San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

2009 Area Source Emissions Inventory Methodology
420 – FOOD AND AGRICULTURE – BREWERIES

I. Purpose

This document describes the Area Source Methodology used to estimate fugitive emissions of ethanol (ethyl alcohol), a volatile organic compound (VOC), from the brewing of beer (malt beverages) in the San Joaquin Valley Air Basin. An area source category is a collection of similar emission units within a geographic area (i.e., a County). An area source category collectively represents individual sources that are small and numerous, and that may not have been inventoried as specific point, mobile, or biogenic sources. The California Air Resources Board (CARB) has grouped these individual sources with other like sources into area source categories. These source categories are grouped in such a way that they can be estimated collectively using one methodology.

II. Applicability

The emission calculations from this Area Source Methodology apply to facilities that are identified by the following Category of Emission Source (CES) code and Reconciliation Emission Inventory Code (REIC):

Table 1. Emission inventory codes.

CES	REIC	Description
89763	420-414-6000-0000	Breweries

III. Point Source Reconciliation

Emissions from the area source inventory and point source inventory are reconciled against each other to prevent double counting. This is done using relationships created by the California Air Resources Board (CARB) between the area source REIC and the point sources' Standard Industry Classification (SIC) code and emissions process Source Category Code (SCC) combinations. The area source in this methodology is not represented within our point source inventory; therefore, reconciliation is not necessary.

IV. Methodology Description

Ethanol is the primary volatile organic compound (VOC) emitted during the production of malt beverages. This methodology estimates fugitive emissions of ethanol during the brewing of beer and the production of flavored malt beverages in the San Joaquin Valley Air Pollution Control District (SJVAPCD).

The production of malt beverages, or beer, is comprised of four main stages: brewhouse operations, fermentation, aging or secondary fermentation, and packaging. VOC may be emitted during each of these stages from sources such as mash tuns, cereal cookers, lauter tuns or strainmasters, brew kettles, hot wort settling tanks, yeast storage and propagation, fermenters, spent grain holding tanks, activated charcoal regeneration systems (at breweries with CO_2 recovery), aging tanks (sometimes referred to as "ruh" storage tanks), other storage tanks, and packaging operations (refer to Appendix A for definitions of brewing terms, and Appendix B for a more detailed discussion of the brewing process).

For this emissions estimate, a survey was conducted to determine the amount of beer and flavored malt beverage (FMB) produced in the District. Breweries were identified as facilities having “Non-Retail Type 01 Beer Manufacturer -(large brewery)“, “Non-Retail Type 23 Small Beer Manufacturer (Brew Pub or Micro-brewery)“, and “Retail On-sale General Brew-Pub Type 75 Brewpub-restaurant” licenses in the California Department of Alcoholic Beverage Control (ABC) licensing database. California Beer Manufacturer Type 01 license (over 60,000 barrels per year) and Small Beer Manufacturer Type 23 license have the same privileges and limitations because there is no legislative distinction other than the license fee. The most common users of a Type 23 license are operators of micro-breweries and brewpubs. A micro-brewery is a small-scale brewery operation that produces approximately 15,000 barrels a year (California Department of Alcoholic Beverage Control. Specific License Types: Definitions, Privileges and Limitations. January 2002) In the survey, breweries were asked to report the quantity of beer and flavored malt beverage (FMB) produced in 2009. The volumes of beer and FMB reported produced in the District were multiplied by emission factors to estimate emissions.

V. Activity Data

Brewers, who produce 5,000 barrels or more per year *or* bottle or keg beer, are required to file a Brewer’s Report of Operations (form 5130.9) with the TTB monthly if their annual production is greater than 10,000 barrels or quarterly if production is less than 10,000 barrels. Brewers, who produce less than 5,000 barrels per year *and* do not bottle or keg beer, are required to file a Brewpub’s Report of Operations (form 5130.26) quarterly with the TTB. An inventory must be taken at least once per month within 7 days of the end of the month and show the date, quantity, losses, gains, and shortages. All entries are in barrels except material used. Since the amount of federal excise tax a brewer pays is tied in with the amount of beer that

they produce. TTB is restricted by statute from disclosing information that could be used to determine an individual brewers tax liability. Therefore, the TTB could not provide county level production data since it is considered confidential.

Facilities located within the District with an active "01- Beer Manufacturer (large brewery)", "23- Small Beer Manufacturer", and "75- on sale general - brewpub" license issued by the California Department of Alcoholic Beverage Control (ABC) were surveyed to determine the quantity (barrels) of beer and flavored malt beverage (FMB) produced in 2009. A copy of the survey is included in Appendix A. Of the 30 facilities surveyed, 22 facilities responded. All large breweries responded, and 73.91% of small breweries responded. Non-respondent small breweries were assumed to produce the average of respondents. The results of the survey are summarized in the following table:

Table 2. Barrels of malt beverages produced in the San Joaquin Valley Air Pollution Control District in 2009.

