California Air Resources Board

Greenhouse Gas Quantification Methodology for the Strategic Growth Council Sustainable Agricultural Land Conservation Program

Greenhouse Gas Reduction Fund
Fiscal Year 2015-16

December 18, 2015

TABLE OF CONTENTS

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 the Strategic Growth Council's (SGC) Sustainable Agricultural Land Conservation (SALC) Program, implemented by the Department of Conservation (DOC), ARB staff developed this GHG quantification methodology to be used by SGC/DOC to estimate the avoided GHG emissions for projects proposed in Fiscal Year (FY) 2015-16.

Methodology Development

For FY 2015-16 of the SALC Program, ARB and SGC/DOC staff followed a set of principles to guide the development of the quantification methodology. These principles ensure that the methodology for SALC Program projects would:

- Apply at the project-level;
- Align with the project types proposed for funding;
- Provide uniform methods to be applied statewide, and be publicly available;
- Use existing and proven methods;
- Use project-level data, when available; and
- Reflect relationships between avoided vehicle miles traveled (VMT) and avoided GHG emissions that are supported by empirical literature.

The methods and tools selected for use as part of this quantification methodology fit these objectives and provide an approach to quantify avoided VMT and the avoided GHG emissions from individual project proposals based on established modeling techniques.

In addition, SGC held a public "Lessons Learned" workshop in August 2015 to discuss issues faced by applicants in the FY 2014-15 SALC application and selection process. ARB attended the workshops to listen to issues specific to the quantification methodology. The input from stakeholders at the Lessons Learned workshops helped to inform the updates in this quantification methodology.

ARB released a draft FY 2015-16 quantification methodology for public comment in November 2015. The draft quantification methodology and draft FY 2015-16 SALC program guidelines were discussed at a set of three public workshops held across the State. Comments were collected by SGC/DOC and considered in the development of this final quantification methodology.

Tools

This quantification methodology uses specific components of the "California Emissions Estimator Model" (CalEEMod) tool to estimate the avoided VMT associated with a project. CalEEMod is a "state-of-the-practice" land use emissions calculator tool

designed to quantify GHG emissions and criteria air pollutants associated with land use development projects. It is used by lead agencies to evaluate the GHG emissions and criteria air pollutants of land use development projects pursuant to California Environmental Quality Act (CEQA), National Environmental Protection Act (NEPA), and for compliance with local air quality rules and regulations. CalEEMod combines project specific data with default data to establish a VMT estimate of a development on the proposed project site. CalEEMod output is the estimated VMT that are avoided in lieu of the development project. The tool is used statewide, publicly available, subject to regular updates to incorporate new information, free of charge, and available to anyone with internet access. The CalEEMod tool, User's Guide, and other supporting documents can be downloaded from: www.caleemod.com.

Major Updates

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. ARB updated the quantification methodology to enhance the analysis and provide additional clarity. The major changes include:

- Emission factors that include upstream GHG emission sources. This "Well-to-Wheels" approach quantifies the emissions produced from the production, distribution of the different fuel types, including hydrogen and electricity, and any associated exhaust emissions. This approach is consistent with other GGRF programs and ARB's Low Carbon Fuel Standard (LCFS) Program.
- Lookup tables for the emission factors based on EMFAC 2014 and a Well-to-Wheels approach. Now DOC/SGC will only run CalEEMod once and will extract VMT from the output report. A description of the derivation of the emission factors is included in an appendix.
- A method for determining the number of development rights to be extinguished inclusive of instructions for determining when and how to account for higher density residential zoning.
- Details on requirements for reporting after funding award consistent with Funding Guidelines for Agencies that Administer California Climate Investments.[1]
- Additional definitions and clarity to the text.

[1] Proposed Funding Guidelines for Agencies that Administer California Climate Investments, September 4, 2015 available at: http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/funding_guidelines_public_proposed_draft_09-04-2015.pdf. After incorporating revisions to reflect the Board's direction, ARB will post the Final Funding Guidelines at: http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/fundingguidelines.htm

Sustainable Agricultural Land Conservation Project Types

SGC/DOC developed the SALC Program to protect critical agricultural lands at risk of conversion to urban and rural residential development, avoid GHG emissions from more GHG-intensive land uses, and provide additional co-benefits. There are two SALC Program project types for FY 2015-16:

- Agricultural Conservation Easements and
- Agricultural Land Conservation Strategies and Outcomes.

