2000). By January 2000, the dairy produced almost twice as much electricity as was needed to supply the electric needs on the farm, approximately 5.5 kilowatt-hours per cow per day.

Haubenschild Farms is projected to yield $66,200 of total annual revenue in 2000 from generated electricity, based on the digester performance between January and June 2000. The projected annual revenue is expected to increase in 2001 as the herd size will be expanded to 1,000 cows (Nelson and Lamb, 2000). The cost to construct the 1,000-cow capacity digester was $355,000 ($355 per cow). Costs included construction of the manure collection, digester, and energy conversion. Therefore, construction and implementation of an anaerobic digester system at a dairy facility is considered to be beneficial, considering the increasing cost of electricity in California and the apparent correction of past operational problems with digesters.

Efficiency of Anaerobic and Aerobic Treatment Systems

All manure contains volatile solids (VS), which constitute the organic portion of the total solids. VS is defined as the organic fraction of total solids that will oxidize and convert into gas at 600 degrees Celsius. VS provides the food and energy source for certain bacteria to grow and reproduce, causing manure to decompose.[25] A wide variety of gaseous compounds are created and released into the environment at various stages of the decomposition process. When ~~100 percent of~~ the VS from the manure is completely removed, ~~no~~ the potential for additional gaseous compounds ~~are~~ released is reduced since the food and energy sources for the bacteria have been depleted. ~~At this point~~ When all of the volatile solids are removed, manure is considered completely stabilized (i.e., complete decomposition).[26] At this point, the potential release of methane, reactive organic gases, hydrogen sulfide, and ammonia and ammonium compounds generated by anaerobic bacteria is minimized. Therefore, the emission of these gases would be significantly reduced if the treatment of manure results in complete oxidation of manure and process water (i.e., aerobic treatment) or if the gases generated during anaerobic decomposition are collected and combusted (i.e., controlled anaerobic digestion).

All VS are completely biodegradable, although a portion is classified as readily biodegradable (consumed by bacteria quickly) and the rest is considered to biodegrade slowly. The fraction of readily biodegradable VS depends on such factors as manure quality and digestion method.

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[25] Volatile solids can be consumed by bacteria under both aerobic and anaerobic conditions (Metcalf & Eddy, Inc, 1972).

[26] It should be noted that volatile solids reduction can also be achieved through solids settling.

Both anaerobic and aerobic treatment systems use the VS concentration in manure as a parameter for treatment design and effectiveness. The design of these systems is based on the VS loading that can be handled by the systems. The effectiveness of these systems is measured by the amount of VS that has been removed from the effluent; the VS removal efficiency is typically expressed as a percent reduction.

Standard testing methods for quantifying the reduction of air pollutant gases from treated manure (anaerobically or aerobically) is currently not readily available. However, the VS removal efficiency level of a treatment system may be considered an appropriate indicator for determining the remaining potential for treated manure to emit air pollutants (including ROG and methane) to the atmosphere.

A discussion of the potential VS removal efficiencies for anaerobic and aerobic treatment systems is provided below. The VS removal efficiency of an anaerobic treatment system (50 to 70 percent) may be lower compared to the efficiency of an aerobic treatment system (70 percent). However, a substantial benefit of an anaerobic treatment system is the capability of recovering biogases for conversion into electricity.

Anaerobic Treatment System

The VS removal efficiency of a livestock manure anaerobic treatment system is highly dependent on several factors, including manure quality, livestock, and digestion treatment method. For example, the removal efficiency increases with increasing readily biodegradable VS in the manure. The level of readily biodegradable VS present in manure depends on the animal's diet. A diet high in sugars generally results in higher readily biodegradable VS in the manure and a diet high in fiber generally results in lower readily biodegradable VS (Martin, 2001; Roos, 2001).

The VS removal efficiency depends on the type of livestock manure. Generally, the VS removal efficiency for treating swine manure is expected to be higher than that for dairy manure because of the amount of readily biodegradable VS in swine manure (Martin, 2001; Roos, 2001) .

The type of anaerobic digester unit also affects the VS removal efficiency. A covered anaerobic lagoon digester system generally exhibits greater VS removal efficiency compared to other types of digester systems (i.e., plug flow, complete mix) primarily because lagoons also allow for the partitioning and settling of VS contained in the manure. Therefore, the level of VS in manure treated in anaerobic lagoons is reduced by two processes: bacteria consumption and partitioning and settling (Martin, 2001; Roos, 2001).

An industry standard VS removal efficiency value for dairy manure anaerobic treatment systems has not been established because of the wide variability of the above-mentioned factors. In addition, limited published studies evaluating VS removal efficiencies of anaerobic treatment systems are currently available to provide a generally accepted efficiency value. Two studies were conducted to evaluate the energy recovery of swine waste from lagoon systems, which were funded by U.S. EPA under the AgSTAR program.