2009 Brewery Production	Barrels
Malt beverages	102,044

VI. Emission Factors

Brewery emission factors were taken from AP-42 Section 9.12.1.2 *Malt Beverages* (EPA, 1996). Large breweries are defined as breweries producing more than 60,000 barrels per year, and small breweries are defined as breweries producing less than 60,000 barrels per year (one barrel equals 31 gallons).

Table 3. Emission factors for malt beverages (breweries).

Emission Process	Emission Factor	Source
Large breweries > 60,000 bbl/yr Brewing beer (malt beverages)	4.1679 lbs VOC/1,000 barrels	AP-42 Emission Factor Documentation Section 9.12.1 Malt Beverages Table 4.3 Large Breweries (10/1996)
Small breweries < 60,000 bbl/yr Brewing beer (malt beverages)	56.743 lbs VOC/1,000 barrels	AP-42 Emission Factor Documentation Section 9.12.1 Malt Beverages Table 4.2 Small Breweries (10/1996)

VII. Emissions Calculations

VOC emissions from brewing can be calculated using the following equation:

$$VOC\ Emissions = \left(\frac{barrels\ produced}{year}\right) \times \left(\frac{lbs\ VOC\ emitted}{1{,}000\ barrels}\right) \times \left(\frac{1\ ton}{2{,}000\ lbs}\right)$$

Example 1. Large Brewery

Given:

1. A large brewery produces 1,000,000 barrels per year.
2. The emission factor for large breweries is 4.1679 lbs VOC/1,000 barrels produced.

Calculate Emissions:

$$VOC\ Emissions = \left(\frac{1{,}000{,}000\ barrels}{year}\right) \times \left(\frac{4.1679\ lbs\ VOC}{1{,}000\ barrels}\right) \times \left(\frac{1\ ton}{2{,}000\ lbs}\right) = \frac{2.084\ tons\ of\ VOC}{year}$$

Example 2. Small Brewery

Given:

1. A small brewery produces 59,999 barrels per year.
2. The emission factor for small breweries in 56.743 lbs VOC/1,000 barrels produced.

Calculate Emissions:

$$VOC\ Emissions = \left(\frac{59{,}999\ barrels}{year}\right) \times \left(\frac{56.743\ lbs\ VOC}{1{,}000\ barrels}\right) \times \left(\frac{1\ ton}{2{,}000\ lbs}\right) = \frac{1.702\ tons\ of\ VOC}{year}$$

VIII. Temporal Variation

We assume the rate of ethanol evaporation and emissions activity is uniform throughout the year.

A. Daily

CARB Code 24. 24 hours per day - uniform activity during the day.

B. Weekly

CARB Code 7. 7 days per week - uniform activity every day of the week.

C. Monthly

Uniform monthly activity.

IX. Spatial Variation

Breweries are located in Fresno, Kern, Merced, San Joaquin, Stanislaus, and Tulare counties.

X. Growth Factor

Growth factors are developed by either the District's Strategies and Incentives Department or CARB for each EIC. These factors are used to estimate emissions in future years. The growth factors associated with this emissions category may be obtained from the District's Strategies and Incentives Department.

XI. Control Level

Control levels are developed by either the District's Strategies and Incentives Department or CARB for each EIC. Control levels are used to estimate emissions reductions in future years due to implementation of District rules. These control levels take into account the effect of control technology, compliance and exemptions at full implementation of the rules.

Control levels associated with this emissions category may be obtained from the District's Strategies and Incentives Department.

XII. CARB Chemical Speciation

CARB has developed organic gas profiles in order to calculate reactive organic gasses (ROG), volatile organic compounds (VOC) or total organic gas (TOG) given any one of the three values. For each speciation profile, the fraction of TOG that is ROG and VOC is given. The organic gas profile codes can also be used to lookup associated toxics. CARB's speciation profile for fermentation is presented in the following table:

Table 4. CARB organic gas speciation profile for 420-414-6000-0000.

Profile Description	CARB Organic Gas Profile#	Fractions	
		ROG	VOC
Fermentation - Ethanol	211	1	1

XIII. Assessment Of Methodology

The accuracy of this methodology depends upon the following:

- Annual production (throughput) based on surveys.
- The District assumed an annual production of 468 barrels for the small breweries (California ABC license Type 23, less than 60,000 barrels per year

and Type 75 license) that did not return their survey. This average production is based on the small brewery surveys received by the District.

