

Chapter 13. Livestock Husbandry

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13.1 Emission Estimation Methodology

This section was adapted from Section 7.6 of CARB's Emission Inventory Methodology. Section 7.6 was last updated in May 2004.

AP-42 does not address livestock husbandry. Thus, the methodology adopted by the California Air Resources Board (CARB) is presented here as the primary emissions estimation methodology for this fugitive dust source category.¹ The CARB methodology only provides estimates of PM10 emissions from cattle feedlot and dairy operations. For each category, the emissions are calculated by multiplying a per animal emission factor by the population of each animal type. The livestock population is available from the US Department of Agriculture. Livestock emissions research is ongoing.

CARB's PM10 emission factor for cattle feedlots is 28.9 lbs PM10/1000 head/day (i.e., 10.55 lb/head-year) based on a work performed by UC Davis.² The corresponding PM10 emission factor for dairy cattle is 6.72 lbs PM10/1000 head/day (i.e., 2.45 lb/head-year) based on an emission factor of 4.4 lbs PM10/1000 lactating head/day, developed by Texas A&M.³ To make the Texas emission factor more California specific, it was multiplied by a scaling factor based on the ratio of the California feedlot PM10 emission factor to a Texas feedlot PM10 emission factor. This ratio is 29:19; thus, the scaling factor is 1.53. The PM10/TSP and PM2.5/PM10 ratios for this source category are 0.48 and 0.11, respectively.

The CARB methodology is subject to the following assumptions:

1. Population data and residence time data adequately represent average animal population values for each county.
2. All animals within a single class produce the same emissions (e.g., dairy cows, calves, and heifers).
3. It is assumed that all dairies or feedlots produce the same PM10 emissions on a per-head basis.
4. For dairies, the baseline PM10 emission factor includes the effects of support stock such as calves and heifers. This is because the emissions testing included these animals within its analysis.
5. For feedlots, the baseline PM10 emission factor represents the population mix at a typical feedlot.
6. The method does not include emissions for animal waste composting or land application.
7. Due to insufficient temporal information, it is assumed that air emissions occur evenly throughout the year seven days a week and 24 hours a day.

The San Joaquin Valley APCD has developed separate emission factors for different operations associated with dairies and cattle feedlots based on CARB's PM10 emission factors of 2.45 lb/head-year for dairies and 10.55 lb/head-year for cattle feedlots.⁴ These emission factors are shown in Table 13-1.

Table 13-1. PM10 Emission Factors for Cattle Feedlot and Dairy Operations

Source Category	Operation	PM10 Emission Factor
Dairies	Corral/Manure Handling	1.845 lb/head-yr (freestall)
		4.6 lb/head-yr (open corral)
	Overall Management/Feeding	1.845 lb/head-yr (freestall)
		4.6 lb/head-yr (open corral)
	Unpaved Road	0.369 lb/head-yr
Unpaved Area	0.123 lb/head-yr	
Cattle Feedlots	Pens/Manure Handling	7.94 lb/head-yr
	Overall Management/Feeding	0.53 lb/head-yr
	Unpaved Road	1.59 lb/head-yr
	Unpaved Area	0.53 lb/head-yr

13.2 Demonstrated Control Techniques

CARB does not list any control measures for this fugitive dust source category. However, the San Joaquin Valley APCD (District) has been very proactive in identifying potential control measures for cattle feedlots and dairies. For example, fugitive dust emissions originating from the disturbance of dry and loose surface material (e.g., feed, bedding material, and manure) caused by animal movement and mechanical disturbances by vehicles can be controlled by sprinkling water on the surface of the open corral or pen, removing manure before it dries, using a layer of wood chips in dusty areas, housing dairy cattle in stalls with concrete floors rather than dirt floors, and adopting a feeding schedule when animals are less active. Wind blown fugitive dust originating from uncovered bulk materials can be controlled by applying water or chemical suppressants, covering the material with tarps or storing the material in enclosure, and erecting wind barriers. Since no data could be found in the literature on which to base a control efficiency factor for these practices, the District has conservatively assumed a minimal 10% control effectiveness. Control measures identified by the District for cattle feedlots and dairies are shown in Table 13-2. A list of control measures for cattle feedlots and dairies is available from the California Air Pollution Control Officers' Association's (CAPCOA) agricultural clearing house website (http://capcoa.org/ag_clearinghouse.htm).