One study compared the performance of two swine waste treatment systems (a covered anaerobic lagoon with a storage pond and an ozonated anaerobic lagoon[27]) with a traditional anaerobic lagoon (not considered an anaerobic treatment system).[28] This study was conducted from 1998 through 1999.[29] The study reported a VS removal efficiency of 92 percent for the covered anaerobic lagoon treatment system, 90 percent for the ozonated anaerobic lagoon, and 89 percent for the traditional anaerobic lagoon (Cheng, et al., undated). The second study evaluated the performance of a swine waste covered anaerobic lagoon treatment system. The study was conducted in the late 1990s at Barnham farm, located in North Carolina, which is a swine farm with 4,000 sows in six houses. The study reported that the covered anaerobic lagoon provided a VS removal efficiency of 88 percent (Cheng, et al., 1999).

Both studies indicate that the VS removal efficiencies of swine waste anaerobic lagoons are in the upper 80 percent range. It should be noted, however, that the VS removal efficiency for swine waste would be expected to be greater than for dairy manure because of the increased readily biodegradable VS typically present in swine waste (Martin, 2001). In addition, the VS removal efficiency for anaerobic lagoons is generally higher compared to other digester systems because of the VS settling potential.

AgSTAR, in coordination with the University of Delaware, is currently in the process of researching the performance of dairy manure anaerobic treatment systems. The research will focus on evaluating the VS removal efficiencies of these systems. The results of the study are expected to be completed before the end of 2001. AgSTAR and University of Delaware staff involved in the research indicate that the VS removal efficiencies are expected to be lower than those observed for swine waste systems, at a range possibly between 60 to 70 percent. Staff indicated that the VS removal efficiency range may be

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[27] The ozonated anaerobic lagoon consisted of a standard anaerobic lagoon equipped with a surface aerator that allowed for the injection of an ozone and air mixture into the lagoon.

[28] A traditional anaerobic lagoon is not considered an anaerobic treatment system since the lagoon is not constructed with a cover or other mechanism to capture gases generated during anaerobic decomposition of the waste.

[29] The covered anaerobic lagoon was installed at a farrow-to-wean swine farm with 4,000 sows in six houses. The ozonated anaerobic lagoon was installed at a finishing swine farm with 5,400 hogs in six houses. The traditional lagoon was installed at a finishing swine farm with 8,100 hogs in nine houses.

optimistic for the plug flow and complete mix digesters, and could possibly be approximately 50 percent (Martin, 2001; Roos, 2001).

Although no regulatory requirements currently exist for specifying a VS removal efficiency for dairy manure treatment systems, Colorado has developed a VS limit for swine wastes to control odor. The Colorado Air Quality Control Commission Odor Emission Regulations (No. 2) Section IX.A.4.e (1) require that all swine process water that is land applied and not injected shall be pretreated to "...achieve sixty percent removal of total volatile solids" (Colorado Air Quality Control Commission, 1999).

Aerobic Treatment System

Similar to anaerobic treatment systems, the VS removal efficiency of livestock manure aerobic treatment systems would be expected to depend on various factors (manure quality, livestock, treatment type). Limited studies have been conducted to evaluate the VS removal efficiency of livestock manure aerobic treatment systems. The recent six-month pilot study conducted at the Longfellow Dairy in Hanford included evaluation of the VS removal efficiency of the treatment system. The study indicated that the treatment system achieved a median VS removal efficiency of 74 percent if only a one-stage system was implemented. A median VS removal efficiency of 83 percent was achieved by the system if a two-stage system were used. The primary purpose of the two-stage system was to eliminate the potential generation of ammonia gas.

As with anaerobic treatment systems, an industry standard VS removal efficiency value for dairy manure aerobic treatment systems has not been established. However, a 50 percent VS removal efficiency (lower efficiency rate for anaerobic treatment system) could possibly be achieved based on the pilot study conducted in Hanford.

CURRENT USDA AGRICULTURAL RESEARCH SERVICE ACTIVITIES

As mentioned previously, available scientific methods for quantifying the release of gaseous compounds from livestock manure is now only being conducted by USDA ARS. USDA ARS acknowledges that a complete understanding of emission and dispersion of gases generated from animal production systems is currently lacking and that greater knowledge is needed about the mechanisms responsible for air pollutant emissions, composition, emission rates, and dispersion from livestock operations to provide effective solutions. During the late 1990s, USDA ARS established various national programs, including the Air Quality and Manure and Byproduct Utilization programs, to develop a systems research approach to evaluate and develop solutions related to air quality problems from livestock operations (USDA ARS, undated).[30] The research is being conducted by USDA ARS and other specialists (i.e., universities, industry).

