water Efficiency and Enhancement Program FY 2015-16. Released July 22, 2016.

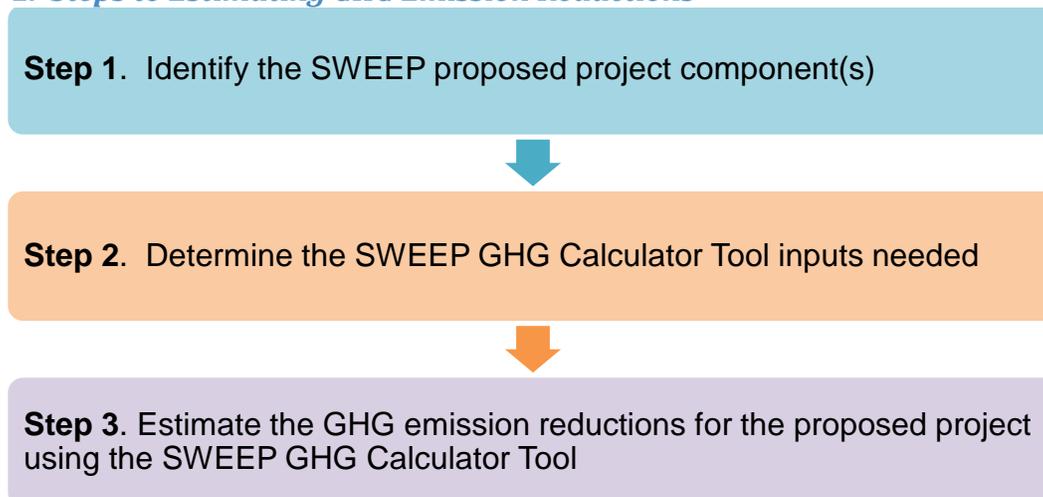# Section B. Greenhouse Gas Quantification Methodology

This quantification methodology accounts for 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/or replacement, reductions in pump demand from irrigation system enhancements, and fuel conversion (i.e., to a less carbon intensive fuel or installation of on-site renewable energy generation). In general, the GHG emission reductions are calculated using the following approaches:

Table 1. General Approach to GHG Quantification by Project Type

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
$GHG\ Emission\ Reductions =$ $GHG\ Emissions\ of\ Displaced\ Fuel\ or\ GHG\ Emission\ Reductions\ from\ Less\ Carbon\ Intensive\ Fuel$

Applicants will follow the steps outlined in Figure 1 to estimate the GHG emission reductions from the proposed project. Detailed instructions for each step are provided on subsequent pages.

Figure 1. Steps to Estimating GHG Emission Reductions

Step 1. Identify the SWEEP proposed project component(s)

Step 2. Determine the SWEEP GHG Calculator Tool inputs needed

Step 3. Estimate the GHG emission reductions for the proposed project using the SWEEP GHG Calculator Tool

Step 1: Identify the Project Components and Appropriate Methods for the Proposed Project

For GHG quantification purposes, eligible SWEEP projects consist of several potential project components. Applicants may incorporate more than one project component and can use multiple methods identified in this quantification methodology, as appropriate, to quantify the GHG emission reductions. Applicants must identify the project components that apply to the project as identified in the 2016 SWEEP "Request for Grant Applications" (i.e., guidelines) or from Table 2 of this document. 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 determine which subsections of this quantification methodology and sections of the accompanying GHG Calculator Tool must be used in order to estimate the 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. Project acreage and funding requested needs only to be included once for a project (i.e., in the first Input tab). Total GHG Emission Reductions are displayed as a cumulative total of each Input tab in the Summary Tab.

Table 2. Project Components and Appropriate Quantification Methods

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 SWEEP GHG Calculator Tool Inputs Needed

Table 3 identifies the required data inputs needed to estimate the GHG emission reductions for proposed projects with the SWEEP GHG Calculator Tool by project component. Links for the SWEEP 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.

Table 3. Required SWEEP GHG Calculator Tool Inputs for Eligible Project Components

All Projects
General Information (Read Me worksheet)   - Project name;   - Project ID – FAAST;   - Contact Name;   - Contact Phone Number;   - Contact Email; and   - Date Completed.   **Existing Conditions** (prior to any project modification)   - Total Irrigated Project Area (acres);   - Total GGRF funds requested ($);   - Pump fuel amount or electricity use (gallons, therms, or kWh); and   - Fuel type.
Pump and Motor Enhancements
Greenhouse Gas Quantification Inputs (both pre-project values and post-project estimates) (Inputs worksheet)   - 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;   - Overall Pumping Efficiency (%); and   - 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 appropriate VFD scenario (booster or well)
Irrigation System Enhancements (for systems utilizing pumps)
Greenhouse Gas Quantification Inputs (Inputs worksheet)   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

Greenhouse Gas Quantification Inputs (Inputs worksheet)

- New fuel type if converting to a different fuel; and
- 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 for the Proposed Project Using the SWEEP GHG Calculator Tool

Applicants must use the SWEEP GHG Calculator Tool to complete this step. The Calculator Tool can be downloaded from www.arb.ca.gov/cci-quantification. The applicant will enter the project details into the SWEEP GHG Calculator Tool to calculate the GHG emission reductions over the useful life[4] using the inputs identified in Step 2.