Investments in agricultural conservation easements (easements) protect strategically located, highly productive, and critically threatened agricultural land, via permanent easements. Funding agricultural land conservation strategies and outcomes result in the implementation of local and regional planning policies that protect agricultural lands from development through the establishment of growth boundaries, zoning ordinances, and/or the use of easements.

Both project types result in the extinguishment of development rights thereby avoiding increases in GHG emissions by limiting opportunities for expansive, vehicle-dependent forms of development. This quantification methodology estimates the avoided GHG emissions based on the avoided VMT. Where applicable, project-type specific instructions should be followed.

GHG Emission Reductions Quantification Approach

This methodology estimates the GHG emissions avoided by protecting agricultural land at risk of conversion. This methodology quantifies the avoided GHG emissions of a proposed SALC project from CalEEMod estimates of avoided VMT and well-to-wheels emission factors. This methodology does not use the CalEEMod input or output screens for calculating construction, energy, and water-related emissions. The avoided VMT estimate is based on three inputs: project location (county), land use setting (urban or rural), and number of development rights to be extinguished.

SGC/DOC will estimate the GHG emission reductions of a proposed SALC project for the duration of the project life. For consistency with SGC's Affordable Housing and Sustainable Communities (AHSC) Program, the SALC Program's avoided GHG emissions are quantified over a project life of 30 years.

The metric used by ARB to assess the efficiency of the project to reduce GHG emissions per dollar of GGRF funds will be reported by SGC/DOC as:

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

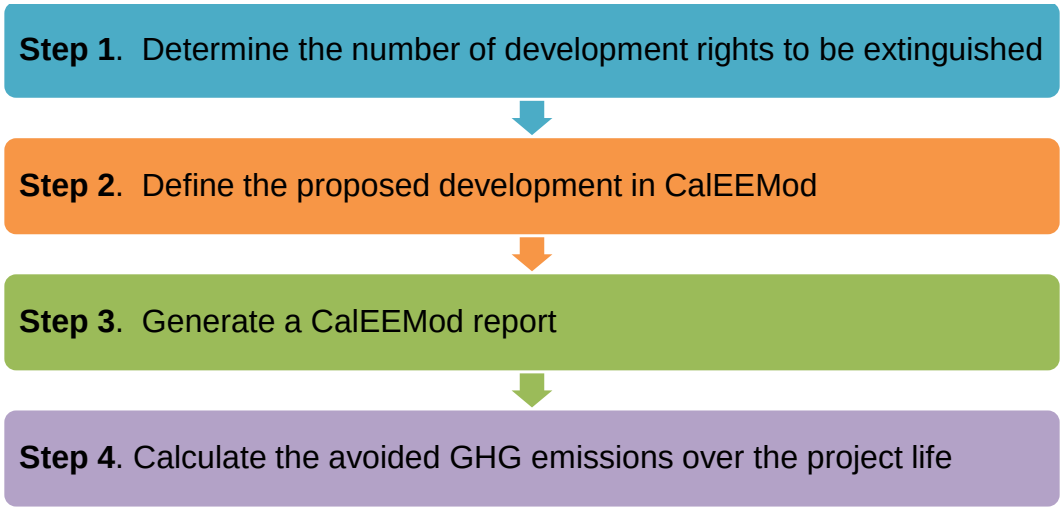
The following sections describe the process for estimating the avoided GHG emissions for proposed projects in the FY 2015-16 SALC Program.

Section B. Quantification Methodology

Overview

SGC/DOC will follow the steps outlined in Figure 1 to estimate the GHG emission reductions for a proposed project.

Figure 1. Steps to Estimating GHG Emission Reductions



Step 1: Determine the number of development rights to be extinguished

The first step in quantifying the avoided GHG emissions is determining the number of development rights to be extinguished for SALC projects. This is done by establishing the appropriate project geographic boundary, establishing the appropriate zoning density, and then calculating the number of development rights to be extinguished based on the zoning density and the number of acres of agricultural land at risk of conversion.