The Air Quality National Program is designed to meet the research needs of those parties involved in controlling, assessing, and regulating air quality associated with agriculture. USDA ARS anticipates that the research results of the Air Quality National Program will provide farmers with cost-effective technology to significantly decrease harmful pollutant emissions and provide a methodology to monitor and evaluate rates and amounts of emissions from agriculture. The Manure and Byproduct Utilization National Program focuses on nutrient management, atmospheric emissions, and pathogens from livestock operations (USDA ARS, undated).

There are currently 33 research projects being performed under the Air Quality National Program and 71 research projects being performed under the Manure and Byproduct Utilization National Program. The research projects are generally expected to be completed by 2005. The following provides a summary of some of the research projects (USDA ARS, undated):

- Nutrient conservation and odor reduction in swine and cattle confinement facilities; this project focuses on understanding and developing methods to inhibit microbial activities that produce offensive gaseous and volatile organic compounds (i.e., ROG) and development of biofilters/biocovers that efficiently metabolize offensive odors to non-odorous compounds (USDA ARS, undated). To date, USDA has identified that the addition of low levels of essential plant oils to livestock manure inhibited odor emissions although field tests are needed to determine the economics and usefulness of these agents in livestock facilities.

- Anaerobic microbiological processes in animal waste management; the purpose of this research is to uncover the underlying microbiological basis for odor and devise strategies to intervene in the production of odor causing chemicals generated during anaerobic decomposition of animal wastes, primarily from swine facilities.

- Developing anaerobic microbiological processes for swine waste management; project objectives include development of fundamental knowledge concerning the microbial population of swine waste and the swine intestinal tract to understand the relationship between microbial population and production of odorous compounds. Also, the project aims to develop improved methods to quantify changes in fecal and stored waste bacterial populations and correlate these with emissions generated.

[30] These programs, as well as other USDA ARS national programs, also deal with other agriculture issues.

- Manure treatments and uses to protect soil-water air quality, food safety, and improve manure value; project objectives include development of methods to improve handling and treatment of animal manure to reduce impact on air and water quality and quantification of odor emissions and bioaerosols to evaluate management practice effects on air quality.

- Influence of soil amendments on gaseous emission of nitrogen, carbon, and sulfur from feedlots; project objectives include: 1) evaluating the effects of adding chemical amendments to beef cattle feedlot surfaces; and 2) chemically characterizing the gaseous emissions from the feedlot surfaces using a laboratory-scale system.

- Holding project for animal manure management research; project objectives include the development of management practices on all phases of livestock operations (animal nutrition, manure handling treatment and storage and field application) for effective use of manure in cropping systems while protecting environmental quality and human health. Management practices and treatment technologies will be developed to control emissions, conserve nutrients, and reduce or eliminate pathogens.

- Conservation of manure nutrients and odor reduction in swine and cattle confinement facilities; project objectives include developing methods to inhibit microbial activities that produce offensive gaseous and volatile organic compounds (i.e., ROG); and developing microbially enriched biofilters and biocovers to efficiently metabolize offensive odors to non-odorous compounds.

- Integrated management regimens that minimize the environmental impact of livestock manure; project objectives include measuring the effects of different diets and feeding regimes on ruminant nutrient excretion and emissions of ammonia, odors, and particulates.

- Improved animal manure treatment methods for enhanced water quality; the purpose of this project is to develop improved treatment technologies and systems to manage animal waste from swine production to protect water and air quality. No corresponding study is currently being conducted for dairy facilities.

- Comprehensive systems for managing nutrient flows and gaseous emissions in relation to dairy manure; project objectives include developing manure treatment, handling, and use practices that reduce release of nutrients, ammonia, odors, bioaerosols, and dust particles to air and water.

- Nutritional, microbial, and land application regimens for use of feedlot wastes; project objectives include developing nutritional and management regimens that reduce nitrogen and phosphorus content of feedlot wastes without adversely affecting animal production efficiency and developing microbial methods to improve nutrient use by feedlot cattle to decrease the quantity of animal waste and improve quality of waste for land application. A study published in June 1999 indicated that application of chemicals, such as aluminum sulfate, calcium chloride, and a urease inhibitor, decreased ammonia production at the feedlot surface by 40 to 70 percent.[31] However, according to USDA ARS, additional research is currently being conducted to evaluate the application of other chemicals, safety of chemical application, and appropriate application rate (Cole, 2001)

The understanding of livestock operation-related air quality issues is limited, as evidenced from the current research projects being performed by USDA ARS. Therefore, the effectiveness of available manure treatment systems to control air pollutant emissions cannot be completely determined until a complete scientific understanding of air pollutant emissions generated from livestock manure can be made. In addition, current research is not specifically addressing all of the issues being faced in the southern San Joaquin Valley. In particular, emission of ROG and other ozone precursors is not currently being studied. Similarly, research directed at estimating or measuring PM_{10} emissions from dairy corrals has not been identified by ARS as a research topic.