- AP-42 emission factors are accurate and represent brewing operations in the SJVAPCD.

XIV. Emissions

Following is the 2009 area source emissions inventory for REIC 420-414-6000-0000 estimated by this methodology.

Table 5. Area source emissions for REIC 420-414-6000-0000 (2009).

District	Emissions (tons/year)					
	NOx	CO	SOx	VOC(1)	PM_{10}	$PM_{2.5}$
Fresno	-	-	-	0.01	-	-
Kern	-	-	-	0.06	-	-
Kings	-	-	-	0.00	-	-
Madera	-	-	-	0.00	-	-
Merced	-	-	-	0.02	-	-
San Joaquin	-	-	-	0.08	-	-
Stanislaus	-	-	-	0.29	-	-
Tulare	-	-	-	0.02	-	-
TOTAL	-	-	-	0.48	-	-

(1) The District only reports ROG to CARB. As noted in Section XII, ROG is the same as VOC.

Following is the net change in total unreconciled emissions between this update (2009 inventory year) and the previous inventory year (2008) for REIC 420-414-6000-0000.

Table 6. Net emissions change for REIC 420-420-6000-0000 (2009 – 2008).

County	Emissions (tons/year)					
	NOx	CO	SOx	VOC(1)	PM_{10}	$PM_{2.5}$(2)
Fresno	-	-	-	0.01	-	-
Kern	-	-	-	0.06	-	-
Kings	-	-	-	0.00	-	-
Madera	-	-	-	0.00	-	-
Merced	-	-	-	0.02	-	-
San Joaquin	-	-	-	0.08	-	-
Stanislaus	-	-	-	0.29	-	-
Tulare	-	-	-	0.02	-	-
TOTAL	-	-	-	0.48	-	-

(1) The District only reports ROG to CARB. As noted in Section XII, ROG is the same as VOC.

XV. Revision History

2009 This is a new District methodology based on a survey of California Department of Alcoholic Beverage Control (ABC) licensed breweries located within the District.

XVI. Update Schedule

In an effort to provide inventory information to CARB and other District programs and maximize limited resources, the District has developed an update cycle based on emissions within the source category as shown in the following table:

Table 7. Area source update frequency criteria.

Total Emissions (tons/day)	Update Cycle (years)
<=1	4
>1 and <= 2.5	3
>2.5 and <=5	2
>5	1

Since ethanol (VOC) emissions are less than 1 tons per day, this area source estimate will be updated every four years.

XVII. References

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XVII. Appendices

Appendix A. Terms and Definitions

Appendix B. Brewing Process

Appendix C. District Brewery Survey

Appendix A. Terms and Definitions

Beer: "Beer, ale, porter, stout, and other similar fermented beverages (including saké and similar products) of any name or description containing one-half of one percent or more of alcohol by volume, brewed or produced from malt, wholly or in part, or from any substitute for malt." (27 CFR part 25 § 25.11 Meaning of Terms)

Brewing: The production of beer for sale (27 CFR part 25 subpart B §25.11).

Brew kettle: The vessel in which wort from the mash is boiled with hops.

Decoction: A method of boiling portions of the mixture (mash) and adding the boiling portions to the mash tun to raise the overall temperature to about 75°C (167°F).

Double mashing: To use grains other than barley (typically corn and rice) as starch adjuncts. Some plants use additives such as corn syrup that function as adjunct grains. The malt and adjuncts are then mixed and heated in the mash tun.

Flavored Malt Beverages: These products differ from traditional malt beverages and beer in several respects. Flavored malt beverages exhibit little or no traditional beer or malt beverage character. Their flavor is derived primarily from added flavors rather than from malt and other materials used in fermentation. Flavored malt beverages are marketed in traditional beer-type bottles and cans, and their alcohol content is similar to most traditional malt beverages—in the 4 to 6% alcohol by volume range. (27 CFR Parts 7 and 25 - beer)

Hops: The flower cones of a climbing plant related to hemp that gives beer much of its bitterness and aroma. Only the females produce the flower cones used in brewing. Once harvested, those flower cones are called hops, so the term "hop" can really refer to both the plant and the flower depending on the context.

Infusion process: Mixing of the malt with hot water to maintain a uniform temperature until starch conversion is complete.

Lauter: Rinse or extract the converted sugars from the grain. Also known as sparging. Lautering is a process in brewing beer in which the mash is separated into the clear liquid wort and the residual grain.

