16. AIR QUALITY AND CLIMATE PROTECTION

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Because it is ubiquitously distributed and generally invisible, air is a critical natural resource that is often taken for granted. Various activities and an expanding human population in California and elsewhere are increasing emissions to the atmosphere, taxing the air quality of California, and placing a disproportionate burden on certain air basins such as the San Joaquin Valley and the South Coast. To address the increasing importance and scope of concerns about air quality and climate change, it is important that everyone takes steps to reduce emissions.

The winegrowing community is an important contributor to California's vibrant economy. Because agriculture constitutes only one source of the state's air emissions and the wine industry is only a fraction of the agricultural component, emissions associated with each vineyard or winery may seem minimal. However, a collective commitment by the winegrowing community to limit emissions acknowledges that all efforts make a difference and moves the dialogue beyond the narrow and reactive focus on individual sources, impacts, and regulations. Through voluntary assessment and proactive efforts to decrease emissions, cost-effective practices and technologies can be identified and implemented, improving air quality and mitigating climate change while maintaining the economic viability of this important business sector.

Certain emissions are categorized and regulated as criteria (or common) air pollutants – specific gases and small particles escaping to the atmosphere during various activities which can include crop production or processing. Through air movement, pollutants can travel great distances, potentially impacting humans, other organisms, crops, and the environment far from the source. Growers and vintners are encouraged to identify sources of criteria air pollutants as a means for developing and implementing plans for effective mitigation. Although not criteria pollutants, carbon dioxide (CO_2), nitrous oxide (N_2O), and other greenhouse gases emitted during the combustion of fossil fuels, applications of nitrogen fertilizer, tillage, refrigerant use, and other activities have been linked with global climate change. Understanding how and which operations produce greenhouse gases help managers develop a strategy for reducing and offsetting them (e.g., carbon sequestration). This chapter provides criteria to assess winegrowing practices for protecting air quality and addressing climate change by focusing on activities to limit emissions of criteria air pollutants and limit and offset greenhouse gases.

Concerns about air quality and climate change have intensified. It is important, therefore, that the winegrowing community leads and highlights its efforts to decrease and offset emissions. Many growers and vintners are proactively implementing preventive measures. Vehicular traffic and speed have been reduced on unpaved roads. Integrated approaches to vineyard management that include cover cropping, low/no tillage, and integrated pest management (IPM) are practiced. Older diesel engines have been replaced with low-emission technology. Moreover, it is crucial to note that agriculture provides key biological filters for some emissions. For example, vines, cover crops, and other plants associated with the vineyard or winery extract CO_2 from the air and sequester the carbon in their tissues. The conservation and augmentation of flora is important for enhancing this capacity.

The purpose of this chapter is to help growers and vintners identify and improve management practices that help protect air quality and mitigate climate change. Included are 10 criteria to self-assess:

- The status of air quality protection and climate change mitigation planning, monitoring, goals, and results for the vineyard or winery
- The greenhouse gas metrics of pounds of CO_2 equivalents emitted per acre and ton of grapes or gallon and case of wine
- The awareness of emission sources by major operation and of conservation practices to reduce and offset emissions
- Management support and employee training to improve air quality and mitigate climate change
- Options in the vineyard or winery operation to prioritize for decreasing and offsetting emissions.

Combustion and vineyard applications of nitrogen are important contributors of criteria air pollutants and greenhouse gases. However, single criteria that document recommended practices for reducing emissions from combustion and from nitrogen use are excluded because pertinent practices are addressed across the criteria and educational boxes in this chapter, and in **Chapter 4 Soil Management** (nitrogen use) and **Chapter 9 Energy Efficiency** (combustion and alternatives).

List of Air Quality and Climate Protection Criteria

Performance Metrics – Greenhouse Gas Emissions

Why are Performance Metrics important?
Knowing and understanding the actual use of resources is an important aspect for controlling costs and increasing the profitability for any business. Including the relationship between practices and measurable outcomes allows your business to accurately benchmark its performance and set achievable targets for improvement using actual, not perceived, outcomes. Whereas the practice-based self-assessment helps determine what winery or vineyard practices affect energy or fuel use, for example, performance metrics calculations provide the rationale for setting targets based on real measurements. As the adage goes, "You can't manage what you don't measure."

The Greenhouse Gas Metric is used to track the carbon dioxide equivalents from fuel and electricity use. For wineries, the metric also includes refrigerant loss and the corresponding Global Warming Potential of the specific refrigerant(s) used. Vineyards also have the option of using a simplified tool called the DeNitrification DeComposition (DNDC) tool within the Online Metrics Center to evaluate the greenhouse gas emissions and soil carbon sequestration potential of their vineyard.

How to Calculate Greenhouse Gas Metrics?
Greenhouse gas emissions for vineyards and wineries can be calculated as carbon dioxide equivalents generated per unit of production (see below for calculation examples).

Using Performance Metrics

1. Collect
Identify and gather data needed to calculate the metric

2. Measure
Calculate metrics and determine your baseline

3. Track
Track your metrics calculations from year to year

4. Manage
Set targets for improvement and identify action plans

Metric Area	Metric Calculation	Data Elements	Data Sources
Greenhouse Gas (GHG) Emissions* (Vineyard)	**GHG Intensity** = Pounds of Carbon Dioxide Equivalents / Acre Pounds of Carbon Dioxide Equivalents / Ton of Grapes	• Fuel usage • Electricity usage • Acreage • Yield (total tons) * additional data elements will be added as GHG calculation models evolve	Utility records; Fuel receipts; Meter & equipment readings
Greenhouse Gas (GHG) Emissions* (Winery) *from energy use and refrigerant loss	**GHG Intensity** = Pounds of Carbon Dioxide Equivalents / Gallon of Wine Pounds of Carbon Dioxide Equivalents / Case of Wine	• Fuel usage • Electricity usage • Refrigerant usage • Gallons and cases produced	Utility records; Fuel receipts; Meter & equipment readings, refrigerant purchase receipts

How do I start tracking my Performance Metrics?
To get started tracking and recording greenhouse gas emissions, as well as other performance metrics (e.g., water, applied nitrogen, and energy use) visit http://www.sustainablewinegrowing.org/metrics.php or click on the "Metrics" tab within the SWP Online System.