Step 1A: Establish the appropriate geographic boundary for the project

The FY 2015-16 SALC program guidelines[2] include requirements to map the project area. DOC/SGC will use the maps provided by applicants and Table 1 to establish maximum project geographic boundaries for assessing agricultural lands. The project geographic boundaries vary by eligible project type and serve to define a boundary for the purpose of estimating the GHG emission reductions at the application stage. This is particularly applicable to Strategy and Outcome projects which are not expected to have a finalized boundary until implementation.

Table 1. Project Geographic Boundaries

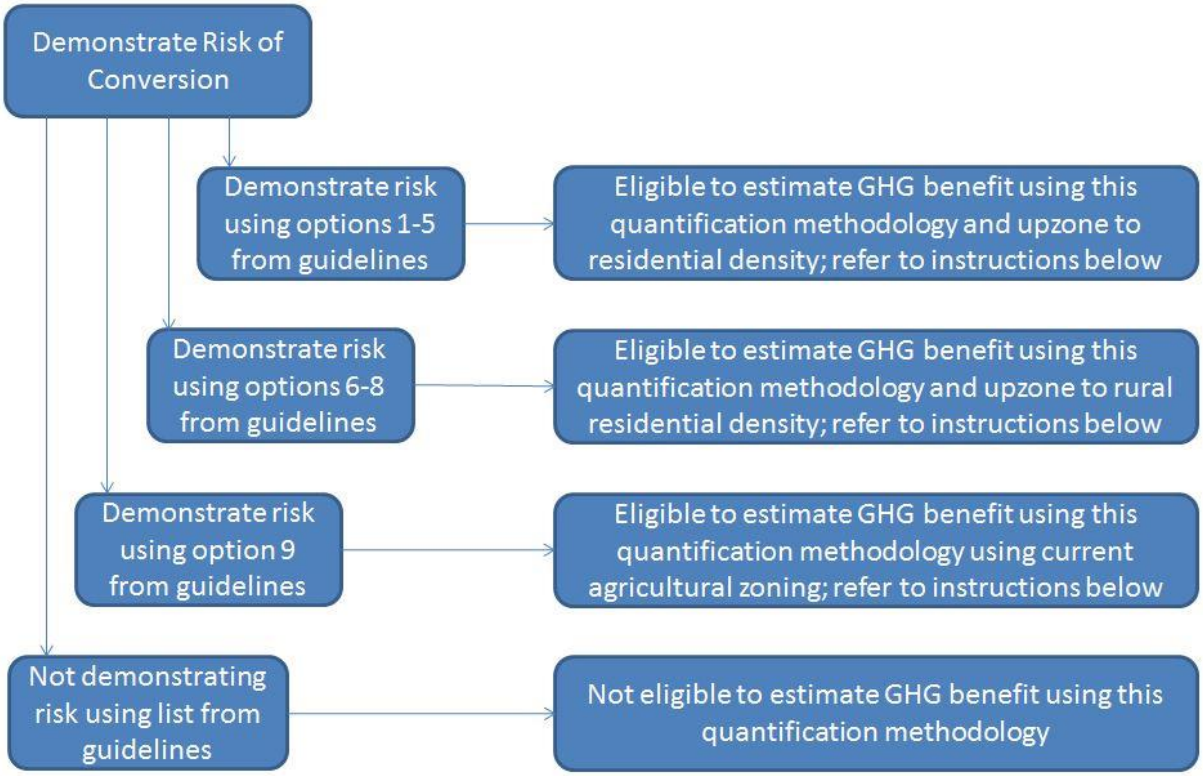
Agricultural Conservation Easement Grants	
Agricultural Conservation Easements	Agricultural lands subject to the easement
Strategy and Outcome Grants	
Agricultural Land Mitigation Program	Agricultural lands within the sphere of influence (SOI) and urban growth boundary (UGB), if applicable, or other applicable boundary such as that defined in a General Plan
Agricultural Conservation Easement Purchase Program	Agricultural lands within the jurisdiction
Adoption of an Agricultural Greenbelt and Implementation Agreement	Agricultural lands within the proposed greenbelt area
Adoption of Urban Limit Lines or Urban Growth Boundaries	If the proposed urban limit line or urban growth boundary is within the city boundary or SOI: Agricultural lands beyond the proposed urban limit line or urban growth boundary within the SOI; If the proposed urban limit line or urban growth boundary is outside the city boundary or SOI: Agricultural land within 2 miles of the proposed urban limit line or urban growth boundary within the county
Increased Zoning Minimum of Designated Strategic Agricultural Areas	Agricultural land within the jurisdiction to be targeted and impacted by the amended zoning