Lauter tun: A large vessel fitted with a false slotted bottom and a drain spigot in which the mash is allowed to settle and the sweet wort is removed from the grains through a straining process. In smaller breweries and in the infusion system, the mash tun is used for both mashing and lautering.

Malt Beverage: **"**A beverage made by the alcoholic fermentation of an infusion or decoction, or combination of both, in potable brewing water, of malted barley with hops, or their parts, or their products, and with or without other malted cereals, and with or without the addition of unmalted or prepared cereals, other carbohydrates or

products prepared therefrom, and with or without the addition of carbon dioxide, and with or without other wholesome products suitable for human food consumption." (CFR 27 Part 7 Subpart B § 7.10 Meaning of Terms)**.** Beer is a type of malt beverage.

Mash: Crushed malt or meal of grain mixed with hot water to form wort

Mash/Lauter Tun: A vessel used to mash (convert starches to sugars) and lauter (rinse or extract the sugars from the grain). In smaller breweries and in the infusion system, the mash tun is used for both mashing and lautering.

Mashout: The term for raising the temperature of the mash to 170°F (77°C). This both stops the enzymatic conversion of starches to fermentable sugars, and makes the mash and wort more fluid.

Mash tun: A brewing vessel designed to hold a mash at a constant or increasing temperature.

Wort: The bittersweet sugar solution obtained by mashing, ie, a liquid, produced from malt and hot water, which can be fermented to make beer.

APPENDIX B. Brewing Process

Large Breweries:

The production of malt beverages, or beer, is comprised of four main stages: brewhouse operations, fermentation, aging or secondary fermentation, and packaging. Breweries typically purchase malted grain (malt) from malting operations. Malt provides the starch-splitting and protein-splitting enzymes that are necessary to convert grain starches into fermentable sugars. The malt (malted grain), along with hot water, is fed to the mash tun and heated to convert grain starches to fermentable sugars. Most breweries use one of three principal mashing processes. These are double mashing, decoction, and infusion. The finished product of mashing is a grain slurry, called mash. From the mash tun, the mash is pumped to a straining tank called a lauter tun, which separates insoluble grain residues from the mash. The product of the lauter tun is called wort.

The strained wort from the lauter tun is transferred to the brew kettle and is boiled, typically for about 90 to 120 minutes. Boiling stops the starch-to-sugar conversion, sterilizes the wort, precipitates hydrolyzed proteins, concentrates the wort by evaporating excess water, and facilitates chemical changes that affect beer flavor. Hops are added to the wort during the boiling process.

After brewing, the hops are strained from the hot wort, and the hot wort is pumped to a large settling tank, where it is held to allow the remaining insoluble material (trub) to settle. After settling, the hot wort is pumped to a cooling system, which cools the liquid to temperatures ranging from about 7° to 12°C (44° to 54°F). Following cooling, yeast is added to the cooled wort as it is pumped to the fermenters. Fermentation, a biological process in which yeast converts sugars into ethyl alcohol (ethanol), carbon dioxide (CO_2), and water, takes place in large tanks (fermenters).

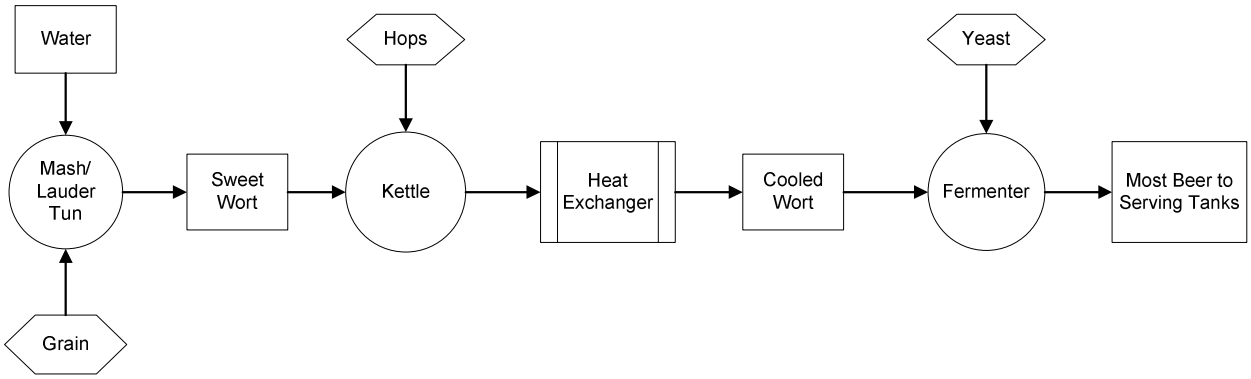
After primary fermentation, waste yeast is typically removed from the liquid and the liquid proceeds to a secondary fermentation or aging process. After the beer is aged, solids are typically removed by centrifugation or filtration and the beer is pumped to final storage (beer storage tanks). From final storage, the beer is pumped to the packaging (canning and bottling) facility.