16-1 Planning, Monitoring, Goals, and Results

Vineyard & Winery

Category 4	Category 3	Category 2	Category 1
Sources of air emissions associated with the vineyard and/or winery were known ***And*** The difference between and sources of PM_{10} and $PM_{2.5}$ particulate matter were known ***And*** Resources for air quality information (e.g., Air Quality Index, regional web sites) were used regularly ***And*** A documented air and climate protection plan** was developed ***And*** Annual greenhouse gas emissions were calculated* ***And*** Goals and reduction targets for limiting emissions were met ***And*** Employees were trained in air and climate protection and training includes written material.	Sources of air emissions associated with the vineyard and/or winery were known ***And*** The difference between and sources of PM_{10} and $PM_{2.5}$ particulate matter were known ***And*** There was awareness of resources for air quality information ***And*** Annual greenhouse gas emissions were calculated* ***And*** Information about air and climate protection was available to employees.	There was awareness of some sources of air emissions associated with the vineyard and/or winery ***And*** There was a general idea of the difference between and sources of PM_{10} and $PM_{2.5}$ particulate matter ***And*** Sources and impacts of emissions from the vineyard and/or winery were being assessed.	There was a general idea about some sources of air emissions (criteria pollutants and greenhouse gases) associated with the vineyard and/or winery ***And*** The difference between PM_{10} and $PM_{2.5}$ particulate matter was not known.

Calculations for wineries should include fuel usage, electricity usage and refrigerant usage. Calculations for vineyards should include emissions from fuel usage and electricity usage, and from soil processes. Available tools for doing the vineyard calculations include the DNDC (DeNitrification-DeComposition) model in the CSWA Metrics Center, COMET-Planner, and COMET-Farm. See **Criterion 4-14** and **Box 4-M** in **Chapter 4 Soil Management** for more information.

A documented air and climate protection plan could include elements such as vineyard floors and unpaved surfaces, combustion and alternative technology or fuels, pesticides, and refrigerants. To see an **air and climate protection plan template for vineyards visit the CSWA Resource Library at: https://library.sustainablewinegrowing.org/ The template is available in English and Spanish.

BOX 16-A AIR QUALITY INDEX (AQI)

The Air Quality Index (AQI) is an index for reporting daily air quality. It tells you how clean or polluted your air is, and what associated health effects might be a concern for you. The AQI focuses on health effects that you may experience within a few hours or days after breathing polluted air. The US Environmental Protection Agency (US EPA) calculates the AQI for five of the criteria air pollutants regulated by the Clean Air Act: ground-level ozone, nitrogen dioxide, particulate matter, sulfur dioxide, and carbon monoxide. For each of these pollutants, US EPA has established national air quality standards to protect public health.

How Does the AQI Work? Think of the AQI as a yardstick that runs from 0 to 500. The higher the AQI value, the greater the level of air pollution and the greater the health concern. For example, an AQI value of 50 represents good air quality with little potential to affect public health, while an AQI value over 300 represents hazardous air quality. An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level that US EPA has set to protect public health. AQI values below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is considered to be unhealthy – at first for certain sensitive groups of people, then for everyone as AQI values get higher.

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0-50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51-100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101-150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151-200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201-300	Health alert: everyone may experience more serious health effects.
Hazardous	> 300	Health warnings of emergency conditions. The entire population is more likely to be affected.

US EPA has assigned a specific color to each AQI category to make it easier for people to understand quickly whether air pollution is reaching unhealthy levels in their communities. For example, the color orange means that conditions are “unhealthy for sensitive groups”, while red means that conditions may be “unhealthy for everyone”, and so on.

Adapted from US EPA at http://www.airnow.gov/index.cfm?action=aqibasics.aqi. Go to this webpage to determine the real-time AQI for your area. Links to local air districts can be found at http://www.arb.ca.gov/capcoa/roster.htm.

BOX 16-B WHAT ARE AIR PARTICLES? WHERE DO THEY COME FROM?

Particles in the air are a mixture of solids and liquid droplets that vary in size and often are referred to as "particulate matter". Small particles or respirable particulate matter – particles less than or equal to 10 microns in diameter (PM_{10}) – pose a greater health concern than larger particles because they can pass through the nose and throat and penetrate the lungs. Ten microns is about one-seventh the diameter of a human hair. Particles exceeding 10 microns usually do not reach the lungs, but can irritate the eyes, nose, and throat.

PM_{10} include "coarse" and "fine" particles. Coarse particles, with diameters ranging between 2.5 and 10 microns, typically are released during crushing or grinding operations and, importantly, as fugitive dust (from non-point sources) disturbed by wind, vehicles, or equipment.

Fine particles ($PM_{2.5}$) have diameters less than or equal to 2.5 microns and pose the greatest health concerns. $PM_{2.5}$ is directly emitted when fuels such as coal, oil, diesel, gasoline, or wood are burned. Fine particles can be emitted during combustion associated with power plants, wood stoves, and motor vehicles (e.g., cars, trucks, buses, marine engines). These particles also are produced during fuel use by construction equipment, agricultural burning, forest fires, and residential fireplaces. Moreover, a large fraction of $PM_{2.5}$ is secondarily formed through the atmospheric reaction of oxides of nitrogen (NOx) or sulfur dioxide with ammonia to form ammonium nitrates and ammonium sulfates, respectively. NOx and sulfur dioxide are combustion by-products.

For more information on air particles and health impacts go to http://www.airnow.gov/index.cfm?action=particle_health.index.

Controlling speeds on dirt roads helps to reduce airborne particulate matter.