[2] http://www.sgc.ca.gov/s_salcprogram.php

Step 1B: Establish the appropriate zoning density

This methodology estimates the GHG emission reductions associated with protecting agricultural land that would otherwise be developed. Current zoning may not accurately reflect the density level of development projects that could be expected for a given property, particularly if in close proximity to existing urban centers. The FY 2015-16 SALC program guidelines provide methods to assess the risk of conversion on agricultural lands based on patterns of development in the vicinity. Use the list of options to demonstrate risk of conversion from the FY 2015-16 SALC program guidelines and the decision tree in Figure 2 below to determine the appropriate zoning density (i.e., the estimated number of dwelling units for the site) to use for quantification.

Figure 2. Decision Tree for Appropriate Zoning Density



Step 1C: Determine the number of development rights to be extinguished

Agricultural lands within the project geographical boundary determined to be at risk of conversion using options 1 through 5 in the list of options to demonstrate risk of conversion in the FY 2015-16 SALC program guidelines are eligible to determine the number of development rights to be extinguished based on residential zoning density. The residential density will be determined using the average single-family residential housing density within the city limit per zoning map and code.[3] The number of

[3] If agricultural land is in an unincorporated area, DOC will use the nearest city or recognized unincorporated community's average residential housing density to determine the number of development rights to be extinguished. Unincorporated communities are listed in the California Secretary of State's annual Roster: http://www.sos.ca.gov/administration/california-roster/ or are recognized as Census Designated Places in the US Census: http://www.census.gov/geo/reference/gtc/gtc_place.html

development rights to be extinguished is equal to the product of the average residential zoning density (dwelling units per acre) and the net acreage of at risk agricultural land within the project geographical boundary.

Agricultural lands within the project geographic boundary determined to be at risk of conversion using options 6 through 8 in the list of options to demonstrate risk of conversion in the FY 2015-16 SALC program guidelines are eligible to determine the number of development rights to be extinguished based on rural residential[4] density. The rural residential density will be determined using the average rural residential housing density within the nearest city or recognized unincorporated community per zoning map and code. The number of development rights to be extinguished is equal to the product of the average rural residential zoning density (dwelling units per acre) and the net acreage of at risk agricultural land within the project geographical boundary.

Agricultural lands within the project geographic boundary determined to be at risk of conversion using option 9 in the list of options to demonstrate risk of conversion in the FY 2015-16 SALC program guidelines are eligible to determine the number of development rights to be extinguished based on the property's current agricultural zoning density. The number of development rights to be extinguished is equal to the product of the current agricultural zoning density (dwelling units per acre) and the net acreage of at risk agricultural land within the project geographical boundary.

While some agricultural lands may be at risk of conversion to commercial, industrial, or recreational development, all projects will assume that one development right is equivalent to a single-family dwelling unit when using this quantification methodology to estimate the avoided VMT and resulting avoided GHG emissions from a proposed project.

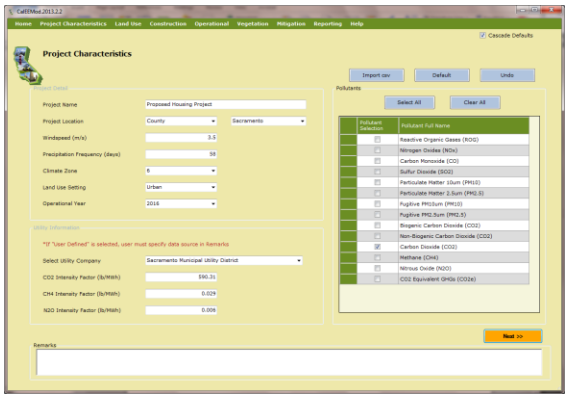
DOC/SGC will provide a map identifying at risk agricultural lands within the project geographic boundaries and the associated number of development rights to be extinguished by the project.

[4] Terms used for "rural residential" zoning type may differ by county.