Microbreweries:

Microbreweries typically produce beer for on-site consumption, although some have limited local keg distribution. The beer production process is similar to that of large breweries, although several processes may be excluded or combined. Most microbreweries purchase bags of either malted barley or malt flour for use in beer making. Malt flour requires no processing and is added directly to the mash tun. The facilities that use malted barley typically have a small "cracker" that cracks the grain prior to mashing. Brew house operations (mashing, brewers grain settling, brewing, and trub settling) may be combined to decrease the number of tanks required. Fermentation tanks and storage tanks are much smaller than large brewery tanks,

with capacities as small as a few barrels. Many microbrews are held in fermentation tanks for three to four weeks (far longer than most mass-produced beers). Canning and bottling operations typically are not found in microbreweries. (AP-42 Section 19.12.1).

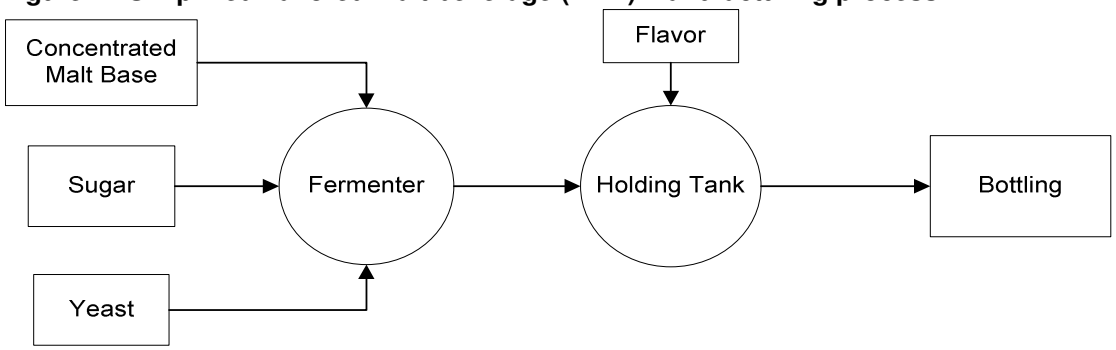
Figure 1. Simplified brewpub (microbrewery) manufacturing process.



Flavored Malt Beverages (FMB)

According to the U. S. Department of the Treasury Alcohol and Tobacco Tax and Trade Bureau (TTB), a*lthough flavored malt beverages are produced at breweries, their method of production differs significantly from the production of other malt beverages and beer. In producing flavored malt beverages, brewers brew a fermented base of beer from malt and other brewing materials. Brewers then treat this base using a variety of processes in order to remove malt beverage character from the base. While the alcohol content of flavored malt beverages is similar to that of most traditional malt beverages, the alcohol in many of them is derived primarily from the distilled spirits component of the added flavors rather than from fermentation."* (70 Fed. Reg. 194 et seq., January 3, 2005)

Figure 2. Simplified flavored malt beverage (FMB) manufacturing process.



Appendix C. District Brewery Survey

San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

Brewery Survey for the 2009 Calendar Year
Beer and Flavored Malt Beverages (FMB)

The District is required by the State of California to periodically update our inventory of area-wide emissions. This inventory is vital to ensure that future air pollution control plans and rules reflect actual emissions and do not overestimate industrial emissions. We would appreciate your assistance in updating our inventory of emissions from brewery operations by completing the survey below and returning it to the District's Central Region office before **February 28, 2010**. If you have any questions, please call Georgia Stewart at (559) 230-5937.

1. What was your 2009 production? (a) Beer _____ Units: _____

   (b) Flavored Malt Beverages _____ Units: _____

2. High proof distilled spirits used for blending or fortifying alcoholic beverages stored in tanks that are **not** under District permit:

   (a) Number of tanks _____

   (b) Aggregate capacity _____

   (c) Annual throughput _____

3. Is heat used in the manufacturing process? (Circle) **YES** (go to #4) **NO** (go to #5)

4. What is the rating/size of the boiler (BTU)? _____

   a) Hours of operation per year _____ **OR**

   b) Hours per day _____ Days per week _____ Weeks per year _____

5. What is your percent (%) of production by season?

   Winter (Jan-March) _____ Spring (April-June) _____ Summer (July-Sept) _____ Fall (Oct-Dec) _____

6. Contact Information: Facility: _____

   Address: _____

   Contact person: _____

   Telephone: _____ FAX _____

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