BOX 16-C CHARACTERIZATION AND REGULATION OF CRITERIA AIR POLLUTANTS

The Federal Clean Air Act required US EPA to set nationwide standards for air quality based on human health concerns. Federal standards have been established for the six criteria or common air pollutants: ground-level ozone, nitrogen dioxide, particulate matter (PM_{10} and $PM_{2.5}$), sulfur dioxide, carbon monoxide, and lead. Moreover, the California Air Resources Board (CARB) generally has adopted more restrictive state standards for these pollutants pursuant to the California Clean Air Act. Standards are reviewed periodically and may be revised. Geographic areas in which the level of a criteria air pollutant exceeds federal and/or state standards are classified as non-attainment areas. There are 15 air basins within California that are designated as being in attainment or non-attainment status. Regional or county air districts associated with non-attainment areas for one or more pollutants must prepare management plans that detail means for ensuring future compliance with federal and/or state standards. Regional or county plans are incorporated into the State Implementation Plan submitted to US EPA describing how California will attain and maintain the national standards.

Criteria Air Pollutant	**Relevant Sources**
Ozone (ground level)	Formed by photochemical reaction involving volatile organic compounds (VOCs) and nitrogen oxides (NOx)
Volatile organic compounds (VOCs)*	Released from handling and combustion of fossil fuels (e.g., diesel, gasoline, oil, coal, natural gas); livestock; solvents, paints, glues, pesticides, and other petroleum-derived products; alcoholic fermentation and storage; and respiration by plants and decomposition of organic matter
Nitrogen dioxide	Combustion of fossil fuels (especially diesel)
Particulate matter (PM_{10} and $PM_{2.5}$)	Combustion of wood and fossil fuels (especially diesel), dust from industrial and agricultural operations and unpaved roadways, some applications of pesticides, and atmospheric conversion of gaseous pollutants
Sulfur dioxide	Combustion of coal and oil
Carbon monoxide	Combustion of fossil fuels, especially during cold temperatures
Lead	Leaded aviation gasoline, paint, smelters, and manufacture of lead storage batteries

Detailed information about the Clean Air Act and criteria air pollutants is at https://www.epa.gov/clean-air-act-overview/plain-english-guide-clean-air-act. For more information and an orientation course on criteria pollutants, and greenhouse gases and climate change, visit https://www.apti-learn.net/LMS/register/EPALearning.aspx?t=0

A glossary of air pollution terms is at http://www.arb.ca.gov/html/gloss.htm.

*Although not criteria pollutants, volatile organic compounds are included because they are important ozone precursors. See **Box 16-E** for more information on VOCs.

BOX 16-D HOW IS OZONE BOTH GOOD AND BAD?

Ozone occurs in two layers of the atmosphere. The stratosphere, which contains the "good" ozone layer, extends from about 6 to 30 miles above earth and protects life from the sun's harmful ultraviolet rays. Ozone is produced naturally in the stratosphere. This "good" ozone has been gradually depleted by man-made chemicals referred to as ozone-depleting substances, including chlorofluorocarbons, hydrochlorofluorocarbons, halons, methyl bromide, carbon tetrachloride, and methyl chloroform. The loss of stratospheric ozone allows additional ultraviolet radiation to reach earth's surface, endangering human health and damaging crops.

The layer closest to earth's surface is the troposphere, extending about six miles up. Here, ground-level or "bad" ozone is an air pollutant causing human health and other concerns. Ground-level ozone is the main component of urban smog and is formed when nitrogen oxides (NOx) react with volatile organic compounds (VOCs) in the presence of sunlight. Highest ozone concentrations occur during the spring and summer, when meteorological conditions (i.e., hot sunny days) are optimum for ozone formation. Such conditions can result in ozone peaks lasting from a few days to a week. Emissions associated with industrial facilities, electricity utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some major NOx and VOC sources.

Ground-level ozone damages vegetation and ecosystems. It can reduce the growth and yield of crops, especially for sensitive species and varieties. Moreover, ozone can increase crop susceptibility to pests and other stresses such as harsh weather. US EPA estimates that annual crop damage caused by ozone amounts to $2 billion to $3 billion nationwide.

Ozone is used as a sanitizer in winery operations and can greatly reduce the salinity of winery wastewater. Because ozone has such a short half-life, it cannot be stored but must be generated on-site and used immediately. Most wineries use ozone dissolved in water and some off-gassing can occur. To protect workers, managers need to thoroughly train staff in standard operating procedures for ozone usage and safety; use only properly designed, correctly sized, and carefully maintained ozone generating equipment; and appropriately test and monitor ozone concentrations.

For more general information, visit http://www.airnow.gov/index.cfm?.action=aqibasics.ozone. For information about impacts on crop productivity, go to https://www.ars.usda.gov/southeast-area/raleigh-nc/plant-science-research/docs/climate-changeair-quality-laboratory/ozone-effects-on-plants/.

BOX 16-E UNDERSTANDING AND REGULATION OF VOLATILE ORGANIC COMPOUNDS (VOCS)

Ground-level ozone, a criteria air pollutant, is produced by chemical reactions involving VOCs, nitrogen oxides (NOx), and sunlight. Although not criteria air pollutants, VOCs are important ozone precursors and considered a key target for reduction in order to achieve federal and state ozone standards. Definitive understanding of the capacity for each VOC to produce ozone is evolving. Nevertheless, State Implementation Plans must address means to reduce VOC emissions in air basins exceeding ozone standards. Plans are continually updated to reflect changes in standards resulting from improved understandings of ozone precursor capacities and health risks (e.g., more stringent federal 8-hr ozone standard established in 2015).