Control measures for unpaved roads and unpaved parking/traffic areas include application of chemical dust suppressants, paving the surface or placing a layer of gravel over the unpaved surface, speed reduction, access restriction, and track out control measures. These control measures and their associated control efficiencies are listed in Chapter 6 of the handbook. Control measures for storage piles of bulk materials other than manure include dust suppressants, watering, covering and wind barriers. These control measures and their associated control efficiencies are listed in Chapter 9 of the handbook.

Table 13-2. Control Measures for Cattle Feedlots and Dairies^a

Source Category	Control Measure
Manure management	Frequent manure removal (every 6 months) with equipment that leaves an evenly corral surface of compacted manure on top of the soil.
	Insert the manure directly beneath the soil.
Dust entrainment by animal	Daily water sprinkling, and timing of watering around 6PM or before sunset.
	Use of freestalls with concrete surface for animal housing/feeding areas to allow frequent manure removal.
	Stocking density adjustment in accordance to the moisture found in the unit area to reduce dust.
	Removal of loose material on surface and maintain a compacted layer of manure 1 to 2 inches thick.
	Addition of fibrous material such as wood chips to working pens.
	Delaying the last daily feeding to reduce end-of-day spike in livestock activity.
Other	Adding moisture to hay
	Using a totally enclosed delivery system and covered feeders, and using palletized feed.
	Planting rows of vegetation around a building to create a barrier for air exiting from the building.

^a Since no data could be found in the literature on which to base a control efficiency factor for these practices, the SJVAPCD has conservatively assumed a minimal 10% control effectiveness for each control measure.

13.3 Regulatory Formats

Fugitive dust control options have been embedded in many regulations for state and local agencies in the WRAP region. However, most air quality districts currently exempt agricultural operations from controlling fugitive dust. Air quality districts that regulate fugitive dust emissions from agricultural operations include Clark County, NV and several districts in California such as the Imperial County APCD, the San Joaquin Valley APCD and the South Coast AQMD. Imperial County APCD prohibits fugitive dust emissions from farming activities for farms over 40 acres. The San Joaquin Valley APCD and the South Coast AQMD prohibit fugitive dust emissions for the larger farms defined as farms with areas where the combined disturbed surface area within one continuous property line and not separated by a paved public road is greater than 10 acres. SJVAPCD's Rule 4550 applies to animal feeding operations (AFOs) that house animals for a total of at least 45 days in any 12 month period for agricultural parcels exceeding 100 acres excluding the AFO. Example regulatory formats downloaded from the Internet for several local air quality agencies in the WRAP region are presented in Table 13-3. CAPCOA's agricultural clearing house website (http://capcoa.org/ag_clearinghouse.htm) provides links to rules of different air quality agencies that regulate fugitive dust emissions from agricultural operations. The website addresses for obtaining information on fugitive dust regulations for local air quality districts within California, for Clark County, NV, and for Maricopa County, AZ, are as follows:

- Districts within California: www.arb.ca.gov/drdb/drdb.htm
- San Joaquin Valley APCD, CA: valleyair.org/SJV_main.asp
- South Coast AQMD, CA: aqmd.gov/rules

- Clark County, NV: www.co.clark.nv.us/air_quality/regs.htm
- Maricopa County, AZ: www.maricopa.gov/aq

Table 13-3. Example Regulatory Formats for Cattle Feedlots and Dairies

Control Measure	Agency
Limit fugitive dust from animal feeding operations for facilities exceeding 100 acres excluding the AFO by requiring owner/operator to implement a Conservation Management Practice (CMP) Plan with district approved control methods.	SJVAPCD Rule 4550 5/20/04
Limit fugitive dust from off-field agricultural sources such as unpaved roads with more than 75 trips/day and bulk materials handling by requiring producers to draft and implement a Fugitive Dust Management Plan with district approved control methods.	SJVAPCD Rule 8081 9/16/04
Producers that voluntarily implement district approved conservation practices and complete and maintain the self-monitoring plan can maintain an exemption from the Rule 403 general requirements.	SCAQMD Rule 403 4/02/04
Cease tilling/mulching activities when wind speeds are greater than 25 mph.	SCAQMD Rule 403.1 4/02/04
Limit fugitive dust from paved and unpaved roads and livestock operations by ceasing all hay grinding activities between 2 and 5 PM if visible emissions extend more than 50 feet from a hay grinding source, and treating all unpaved access connections to livestock operations and unpaved feed lane access areas with either pavement, gravel (maintained to a depth of 4 inches), or asphaltic road-base.	SCAQMD Rule 1186 4/02/04
Reduce fugitive dust from livestock feed yards by requiring that the moisture content in the top three inches of manure piles for occupied pens be maintained between 20% and 40%. This rule also outlines manure management practices, including removal.	SCAQMD Rule 1186 4/02/04
Reduce fugitive dust from livestock feed yards by requiring that the moisture content for manure piles be maintained between 20% and 40%.	ICAPCD Rule 420 8/13/02