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. Project acreage and funding requested needs only to be included once for a project, in the first Input tab. 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.

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[4] For purposes of SWEEP projects, the life of a proposed project (i.e., 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.

- **Net GHG Benefits over Useful Life** is equal to the sum total of each of the GHG emission reductions calculated in Section B and are automatically summed over the useful life in the SWEEP GHG Calculator Tool.

- **Total GHG Emission Reductions per Total GGRF Funds Requested** is calculated as:

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

Project Name:	Smith Brothers Farm
Tax ID:	12-3456789

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

Section C. Documentation

In addition to SWEEP application requirements, applicants for GGRF funding are required to document results from the use of this quantification methodology, including supporting materials to verify the accuracy of project-specific inputs.

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 agency staff.

The following checklist is provided as a guide to applicants; additional data and/or information may be necessary to support project-specific input assumptions.

	Documentation Description	Completed
1.	Project Application	
2.	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	
3.	Populated SWEEP GHG Calculator Tool file (in.xls) with worksheets applicable to the project populated (ensure that the Total Project GHG Emission Reductions and Total Project GHG Emission Reductions/SWEEP GGRF Funds Requested fields in the summary worksheet contain calculated values)	
4.	Project data support, including: • Calculator inputs determined in Step 2; • Documentation of the project data used to support SWEEP GHG Calculator Tool 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; and • Any other information as necessary and appropriate to substantiate inputs	

Section D. Reporting after Funding Award

Accountability and transparency are essential elements for all GGRF California Climate Investment projects. As described in ARB's Funding Guidelines for Agencies that Administer California Climate Investments (Funding Guidelines),[5] each administering agency is required to track and report on the benefits of the California Climate Investments funded under their program(s). Each project funded by the GGRF is expected to provide real and quantifiable GHG emission reductions. The previous sections of this document provide the methods and tools to estimate the GHG emission reductions of a proposed project based on project characteristics and assumptions of expected conditions and activity levels. This section explains the minimum reporting requirements for administering agencies and funding recipients during project implementation, termed Phase 1, and after a project is completed, termed Phase 2. Table 4 below shows the project phases and when reporting is required.

Table 4. Quantification and Reporting By Project Phase

	Timeframe & Reporting Frequency	Quantification Methods
Project Selection	Period from solicitation to selection of projects and funding awards. Applicant submits application to SWEEP by due date in solicitation materials.	All applicants use methods in ARB's quantification methodology to estimate the GHG emission reductions of the project.
Phase 1	Covers the period from the beginning of the project until it becomes operational or the initial implementation is completed.	All awarded projects use methods in ARB's quantification methodology to update initial estimate of GHG emission reductions, as needed, based on project changes.
Phase 2	Starts after Phase 1 is complete and a project becomes operational.	GHG reduction achieved are quantified and reported for a subset of funded projects.

Phase 1 reporting is required for all SWEEP funded projects. CDFA will collect and submit data to ARB to satisfy Phase 1 reporting requirements. Funding recipients must report any changes that impact GHG emission reduction estimates (i.e. assumptions or quantitates) 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:

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[5] California Air Resources Board. Funding Guidelines for Agencies Administering California Climate Investments. (December 21, 2015). www.arb.ca.gov/cci-fundingguidelines

- 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 fields 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 is a hypothetical project[6] to demonstrate how the FY 2016-17 SWEEP Program Quantification Methodology would be applied. This example does not provide examples of the supporting documentation that is required of actual project applicants.

Overview of the proposed project

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 an overall pumping efficiency of 70%. 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 SWEEP GHG Calculator Tool.

Methods to apply

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 SWEEP 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.

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[6] The hypothetical project has not undergone verification of any SWEEP Program requirements; all assumptions about location type and features are for quantification methodology demonstration purposes only.

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

The applicant determines all of the required inputs from Table 2 for the SWEEP GHG Calculator Tool to estimate GHG emission reductions. The next step for the applicant is to review the **Read Me** tab of the SWEEP GHG 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 SWEEP GHG Calculator Tool 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 SWEEP GHG Calculator Tool 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
Field or Ranch Name	West Field
Total Irrigated Project Area (acres)	100
Total GGRF funds requested ($)	$ 100,000
Pump fuel or electricity use (gallons, scf, kWh)	5,000
Fuel type	Diesel
Fuel Emissions Factor	0.013818137

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		
Overall Pumping Efficiency (%)	75%	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

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 Percentage (%) 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 SWEEP GHG Calculator Tool.