The reality is that VOC emissions associated with agriculture continue to be scrutinized. It is important for the California winegrowing community to remain alert to issues and take proactive steps to minimize emissions where feasible and collaborate with regulators about possible additional regulations. Scrutinized sources of VOCs associated with the wine industry include pesticides (see **Box 16-M** for more detail and proactive mitigative measures) and fermentation/storage processes affecting ethanol releases. Winery personnel should keep abreast of their Air District's regulations regarding VOC emissions from fermentation and storage. The wine industry must invest its vast knowledge and experience in actively participating in dialogue and research towards improved understandings of impacts to air quality and reasonable solutions.

Updated information and links pertaining to State Implementation Plans for VOCs and the criteria air pollutants are at http://www.arb.ca.gov/planning/sip/sip.htm.

BOX 16-F CALIFORNIA AIR RESOURCES BOARD AGRICULTURAL ACTIVITIES

Agricultural activities are becoming increasingly subject to air pollution permits and other regulations. One purpose of the Air Resources Board website is to keep the California agricultural community informed about air quality related activities that may impact their operations. It includes board meetings (past and future), actions, programs, news clips, and other details. To explore this site, go to http://www.arb.ca.gov/ag/ag.htm.

To obtain electronic notices about significant regulatory activities and developments, register at http://www.arb.ca.gov/listserv/listserv_grp.php?listtype=A0.

BOX 16-G GREENHOUSE GASES, CLIMATE CHANGE, AND CARBON SEQUESTRATION

Human activities have been linked to four key greenhouse gases – carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and the halocarbons (includes refrigerants). Unlike criteria air pollutants, greenhouse gases are of concern primarily because of their impacts on climate change and ramifications such as glacial melting, rising sea levels, and more intense and frequent weather events (e.g., heat waves, droughts, floods, hurricanes). These gases warm the Earth's surface and lower atmosphere by absorbing thermal radiation emitted by the land and ocean and reradiating it back to Earth. CO_2 is the most prevalent greenhouse gas but the CO_2 equivalents of CH_4 and N_2O are 25 and 298 times higher, respectively. While various factors affect climate, most scientists agree that greenhouse gases associated with human activities, predominantly the burning of fossil fuels and clearing of forests, are responsible for the warming observed over the past 50 years. Climate change could impact California agriculture by decreasing the reliability of water supplies, changing the dynamics of pest populations, causing variations in crop yield and quality, and creating more extreme weather events.

The major greenhouse gases associated with grape and wine production are CO_2 and N_2O. In the vineyard, CO_2 can be emitted or stored (sequestered) by plants and soils as a result of plant and microbial activities and management practices. The combustion of fuels by electrical utilities, irrigation pumping plants, or by tractors or other vehicles is a key source of CO_2. N_2O is mostly attributed to excessive use of fertilizers. The precise impacts of a number of management practices (e.g., tillage, irrigation) on the timing and quantity of CO_2 and N_2O emissions from soil microbiological activities are being refined by research and modeling. Combustion-related CO_2 emissions and evaporative losses of refrigerants are important sources of greenhouse gas emissions for wineries.

Carbon sequestration can be defined as the long-term storage of carbon in vegetative structures and soils. Plants are considered a "sink" for CO_2 because they uptake this gas during photosynthesis. Carbon sequestration offsets atmospheric concentration of CO_2, and can be increased by maximizing and diversifying vegetation in and around the vineyard, such as utilizing cover crops (especially permanent covers), maintaining or planting hedgerows, and planting trees and shrubs. Sequestration and emission reductions generally are maximized by combining beneficial practices, e.g., cover crops with no or minimal tillage and additions of compost. According to some models, perennial crops like vineyards may sequester more carbon than annual crops. The net balance of greenhouse gas emissions and carbon sequestration for a vineyard is termed its "carbon footprint." The DeNitrification-DeComposition (DNDC) model has been modified to help quantify soil-related greenhouse gas emissions and carbon sequestration in California vineyards. Key inputs impacting results are vineyard location (climate and soils), row spacing, tillage practices, use and type of cover crop, and amounts of compost and applied nitrogen fertilizer. For more information and how to use the model, see https://www.sustainablewinegrowing.org/docs/Vineyards_GHGs_Handout_7.3.13_rev13.lorez.pdf. For general information about climate change, see https://www.ipcc.ch/reports/ . Updated information for California is at https://www.climatechange.ca.gov/.

To review current understandings about vineyard management practices and carbon footprints, visit the CSWA Resource Library and search for **Vineyard Management Practices and Carbon Footprints** (https://library.sustainablewinegrowing.org/).
To learn more about winery carbon footprints, search for **California Wine's Carbon Footprint** in the CSWA Resource Library.

16-2 Vineyard Floors

Vineyard

Category 4	Category 3	Category 2	Category 1
Soil management practices for mitigating airborne dust and PM_{10} were known ***And*** A written soil conservation plan* was implemented that included a permanent or no-till cover crop, no or minimally disruptive under-the-vine tillage, and other practices (e.g., wind barriers such as trees and hedgerows, nighttime farming, under-the-vine mulches/compost, vegetated non-farmed areas, combined operations enabling reduced tractor passes).	Soil management practices for mitigating airborne dust and PM_{10} were known ***And*** A soil conservation strategy was implemented that included cover cropping, reduced tillage, and one or more other practices.	There was awareness of soil management practices for mitigating airborne dust and PM_{10} ***And*** A soil conservation strategy was implemented that included reduced tillage.	Soil management practices were not implemented to mitigate airborne dust and PM_{10} unless required by regional regulations (see **Box 16-H**).

In addition to benefiting air quality, the minimization of dust also prevents outbreaks of mite pests.

* A soil conservation plan can be a component of a larger air and climate protection plan. To see an air and climate protection plan template for vineyards visit the CSWA Resource Library at: https://library.sustainablewinegrowing.org/ The template is available in English and Spanish.