13.4 Compliance Tools

Compliance tools assure that the regulatory requirements, including application of dust controls, are being followed. Three major categories of compliance tools are discussed below.

Record keeping: A compliance plan is typically specified in local air quality rules and mandates record keeping of source operation and compliance activities by the source owner/operator. The plan includes a description of how a source proposes to comply with all applicable requirements, log sheets for daily dust control, and schedules for compliance activities and submittal of progress reports to the air quality agency. The purpose of a compliance plan is to provide a consistent reasonable process for documenting air quality violations, notifying alleged violators, and initiating enforcement action to ensure that violations are addressed in a timely and appropriate manner.

Site inspection: This activity includes (1) review of compliance records, (2) proximate inspections (sampling and analysis of source material), and (3) general observations. An inspector can use photography to document compliance with an air quality regulation.

On-site monitoring: EPA has stated that “An enforceable regulation must also contain test procedures in order to determine whether sources are in compliance.” Monitoring can include observation of visible plume opacity, surface testing for crust strength and moisture content, and other means for assuring that specified controls are in place.

Table 13-4 summarizes the compliance tools that are applicable for cattle feedlots and dairies.

Table 13-4. Compliance Tools for Cattle Feedlot and Dairies

Record keeping	Site inspection/monitoring
Maintain daily records to document the specific dust control options taken; maintain such records for a period of not less than three years; and make such records available to the APCO upon request. Submit a Conservation Management Practice (CMP) Plan to the APCO listing the selected CMPs for implementation, contact information for the owner/operator, a site plan or map of the site.	Observation of dust plumes and dust plume opacity (visible emissions) exceeding a standard; observation of high winds (e.g., >25 mph).

13.5 Sample Cost-Effectiveness Calculation

This section is intended to demonstrate how to select a cost-effective control measure for cattle feedlots and dairies. A sample cost-effectiveness calculation is presented below for cattle feedlots for a specific control measure (frequent scraping and manure removal) to illustrate the procedure. The sample calculation includes the entire series of steps for estimating uncontrolled emissions (with correction parameters and source extent), controlled emissions, emission reductions, control costs, and control cost-effectiveness values for PM10 and PM2.5. In selecting the most advantageous control measure for cattle feedlots and dairies, the same procedure is used to evaluate each candidate control measure (utilizing the control measure specific control efficiency and cost data), and the control measure with the most favorable cost-effectiveness and feasibility characteristics is identified.

Sample Calculation for Cattle Feedlots	
<u>Step 1. Determine source activity and control application parameters.</u>	
Number of cattle at the feedlot	1,000
Control Measure	Scraping and manure removal
Frequency of operations per year	2
Control Efficiency	10%
<p>Scraping and removal of manure from feedlot pens every six months has been chosen as the applied control measure. The number of cattle at the feedlot is an assumed value for illustrative purposes. Since no data could be found in the literature on which to base a control efficiency factor for control measures for cattle feedlots and dairies, the SJVAPCD has conservatively assumed a minimal 10% control effectiveness for each control measure (SVAPCD, 2004⁴).</p>	

Step 2. Obtain Uncontrolled PM10 Emission Factor.

The uncontrolled PM10 emission factor for cattle feedlots is 10.55 lb/head/year (CARB, 2004¹).