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 733.37 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 0.0073 MTCO$_2$e per GGRF $.

Results	GHG Emissions (MTCO2e)	Description
GHG Benefits per Growing Season	73.34	Annual GHG Emission Reductions (MTCO2e/yr)
Net GHG Benefits over Useful Life	733.37	Total GHG Emission Reductions (MTCO2e)
GHG Benefits per Acre	7.33	Total GHG Emission Reductions (MTCO2e) per Acre
Total GGRF Funds Requested ($)	100,000.00	Total SWEEP funds requested
Total GHG Emission Reductions per Total GGRF Funds Requested ($)	0.0073	Total Reductions per SWEEP funds requested

Appendix B.   Equations Supporting the SWEEP GHG Calculator Tool

Methods used in the SWEEP GHG Calculator Tool for estimating the GHG emission reductions by activity type are provided in this appendix. The GHG emission reductions from the project are quantified within the SWEEP GHG Calculator Tool using the equations below.

A.   Irrigation System Pressure Changes

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

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

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

B.   GHG Emissions from Motor and Pump Efficiency Improvements

(Eq. 2.a) GHG Emissions from Existing Pump for Non-Electric Pumps

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

(Eq. 2.b) GHG Emissions from Existing Pump for Electric Pumps with actual use data

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

(Eq. 2.c) GHG Emissions 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,			Units
$\eta_{project}$	=	Overall pumping plant efficiency, pre and post project	%
$\eta_{project}$	=	Overall pumping efficiency, pre and post project. This value	%

		incorporates pump efficiency and motor efficiency, among other factors.	
$GHG_{pre\ project}$	=	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)[7]	$MTCO_2e$/kWh
$HP_{pre\ project}$	=	Pre project rated motor horsepower	hP
Operational Hours $_{baseline}$	=	baseline irrigation hours based on plant requirements, area, and flow rate	Hours
0.746	=	conversion from hP to kilowatts	kWh/hP

C. GHG Emissions from Post Project Pump Demand and Fuel Conversions

(Eq. 3.a) GHG Emissions from Post Project Pump Demand

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

(Eq. 3.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,			Units
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[8]	g/MJ

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[7] For the purposes of GGRF quantification methodologies, ARB developed a California grid electricity emission factor based on total in-state and imported electricity emissions (MTCO₂e) 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

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

D. GHG Emission Reductions from VFD Installation and System Pressure Reductions

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(Eq. 4.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. 4.b) GHG Emission Reductions from VFD Installation (for Electric Pumps) accounting for reduced pressure demand from irrigation system changes

$$GHG_{VFD} = Energy\ Savings_{VFD}\ x\ HP_{post\ project}\ x\ (1 - Water\ Savings_{NRCS})\ x\ GWR\ x\left(1 - \frac{TDH_{pre\ project} - TDH_{post\ project}}{TDH_{pre\ project}}\right) x\ EF_{electricity}$$

Where,			*Units*
GHG_{VFD}	=	GHG emissions reductions from VFD installation	MT CO_2e
Energy Savings$_{VFD}$	=	Energy savings for VFD installations (from DEER). The energy savings here incorporate an assumed VFD efficiency of 97%[9]	kWh/hP
$HP_{post\ project}$	=	Post project rated motor horsepower	hP

E. GHG Emissions Reductions from Installation of Renewable Energy

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(Eq. 5) 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,			*Units*
Capacity	=	Capacity of renewable energy installation	kW
Capacity Factor	=	Statewide average of renewable performance, 18%[10]	%
8,766	=	Hours per year of renewable energy generation potential	Hours
GHG_{Renew}	=	GHG emissions reductions from on-site renewable energy	MTCO$_2$e

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[9] United States Department of Agriculture, Natural Resources Conservation Service (January 2010). Engineering Technical Note No. MT-14, "Variable Speed Drive (VSD) for Irrigation Pumping." Available online at: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_054026.pdf

[10] 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

F.   GHG Emissions Reductions from SWEEP Project Implementation

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

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

Where,   Units
GHG $_{post\ project}$ =   GHG emissions reductions from the SWEEP project improvements   MTCO$_2$e
                                                  compared to the previous irrigation system

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: http://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: http://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 to the bottom of the NRCS Calculator input tab and enter project acreage impacted by the irrigation practice.

4. Scroll to the upper section and select the predominant soil type for 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 proposed CDFA SWEEP project area.
    - 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. If the project will include more than one irrigation practice, run the calculator once for each practice.

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 C31.

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