BOX 16-H CONSERVATION MANAGEMENT PRACTICES TO REDUCE PM_{10}

The San Joaquin Valley Unified Air Pollution Control District requires that growers with 100 or more acres of continuous, or adjacent, farmland prepare, update, and implement Conservation Management Practices (CMPs) that minimize PM_{10} emissions for each crop farmed. Affected growers must implement at least five CMPs per crop, generally one from each of five categories: land preparation and cultivation, harvest activities, unpaved roads, unpaved equipment yards, and other cultural practices. Detailed information, including the characterization of various CMPs, is available from *Agricultural Air Quality, Conservation Management Practices for San Joaquin Valley Farms* (2004) found at http://www.valleyair.org/farmpermits/updates/cmp_handbook.pdf.

16-3 Unpaved Surfaces – Roadways and Traffic and Equipment Staging Areas			*Vineyard & Winery*
Category 4	**Category 3**	**Category 2**	**Category 1**
Practices for mitigating airborne dust and PM_{10} from unpaved surfaces were known ***And*** A conservation strategy was implemented that included effectively timed applications of water or regulatory compliant anti-dust materials* and/or layering gravel, chipping, mulching, sanding, paving, or seeding ***And*** Speeds and travel were restricted on and around the operation ***And*** Employees were trained to reduce fugitive dust from unpaved areas.	Practices for mitigating airborne dust and PM_{10} from unpaved surfaces were known ***And*** A conservation strategy was implemented that included effectively timed applications of water or regulatory compliant anti-dust materials* and/or layering gravel, chipping, mulching, sanding, paving, or seeding ***And*** Speeds and travel were restricted on and around the operation.	There was awareness of practices for mitigating airborne dust and PM_{10} from unpaved surfaces ***And*** A conservation strategy was implemented that included effectively timed applications of water or regulatory compliant anti-dust materials* and/or layering gravel, chipping, mulching, sanding, paving, or seeding ***Or*** Speeds and travel were restricted during high use periods on and around the operation.	Practices were not specifically implemented to mitigate airborne dust and PM_{10} from unpaved surfaces unless required by regional regulations (see **Box 16-H**). *(Select N/A if all roadways and staging areas are paved)*
*Check with local regulatory officials about regulatory compliant and environmentally sustainable anti-dust materials for your area. See **Box 16-I** for more information on anti-dust materials. In addition to benefiting air quality, the minimization of dust also prevents outbreaks of mite pests. To evaluate the economic costs and returns of various management practices for unpaved roads, see the **CSWA Dust Mitigation Comparison Tool** available from the CSWA Resources Library at: https://library.sustainablewinegrowing.org/.			

BOX 16-I ANTI-DUST MATERIALS AVAILABLE FOR CONTROLLING PM_{10}

Chips/Mulches, Organic Materials, Polymers, "Road Oil", and Sand: Using regional or county air district approved materials to suppress dust on roads that meet the vehicle trips per day threshold.

Paving: Paving the roads greatly reduces the amount of dust released. Be advised that paving can increase runoff in certain circumstances.

Gravel: Adding gravel to a sufficient depth will reduce dust. If the road has greater than 75 trips per day, the applied gravel must be washed.

Seeding: Seeding to establish ground cover where feasible can greatly reduce roadway dust.

Detailed information and specific products recommended for the San Joaquin Valley are available from *Agricultural Air Quality, Conservation Management Practices for San Joaquin Valley Farms* (2004) found at http://www.valleyair.org/farmpermits/updates/cmp_handbook.pdf. Additional information regarding regulations for controlling PM_{10} from unpaved roadways and traffic areas for the San Joaquin Valley is at http://www.valleyair.org/busind/comply/PM10/compliance_PM10.htm.

For products and practices appropriate for other regions, check with your regional or county air district. The list of air districts is at http://www.arb.ca.gov/capcoa/roster.htm.

Cover crops provide many air quality benefits for vineyards, including dust abatement and reduced soil erosion, improved soil structure and often reduces the number of tractor passes between rows.

16-4 Vineyard Water Use* *Vineyard*

Category 4	Category 3	Category 2	Category 1
There was knowledge about how irrigation design and practices affect air quality and climate change ***And*** A cost-effective strategy for reducing emissions was implemented that included a monitored and maintained irrigation system ***And*** The irrigation strategy (including frost protection) delivered minimal amounts of water to achieve yield and quality goals ***And*** Irrigation occurred before mid-morning or at night (decreases ozone formation and conserves energy) ***And*** If applicable, older diesel-powered irrigation units were replaced/retrofitted with cleaner-burning technology (e.g., low-emission diesel engines), converted to electric motors, or use alternative fuels (e.g., biodiesel, propane, natural gas, methane).	There was knowledge about how irrigation design and practices affect air quality and climate change ***And*** A cost-effective strategy for reducing emissions was implemented that included a monitored and maintained irrigation system ***And*** The irrigation strategy (including frost protection) delivered minimal amounts of water to achieve yield and quality goals.	There was awareness of how irrigation design and practices affect air quality and climate change ***And*** The irrigation strategy (including frost protection) delivered minimal amounts of water to achieve yield and quality goals.	The relationship between irrigation operations and air quality and climate change was not known. *(Select N/A if no water was applied during the assessment year)*

*Air emissions associated with pumping water include nitrogen oxides (NOx), fine particulate matter ($PM_{2.5}$), volatile organic compounds (VOCs), and greenhouse gases (e.g., CO_2). Different irrigation systems and practices can variously affect emissions of greenhouse gases from soils (visit the CSWA Resource Library and search for Vineyard Management Practices and Carbon Footprints available at: https://library.sustainablewinegrowing.org/.

BOX 16-J AGRICULTURAL PUMPING EFFICIENCY PROGRAM

The Advanced Pumping Efficiency Program (APEP) is an educational and incentive rebate program funded by PG&E through October 31, 2020 using the Public Purpose Programs Fund under the auspices of the California Public Utilities Commission. The goal of the program is to improve overall pumping plant efficiency and encourage energy conservation. Eligible participants often receive rebates for costs associated with on-site efficiency tests and necessary equipment upgrades. Increases in pumping efficiency lead to less energy consumption, decreased cost, and fewer air emissions.