Step 3. Calculate Uncontrolled PM Emissions. The PM10 emission factor, EF, (given in Step 2) is multiplied by the number of cattle (see activity data) and then divided by 2,000 lb/ton to compute the annual PM10 emissions in tons per year, as follows:

$$\begin{aligned}\text{Annual PM10 emissions} &= (\text{EF} \times \text{Number of Cattle}) / 2,000 \\ \text{Annual PM10 Emissions} &= (10.55 \times 1,000) / 2,000 = 5.28 \text{ tons}\end{aligned}$$

$$\begin{aligned}\text{Annual PM2.5 emissions} &= (\text{PM2.5/PM10}) \times \text{PM10 emissions} \\ \text{where the PM2.5/PM10 ratio for cattle feedlots is } &0.11 \text{ (CARB, 2004}^1\text{)}.\end{aligned}$$

$$\begin{aligned}\text{Annual PM2.5 emissions} &= 0.11 \times \text{PM10 emissions} \\ \text{Annual PM2.5 Emissions} &= (0.11 \times 5.28 \text{ tons}) = 0.58 \text{ tons}\end{aligned}$$

Step 4. Calculate Controlled PM Emissions. The controlled PM emissions (i.e., the PM emissions remaining after control) are equal to the uncontrolled emissions (calculated above in Step 3) multiplied by the percentage that uncontrolled emissions are reduced, as follows:

$$\text{Controlled emissions} = \text{Uncontrolled emissions} \times (1 - \text{Control Efficiency})$$

For this example, we have selected frequent scraping and removal of manure as our control measure. Based on a control efficiency estimate of 10%, the annual controlled PM emissions are calculated to be:

$$\begin{aligned}\text{Annual Controlled PM10 emissions} &= (5.28 \text{ tons}) \times (1 - 0.10) = 4.75 \text{ tons} \\ \text{Annual Controlled PM2.5 emissions} &= (0.58 \text{ tons}) \times (1 - 0.10) = 0.52 \text{ tons}\end{aligned}$$

Step 5. Determine Annual Cost to Control PM Emissions.

The SJVAPCD assumes that the cost for scraping and removal of manure is \$3 per head.⁴ Thus, the annualized cost of scraping and removal of manure from feedlot pens holding 1,000 head of cattle every six months is calculated as follows:

$$\begin{aligned}\text{Annual Costs} &= \text{Cost per head to remove manure} \times \text{Head of Cattle} \times \text{Frequency of Ops/year} \\ \text{Annual Costs} &= \$3/\text{head} \times 1,000 \text{ head} \times 2/\text{year} = \$6,000\end{aligned}$$

Step 6. Calculate Cost-effectiveness. The cost-effectiveness is calculated by dividing the annual cost by the emissions reduction. The emissions reduction is determined by subtracting the controlled emissions from the uncontrolled emissions as follows:

$$\text{Cost-effectiveness} = \text{Annual Cost} / (\text{Uncontrolled emissions} - \text{Controlled emissions})$$

$$\begin{aligned}\text{Cost-effectiveness for PM10 emissions} &= \$6,000 / (5.28 - 4.75) = \$11,374/\text{ton} \\ \text{Cost-effectiveness for PM2.5 emissions} &= \$6,000 / (0.58 - 0.52) = \$103,404/\text{ton}\end{aligned}$$

Note: The actual cost-effectiveness values for this control measure are lower than the calculated values shown here since the SJVAPCD assumes that the control efficiency is at least 10%.

13.6 References

1. CARB, 2004. *Livestock Husbandry*, Section 7.6 of CARB's Emission Inventory Procedural Manual, Volume III: Methods for Assessing Area Source Emissions, May.
2. Flocchini, R.G., James, T.A., et. al., 2001. *Sources and Sinks of PM10 in the San Joaquin Valley*, Interim Report prepared by the Air Quality Group, Crocker Nuclear Laboratory, University of California, Davis. August 10.
3. Goodrich, L.B., Parnell, C.B., Mukhtar, S., Lacey, R.E., Shaw, B.W., 2002. *Preliminary PM10 Emission Factor for Freestall Dairies*, Department of Biological and Agricultural Engineering, Texas A&M University, paper presented at the 2002 ASAE Annual International Meeting, Chicago, IL, July 28-31.
4. SJVAPCD, 2005. *Emission Reduction Calculation Methodology for Dairies and Feedlot Conservation Management Practices*, Draft Report prepared by San Joaquin Valley APCD, November 24.