Step 2: Define the proposed development

Use the CalEEMod "Project Characteristics" and "Land Use" screens as well as some defined default values for specific data inputs provided below to define a proposed development, defined as the conservative projection of development that could have occurred if the development rights were not extinguished.

Project Characteristics Screen



Cascade Defaults: Leave this box checked

Project Name: Enter project name

Project Location: Select "County" and enter the county of the project site[5]

Climate Zone: Enter any climate zone from the drop-down box[6] (Windspeed and Precipitation will autofill)

Land Use Setting: Select "Rural" or "Urban" as defined by census tract[7]

Operational Year: Enter the year when the first development rights are expected to be extinguished[8]

Select Utility Co.: Select "Statewide Average"[9] (CO_2, CH_4, and N_2O Intensity Factors will autofill)

Pollutants: All boxes may be unchecked[9]

[5] For projects that span multiple counties, select the county that includes the most extinguished development rights. For counties that are divided between air districts, air basins or district requested subregions; select the sub-county area which best represents the project location.

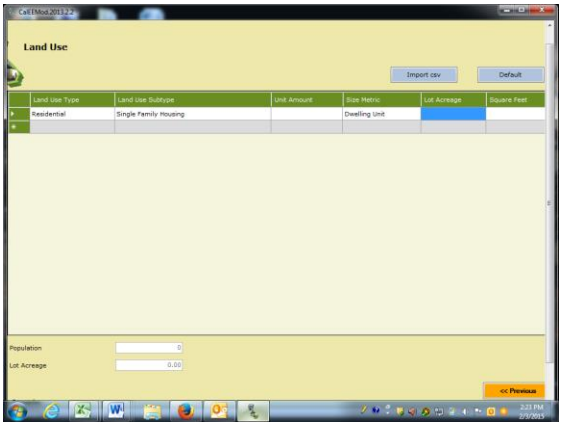
[6] The climate zone for a project can be looked up using the CalEEMod User's Guide Appendix F - Climate Zones Zip Code/Cities Lookup, Climate Zone Zip Code/Cities Lookup or the Climate Zone Map. However, the applicant may enter any allowable climate zone as this information is not used for calculations in this quantification methodology.

[7] See the US Census Bureau's national, state-sorted list of all 2010 urbanized areas and urban clusters for the U.S., Puerto Rico, and Island Areas first sorted by state FIPS code, then sorted by UACE code

[8] This value is not used in the computation of VMT but will be used in Step 4 to determine the appropriate emission reduction factors.

[9] CalEEMod is used to develop VMT reductions only; GHGs are calculated outside of CalEEMod.

Land Use Screen



Cascade Defaults: Leave this box checked

Land Use Type: Select "Residential"

Land Use Subtype: Select "Single Family Housing"

Unit Amount: Enter number of units (equal to the number of development rights extinguished by the project)

Size Metric: Select "Dwelling Unit"

Lot Acreage: Leave default values[10]

Square Feet: Leave default values[10]

Population: Leave default values[10]

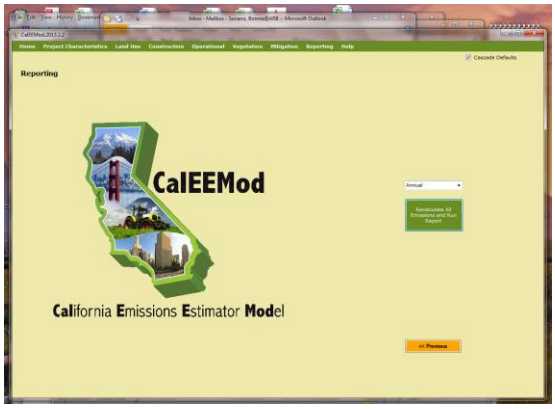
Applicant should <u>not</u> enter any values into the following screens: Construction, Operational, Vegetation, and Mitigation.

[10] These values are not used in the computation of VMT.

Step 3: Generate a CalEEMod report

Use the CalEEMod "Reporting" screen to generate an output file that will automatically calculate the estimated avoided VMT from the conservative projection of development that could have occurred at the proposed project site.