Who is eligible?
All owners or users of a non-residential, PG&E electric or natural gas account that is primarily used for pumping water for production agriculture, landscape or turf irrigation, or specified municipal purposes. Customers must pay the Public Purpose Programs Charge on their utility bill. An electric or natural gas utility account that is used for production agriculture or large turf irrigation (non-residential accounts of five or more horsepower for turf irrigation) who are paying the Public Goods Charge are eligible (normally customers of PG&E, SCE, SCG, or SDG&E – SDG&E customers should contact APEP to ensure their eligibility).

For additional eligibility requirements, details, and contact information, visit http://www.pumpefficiency.org.

BOX 16-K AIR QUALITY AND DIESEL ENGINES

In 1998, the California Air Resources Board (CARB) designated diesel exhaust as a toxic air contaminant after an exhaustive, 10-year scientific assessment process. Using the newly developed cancer risk assessment for diesel, CARB estimated that diesel particulate matter or soot was responsible for 70% of the state's risk of cancer from airborne toxics for the year 2000. In September 2000, CARB adopted the Diesel Risk Reduction Plan (Diesel RRP or Plan), which recommended control measures to reduce risks by achieving a 75% reduction in diesel particulate matter by 2010 and 85% by 2020, compared to the year 2000.

Agricultural engines are not being singled out. To meet goals, all uses and categories (on road, off road, and stationary) of diesel-fueled engines are being examined and controls implemented where determined to be technically and economically feasible. Based on the statewide diesel particulate matter emissions inventory for the year 2000, emissions from agricultural operations (excluding logging) represented 14% of the total and were comparable to that from on-road heavy-duty trucks (16% of total). Diesel engines also are an important source of the nitrogen oxides (NOx) and volatile organic compounds (VOCs).

Since implementation of the Diesel RRP, emission standards for diesel engines have gradually become more and more stringent. By January 1, 2023 most diesel engines will have to have been retrofitted or replaced to meet the 2010 Model Year Emissions Equivalent Engine standard.

CARB has also instituted Airborne Toxic Control Measures (ATCM's) to further restrict the amount of diesel particulate matter released into the air. These ATCM's are codified in the California Code of Regulations. (https://ww2.arb.ca.gov/resources/documents/airborne-toxic-control-measures)

The new emission standards have been successful, achieving a 68% reduction in diesel particulate matter in 2012, as compared to 1990. (The most recent data available, which can be found here: https://ww2.arb.ca.gov/resources/overview-diesel-exhaust-and-health).

For detailed information about agricultural diesel engines and air quality, see http://www.arb.ca.gov/diesel/ag/agengine.htm.

The CARB Diesel Risk Reduction Plan is at http://www.arb.ca.gov/diesel/documents/rrpapp.htm.

BOX 16-L COST-SHARE PROGRAMS TO IMPROVE AIR QUALITY AND/OR MITIGATE CLIMATE CHANGE

Detailed below are select programs by the US Department of Agriculture Natural Resources Conservation Service (NRCS) and others which provide the winegrowing community with cost-share incentives for improving technology or practices to reduce air emissions of criteria pollutants and/or greenhouse gases. For a complete list, visit the CSWA website at: add URL.

NRCS Environmental Quality Incentives Program (EQIP) – National Air Quality Initiative

- A program administered by NRCS that provides cost-share incentives and technical assistance for qualified growers in non-attainment areas for $PM_{2.5}$, PM_{10}, and/or ozone
- Diesel Engine Replacement – to reduce pollutants and greenhouse gases from diesel irrigation engines by replacing older engines with certified cleaner-burning diesel engines, electric motors, or natural gas or propane fueled engines
- Unpaved Roads and Equipment Areas – to reduce $PM_{2.5}$ and PM_{10} pollutants by implementing dust control technologies
- Chipping Removed Vineyards – to reduce pollutants and greenhouse gases by chipping instead of burning removed vines
- Planting Cover Crops – to reduce $PM_{2.5}$ and PM_{10} pollutants by dust mitigation
- Use of Integrated Pest Management – to reduce pollutants and greenhouse gases by mitigation of dust and combustion
- Implementation of Nutrient Management Plans – to reduce pollutants and greenhouse gases by reduced combustion and efficient nitrogen use
- Disposing Chemically Treated Stakes and End-Posts – to prevent toxic dust emissions by disposal at appropriate landfills instead of burning
- Developing Conservation Activity Plans (CAPs) for Comprehensive Air Quality Management or Energy Management
- Updated information about these and other practices and technologies eligible for cost-share incentives and application procedures are at https://www.nrcs.usda.gov/wps/portal/nrcs/main/ca/programs/

Carl Moyer Program

- A statewide grants program administered by local air districts to retrofit or replace diesel engines for heavy-duty vehicles and equipment (e.g., off-road heavy-duty vehicles, irrigation pumps) with lower-emission technology
- More information is at https://ww2.arb.ca.gov/our-work/programs/carl-moyer-memorial-air-quality-standards-attainment-program.

16-5 Pest Management Strategy

Vineyard

Category 4	Category 3	Category 2	Category 1
There was knowledge about how pest management practices affect air quality and climate change ***And*** A cost-effective strategy was implemented that reduced emissions from soil disturbance, fuel use, and pesticides while maintaining pests at tolerable levels ***And*** The strategy first relied on biological and cultural tactics that minimize equipment passes and pesticide inputs ***And*** Decisions for pesticide applications were based on economic thresholds and/or weather model decision tools ***And*** Weed and floor management practices mitigated dust and PM_{10}.	There was knowledge about how pest management practices affect air quality and climate change ***And*** A cost-effective strategy was implemented that reduced emissions from soil disturbance, fuel use, and pesticides while maintaining pests at tolerable levels ***And*** The strategy first relied on biological and cultural tactics that minimize equipment passes and pesticide inputs.	There was awareness of how pest management practices affect air quality and climate change ***And*** A strategy was being developed to reduce emissions from pest management operations while maintaining pests at tolerable levels.	The relationship between pest management practices and air quality and climate change was not known.

16-6 Pesticide Stewardship *Vineyard*

Category 4	Category 3	Category 2	Category 1
Recommended practices were followed to minimize PM_{10} and drift* from dust (e.g., sulfur) and liquid applications ***And*** Pesticides associated with higher VOC emissions were known or determined and avoided for use (see **Box 16-M**) ***And*** Applicators were trained about pesticide issues relevant to air quality.	Recommended practices were followed to minimize PM_{10} and drift* from dust (e.g., sulfur) and liquid applications ***And*** There was some understanding of pesticide products associated with higher VOC emissions (see **Box 16-M**).	Recommended practices were followed to minimize PM_{10} and drift* from dust (e.g., sulfur) and liquid applications.	Pesticides were chosen and applied without considering impacts to air quality other than following legal requirements.

*Recommended practices to avoid pesticide drift and PM_{10} are detailed in **Criteria 6-28** and **6-29** and associated educational boxes in **Chapter 6 Pest Management**. Additional sources of information about pesticide drift, spray particle size, and mitigative practices are at https://www.curesworks.org/best-management-practices/.

The use of electrostatic sprayers can allow for less use of products and better on-target deposition – both potentially leading to less offsite movement (drift, etc.). To evaluate the economic costs and returns of electrostatic sprayers vs. air blast sprayers, see the **CSWA Sprayer Decision Tool – Air Blast vs. Electrostatic Sprayers** available from the CSWA Resources Library at: https://library.sustainablewinegrowing.org/.

BOX 16-M VOLATILE ORGANIC COMPOUNDS (VOCS) AND PESTICIDES

Many pesticide active and inert ingredients are sources of VOCs, which can react with nitrogen oxides (NOx) and sunlight to form ground-level ozone. Emissions data from the San Joaquin Valley in 2006 list agricultural pesticides as the sixth highest contributor to VOCs (5%), following passenger vehicles (14%), other (13%; waste disposal/composting), livestock waste (9%), oil and gas production (6%), and consumer products (5%). Because ozone concentrations exceed federal and state standards in some air basins, State Implementation Plans include elements to reduce VOC emissions from pesticides in non-attainment areas. In addition, the California Department of Pesticide Regulation (DPR) began adopting regulations in 2008 restricting uses and enforcing new reporting requirements for fumigants (highest in VOCs) in VOC non-attainment areas. Regulations include limiting fumigant applications occurring May 1 to October 1 in the San Joaquin Valley to specific methods (https://www.cdpr.ca.gov/docs/emon/vocs/vocproj/newreg.htm). Regulations imposing sales and use restrictions for high-VOC, non-fumigant pesticides began in 2013. These include the requirement that grape and other growers must obtain written recommendation from a licensed pest control adviser for use of high-VOC products containing abamectin, chlorpyrifos, gibberellins, or oxyfluorfen between May 1 and October 31 in the San Joaquin Valley (https://www.cdpr.ca.gov/docs/emon/vocs/vocproj/reduce_nonfumigant.htm).

In cooperation with the California Air Resources Board, DPR determines and maintains pesticide VOC emission inventories using estimates of product-specific emission potentials (EPs) and pesticide use report data. The EP is that fraction of the product assumed to potentially contribute to atmospheric VOCs.

Potential VOC emission (pounds) = pounds pesticide product applied x EP

Understanding the relationship of estimated laboratory EPs to field emission rates and subsequent ozone formation is evolving. However, growers should keep abreast of current understandings and limit use of pesticides with higher estimated EPs, especially fumigants (also directly toxic) and emulsifiable concentrates. Additional information and pesticide VOC calculators are at https://apps.cdpr.ca.gov/voc-calculator/.

16-7 Agricultural and Winery Chemicals and Materials (excluding pesticides)			*Vineyard & Winery*
Category 4	**Category 3**	**Category 2**	**Category 1**
There was knowledge about how chemicals and materials used in the vineyard and/or winery affect air quality ***And*** A strategy was implemented for chemical acquisition and use that included considerations of VOC potential, air toxicity, potential for ozone depletion* ***And*** The strategy included the purchase and use of only materials with both low potential to emit VOCs and low toxicity ***And*** Proven or suspected ozone depleting materials were not used ***And*** Employees were trained about relevant air quality issues, and safe storage, use, and cleanup procedures.	There was knowledge about how chemicals and materials used in the vineyard and/or winery affect air quality ***And*** A strategy was implemented for chemical acquisition and use that included considerations of VOC potential, air toxicity, potential for ozone depletion* ***And*** The strategy included the preferential purchase and use of materials with both low potential to emit VOCs and low toxicity ***And*** Proven or suspected ozone depleting materials were being eliminated from use.	There was awareness of how chemicals and materials used in the vineyard and/or winery affect air quality ***And*** A strategy was being developed for chemical acquisition and use that included VOC potential, air toxicity, potential for ozone depletion*	The relationship between chemicals and materials used in the vineyard and/or winery and air quality was not known.
*See **Chapter 11 Material Handling** for more details.			