Reporting Screen



Select "Annual" emissions

Click "Recalculate Emissions and Run Report"

CalEEMod will generate a report that includes an "unmitigated" scenario in the CalEEMod report. Unmitigated refers to the estimated avoided VMT from a conservative projection of development that could have occurred at the proposed project site.

The VMT outputs are found in Section 4.2 of the report.

Applicants should use the Total Unmitigated Annual VMT value shown in Figure 3 for the remaining calculations.

User Tip:
GHG emissions are calculated outside of CalEEMod based on the VMT estimates in the CalEEMod report.

Figure 3. CalEEMod Report Section 4.2 VMT Output

4.2 Trip Summary Information

	Average Daily Trip Rate			Unmitigated	Mitigated
Land Use	Weekday	Saturday	Sunday	Annual VMT	Annual VMT
Single Family Housing	153.12	161.28	140.32	340,340	340,340
Total	153.12	161.28	140.32	340,340	340,340

Step 4: Calculate the avoided GHG emissions over the project life

Calculate the avoided GHG emissions over the 30 year project life using the following equations:

$$Avoided\ GHG\ (Yr\ 1) = \frac{Annual\ CalEEMod\ VMT\ Reductions \times AVEF_{Yr\ 1}}{1{,}000{,}000} \quad \textbf{(Eq. 1)}$$

$$Avoided\ GHG\ (Yr\ F) = \frac{Annual\ CalEEMod\ VMT\ Reductions \times AVEF_{Yr\ F}}{1{,}000{,}000} \quad \textbf{(Eq. 2)}$$

$$Avoided\ GHG\ (Total) = \frac{Avoided\ GHG\ (Yr\ 1) + Avoided\ GHG\ (Yr\ F)}{2} \times 30 \quad \textbf{(Eq. 3)}$$

Where,

Avoided GHG (Yr 1 or Yr F)	=	The estimated annual avoided GHG emissions resulting from the project in Yr 1 or Yr F (MT CO_2e)
Annual CalEEMod VMT Reductions	=	The estimated avoided VMT from a conservative projection of development that could have occurred at the proposed project site (Total Unmitigated Annual VMT from Step 3) (miles)
AVEF (Yr 1 or Yr F)	=	Auto Vehicle Emission Factor by county for Yr 1 or Yr F; see appendix (g CO_2e/mile)
Yr 1	=	The first year of the project life (the year when the first development rights are expected to be extinguished)
Yr F	=	The final year of the project life (Yr 1 + 30 years)
Avoided GHG (Total)	=	The estimated total avoided GHG emissions over the project life (MT CO_2e)

SGC/DOC will report the avoided GHG emissions per dollar of GGRF funds requested, calculated as follows:

$$\frac{Total\ Avoided\ GHG\ Emissions\ over\ the\ Project\ Life\ (MT\ CO_2e)}{GGRF\ Funds\ Requested\ (\$)}$$

Section C. Documentation

The final step to complete this quantification methodology is to document the estimated avoided GHG emissions and provide documentation of the calculations. SGC/DOC is required to provide electronic documentation that is complete and sufficient enough to allow the quantification calculations to be reviewed and replicated. Paper copies of any materials must be available upon request by ARB staff.

Documentation must include, at a minimum:

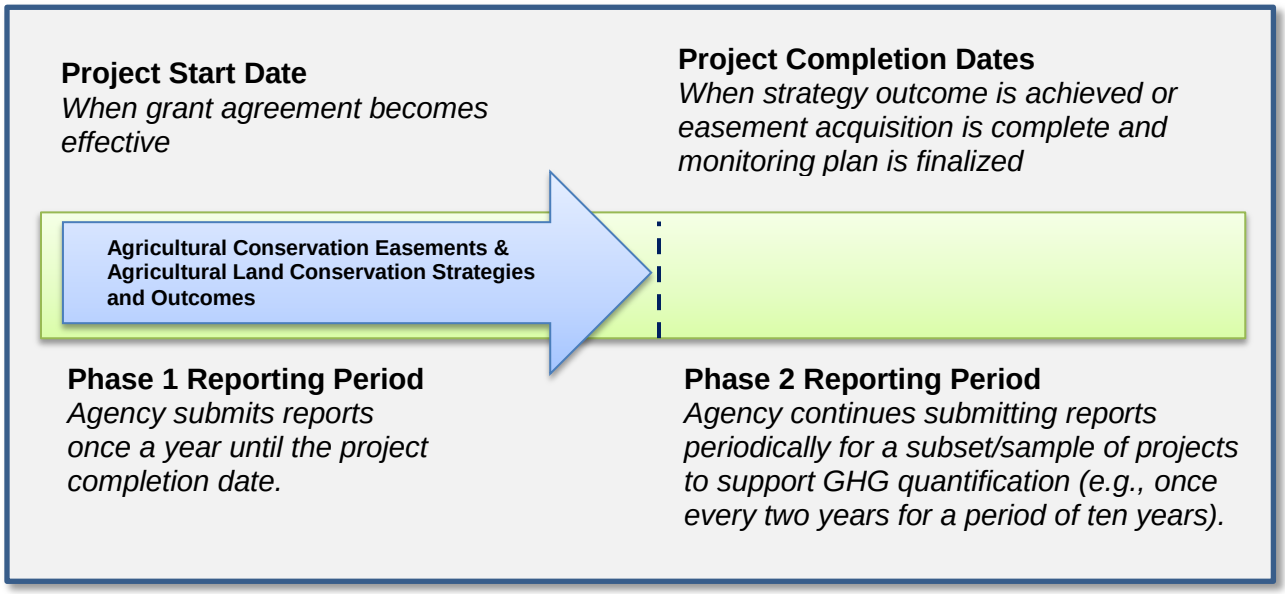
- Contact information for the person who can answer project specific questions from staff reviewers on the quantification calculations;
- Project description, including excerpts or specific references to the location in the main SALC application of the project information necessary to complete the applicable portions of the quantification methodology;
- Documentation supporting the determination of risk of conversion demonstrated using one of the options to demonstrate risk of conversion in the FY 2015-16 SALC program guidelines ;
- Electronic copies of the CalEEMod input and output files;
- Electronic documentation of calculations (spreadsheets, etc.) for all additional calculations;
- Summary page with, at minimum, the following information:
    - Avoided GHG emission estimates for Yr 1 and Yr F;
    - Estimate of total avoided GHG emissions over the project life;
    - GGRF funds requested for the project;
    - Estimated total avoided GHG emissions per GGRF funds requested

Section D. Reporting After Funding Award

Accountability and transparency are essential elements for all projects funded by the GGRF. 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 that Administer California Climate Investments (Funding Guidelines).[11] These Funding Guidelines describe the reporting requirements and set the minimum project-level reporting requirements for projects funded by SGC/DOC. Volume III of ARB's Funding Guidelines summarizes the major reporting components that SGC/DOC must report to ARB. Because much of this data is project specific and benefits may increase over the project life, SALC funding recipients will need to provide project data to SGC/DOC to support these reporting requirements.

The figure below illustrates the project phases and when reporting is required.



[11] Proposed Funding Guidelines for Agencies that Administer California Climate Investments, September 4, 2015 available at: http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/funding_guidelines_public_proposed_draft_09-04-2015.pdf. After incorporating revision to reflect the Board's direction, ARB will post the Final Funding Guidelines at: http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/fundingguidelines.htm

Table 2. Quantification and Reporting By Project Phase

	Timeframe	Quantification Methodology Section
Project Selection	Covers the period from solicitation to selection of projects and funding awards	SGC/DOC 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	SGC/DOC 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 SALC funding recipients during project implementation. This quantification methodology provides guidance on how to estimate project benefits to satisfy Phase 1 reporting requirements. At a minimum, ARB expects that SALC funding recipients will report to SGC/DOC once a year during project implementation and once at the end of the project.

Phase 2 reporting is required for only a subset of SALC 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. SGC/DOC 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 SGC/DOC 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 SGC/DOC 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: Auto Vehicle Emission Factor Lookup Tables

DOC/SGC will use Auto Vehicle Emission Factors (AVEF) lookup tables available from: http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/ef_avef_final.pdf to find the appropriate emission factors for a given County and year (Yr 1 and Yr F).