16-8 Transportation

Vineyard & Winery

Category 4	Category 3	Category 2	Category 1
There was knowledge about links between miles traveled, air quality, and climate change ***And*** The miles traveled, fuel use, or greenhouse gas emissions by the vineyard and/or winery operations' trucks each year were tracked ***And*** A strategy was implemented for over one year to minimize the miles traveled to and from the facility (e.g., consolidating deliveries, video conferencing/virtual meetings, carpooling) and to reduce engine idling time each year ***And*** Employees were trained to reduce emissions from travel ***And*** Employees utilize commute alternatives or credits were purchased to offset emissions.	There was knowledge about links between miles traveled, air quality, and climate change ***And*** The miles traveled, fuel use, or greenhouse gas emissions by the vineyard and/or winery operations' trucks each year were known ***And*** A strategy was developed to minimize the miles traveled to and from the facility (e.g., consolidating deliveries, video conferencing/virtual meetings, carpooling) and to reduce engine idling time each year ***And*** Employee training to reduce emissions from travel was provided.	There was awareness about links between miles traveled, air quality, and climate change ***And*** There was a general idea of the miles traveled by the vineyard and/or winery operations' trucks each year ***And*** A strategy was being developed to minimize the miles traveled to and from the facility each year.	The relationship between miles traveled, air quality, and climate change was not known ***And*** The miles traveled by the vineyard and/or winery operations' trucks each year was not known.

16-9 Agricultural Burning *Vineyard*

Category 4	Category 3	Category 2	Category 1
No burning was done in the vineyard ***And*** Vineyard prunings and diseased vines were managed to minimize air quality issues (such as by being chipped, ground, and either composted and utilized in the vineyard or sent for biomass processing or use elsewhere).	Vineyard prunings (but not diseased vines) were managed to minimize air quality issues (such as by being chipped, ground, and either composted and utilized in the vineyard or sent for biomass processing or use elsewhere) ***And*** Only diseased vines were burned ***And*** All burning was done under the supervision of a trained vineyard manager.	Only vineyard prunings, diseased vines, and/or weeds were burned ***And*** All burning was done under the supervision of a trained vineyard manager ***And*** Alternatives to burning were being investigated and tested.	Various flammable materials were burned following legal requirements* ***And*** Field workers were allowed to supervise the burning.

*Legal requirements for open-field burning include the need to obtain a burn permit and burn authorization from the regional or county air district. Never burn chemically treated wood (see **Box 16-N**). The California Health and Safety Code requires the San Joaquin Valley Unified Air Pollution Control District to prohibit the burning of many categories of agricultural waste, including vineyard prunings (http://www.valleyair.org/burnprograms/Ag_Burning.htm). Check with your air district and Agricultural Commissioner's office for additional and specific requirements and restrictions.

BOX 16-N REMOVAL AND DESTRUCTION OF CHEMICALLY TREATED WOOD

Because of the significant public health risk determined by the California Department of Toxic Substances Control, stakes and end-posts treated with the preservative chromated copper arsenate cannot be burned or chipped. Chromated copper arsenate is regulated as a toxic substance and burning or chipping releases toxic dust. Chemically treated wood must be extracted prior to waste piling and hauled to and disposed of at certified Class II or specified Class III composite-lined landfills. After inspection by regional or county air district personnel, remaining vineyard waste may be piled and burned according to legal requirements, chipped and utilized in the vineyard, or processed as an energy source.

A compliance assistance bulletin for vineyard removal for the San Joaquin Valley is at http://www.valleyair.org/BurnPrograms/Ag_burning.htm.

16-10 Winery Refrigerants

Winery

Category 4	Category 3	Category 2	Category 1
The type, amount, and global warming potential (GWP)* of the current refrigerant(s) were known ***And*** The amount of refrigerant(s) was monitored and tracked ***And*** Results of the refrigeration audit were used to make efficiency improvements were made to the refrigeration system ***And*** Information on refrigerants and impacts on human health and the environment was used in employee training ***And*** Refrigerant leak inspections were performed weekly, or there was an automatic leak detection system.	The type, amount, and global warming potential (GWP)* of the current refrigerant(s) were known ***And*** The amount of refrigerant(s) was monitored ***And*** Results of the refrigeration audit were considered ***And*** Information on refrigerants, leaks, and impacts on human health and the environment was available to employees ***And*** Refrigerant leak inspections were performed monthly.	The type, amount, and the global warming potential (GWP)* of the current refrigerant(s) were known ***And*** An audit of the refrigeration system was completed.	The type, amount, and global warming potential (GWP)* of the current refrigerant(s) were unknown ***And*** The refrigeration system was operated and maintained much as it has been since installation. ***And*** If applicable, regulatory requirements for the refrigeration system were met.**

* Determine details about refrigerants from the refrigeration service company, or visit the Air Resources Board website for a list of refrigerant's global warming potential at: https://ww2.arb.ca.gov/resources/documents/high-gwp-refrigerants

**Any facility with a refrigeration system with over 50 pounds of high-GWP (global warming potential) refrigerant has to register and participate in the California Air Resources Board's Refrigeration Management Program (RMP). To learn more about requirements based on size of the refrigeration system visit: https://ww2.arb.ca.gov/our-work/programs/refrigerant-management-program/rmp-businesses-refrigeration-systems

BOX 16-O TIPS FOR IMPROVING AIR QUALITY

You Can Help Keep the Air Cleaner!

Every day tips:

- Conserve electricity. Consider setting your thermostat a little higher in the summer and lower in winter. Participate in local energy conservation programs. Look for the ENERGY STAR label when buying home or office equipment.
- Keep car, boat, and other engines properly tuned, and avoid engines that smoke.
- Carpool, use public transportation, bike, or walk when possible.
- Combine errands to reduce "cold starts" of your car and avoid extended idling.
- Consider using gas logs instead of wood. If you use a wood-burning stove or fireplace insert, make sure it meets EPA design specifications. Burn only dry, seasoned wood.
- Mulch or compost leaves and yard waste.

Tips for days when particle pollution is expected to be high:

- Reduce the number of trips you take in your car.
- Reduce or eliminate fireplace and wood stove use.
- Avoid using gas-powered lawn and garden equipment.
- Avoid burning leaves and other materials.

For your local forecast visit EPA's Website at: https://airnow.gov/

Source: Office of Air and Radiation (6301A), EPA 452/F-03-002 ().

Efficiency improvements to the refrigeration system can include insulating glycol lines.

For additional air quality resources visit:
http://www.sustainablewinegrowing.org/webresources.php.