Examples
A proposed project is located in Ventura County and is expected to extinguish the first development rights in 2017, the appropriate emission factors would be:
Year 1 (2017): 508 g CO_2e/mi and
The project life is 30 years; therefore, Year F is 2017 + 30 = 2047.
Year F (2047): 304 g CO_2e/mi

Methodology for Developing the Emission Factors
GGRF programs estimate transportation-related emissions using a "Well-to-Wheels" approach, which consists of emissions resulting from the production and distribution of different fuel types, including hydrogen and electricity, and any associated exhaust emissions. Applicants use project-specific data to calculate new or avoided VMT and convert VMT to greenhouse gas emissions using Well-to-Wheels emission factors.

To simplify the application process for GGRF Programs, ARB developed the emission factors for applicants. The emission factors were developed using fuel consumption rates from ARB's Mobile Source Emission Factor Model (EMFAC 2014)[12] and carbon intensity values for different fuel types from ARB's Low Carbon Fuel Standard (LCFS) Program.[13] This approach provides consistency amongst transportation-related GGRF programs and ARB's Low Carbon Fuel Standard (LCFS) Program.

The emission factors are included as lookup tables or in the quantification methodology and the quantification methodology describes which factors to use and how to estimate project-specific emissions. A description of the derivation of the emission factors is included below.

Auto Vehicle Emission Factors
Passenger (auto) vehicle emission factors (**AVEF**) were derived using the following steps.

1. Emissions by county for each calendar year from 2016 through 2050 were downloaded from EMFAC 2014 with the following parameters:
    a. Annual Average
    b. EMFAC2011 vehicle categories LDA, LDT1, LDT2, and MDV
    c. Aggregated model year
    d. Aggregated speed

[12] http://www.arb.ca.gov/emfac/2014/
[13] http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

e. Gasoline fuel

2. The auto fuel consumption rate (**AFCR**, in gallons of gasoline per mile) was calculated using the total gallons of gasoline used by each vehicle category divided by the total mileage by vehicle category by county and year, using the following equation:

$$AFCR = \frac{(Fuel\_Consumption_{LDA} + Fuel\_Consumption_{LDT1} + Fuel\_Consumption_{LDT2} + Fuel\_Consumption_{MDV}) * 1{,}000}{VMT_{LDA} + VMT_{LDT1} + VMT_{LDT2} + VMT_{MDV}}$$

Where,
Fuel_Consumption is the total fuel consumption for the vehicle type, in 1,000 gallons per day, from EMFAC 2014, and
VMT is the total vehicle miles traveled for the vehicle type, in miles per day, from EMFAC 2014.

3. The auto vehicle emission factors (**AVEF**, in grams of CO_2e per mile) was calculated for each year and county by multiplying auto fuel consumption rate the by the Well-to-Wheels carbon content factor for gasoline, which is 11,460.09 g CO_2e per gallon (Table 3), using the following equation:

$$AVEF = 11{,}460.09 * AFCR$$

Table 3. Fuel-Specific Factors

Fuels (units)	Energy Density	Carbon Content gCO_2e/unit*	EER Values Relative to Diesel
Diesel (gal)	134.47 (MJ/gal)	13,818.14 (gCO_2e/gal)	1.0
Gas (gal)	115.63 (MJ/gal)	11,460.09 (gCO_2e/gal)	0.9
CNG (scf)	0.98 (MJ/scf)	77.88 (gCO_2e/scf)	0.9
LNG (gal)	78.83 (MJ/gal)	6,824.31 (gCO_2e/gal)	0.9
Hydrogen (kg)	120.00 (MJ/kg)	12,678.00 (gCO_2e/kg)	1.9
Hydrogen SB 1505 compliant (kg)		10,466.4 (gCO_2e/kg)	
Electric (KWh)	3.6 (MJ/KWh)	378.58 (gCO_2e/KWh)	4.2 (Bus) 2.7 (Shuttle/Van)

*Calculated using fuel type megajoule (MJ) per unit of fuel from Table III-2. Energy Densities of LCFS Fuels and Blendstocks[14] and fuel type grams of CO_2e per MJ from CA-GREET 1.8b versus 2.0 CI Comparison Table.[15]

[14] Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Proposed Re-Adoption of the Low Carbon Fuel Standard, December 2014
[15] Direct values (without energy efficiency ratio adjustments). Source: California Air Resources Board, CA-GREET 1.8b versus 2.0 CI Comparison Table, April 1, 2015