EXISTING CONDITIONS

The areas within Kings County covered under the Element are currently being used for agricultural purposes, of which approximately 245,300 acres are used as cropland, 4,756 acres are occupied by dairy facilities, and the remaining areas are used for nondairy livestock operations (i.e., beef cows, hogs, pigs, and poultry) and agricultural cropland.[32] Current cropland and livestock operations are also capable of generating air pollutant emissions.

Air pollutant emissions from cropland activities include PM_{10} emissions from fugitive dust due to land preparation, crop harvesting, and fugitive windblown dust; and exhaust emissions (ROG, NOx, and PM_{10}) from agricultural equipment. Air pollutant emissions from dairy operations include: 1) PM_{10} emissions from fugitive dust due to cattle movement at unpaved corrals, unpaved roadways, and other unpaved areas; 2) ROG,

[31] The study was based on laboratory experiments although some field studies have been conducted.

[32] It is assumed that new or expanded dairies would be built on cropland and not on existing nondairy livestock operations; therefore, emissions generated from nondairy livestock operations were not estimated since they would not affect net emissions from new or expanded dairies subject to the Element.

hydrogen sulfide, ammonia, and methane from manure decomposition; 3) methane from cattle; and 4) exhaust emissions (ROG, NOx, and PM_{10}) from dairy equipment.

Cropland Emissions

PM_{10} Emissions from Fugitive Dust

PM_{10} emissions from fugitive dust are released into the atmosphere during land preparation for planting and post-harvest activities. Typical land preparation operations include stubble disking, finish disking, mulching, and other mechanical disturbances. Soil preparation activities are dependent on the crop type being grown. Based on the crop types harvested in 1999 countywide, crops grown in the County include alfalfa, alfalfa seed, hay, barley, corn (silage), cotton (lint, all varieties), cotton (seed), pasture (fescue), safflower, sugar beets, wheat, and wheat (seed).[33]

PM_{10} emissions from land preparation activities were estimated using a PM_{10} emission factor published in the August 1997 CARB Emission Inventory Procedural Manual, Volume III, Section 7.4, Agricultural Land Preparation. Land preparation activities from current cropland could generate up to 1,241 tons per year of PM_{10} emissions (Table 4.2-5a). In addition, crop harvesting activities would also generate PM_{10} emissions. PM_{10} emission factors for all the crop types were not available and, therefore, PM_{10} emissions from crop harvesting could not be estimated accurately. However, according to CARB's 2000 Emission Inventory, approximately 12.66 tons per day (or 4,621 tons per year) of PM_{10} emissions were emitted from farming operations throughout Kings County in 2000 (Table 4.2-2). Farming operations generate particulate matter during land preparation, harvest operations, growing season operations, cattle feedlots, and any other activities (CARB, 1998).

Windblown dust across agricultural fields also releases PM_{10} emissions to the environment. Up to 1,577 tons per year of PM_{10} emissions could be released due to windblown dust throughout the existing cropland; the estimated emissions were based on the current cropland size, a PM_{10} emission factor published in the August 1997 CARB Emission Inventory Procedural Manual, Volume III, Section 7.12, Wind Blown Dust, Agricultural Land (Table 4.2-5a). According to CARB's 2000 Emission Inventory, an average of 7.91 tons per day (2,887 tons per year) of PM_{10} emissions from fugitive windblown dust attributed to agricultural lands, pasture lands, and unpaved areas were emitted from Kings County in 2000 (Table 4.2-2) (CARB, 1998).

[33] The crop types are included in the Theoretical Capacity Model.

Exhaust (ROG, NOx, and PM_{10}) Emissions from Agricultural Equipment

Air pollutant emissions from agricultural equipment exhaust include ozone precursors (i.e., ROG and NOx) and PM_{10}. ROG, NOx, and PM_{10} emissions would be dependent on the types of equipment used (e.g., diesel-fueled equipment, such as stalk cutters, cultivators, discing equipment, seeder, dressing- and mulch-related equipment, tractors, trucks, and miscellaneous equipment), equipment use duration, equipment horsepower, crop areas, annual operating hours for each equipment, emission factors, and load factors. Since this information varies throughout the County, and is site-specific, estimations of ROG, NOx, and PM_{10} emissions under current conditions could not be estimated. However, according to CARB's 2000 Emission Inventory, an average of 172, 1,267, and 80 tons per year of ROG, NOx, and PM_{10}, respectively, are generated annually from farm equipment in Kings County (Table 4.2-2) (CARB, 1998). Farm equipment included light and heavy duty equipment used in farming.

Dairy Facility Emissions

Air pollutant emissions from dairy facility operations include PM_{10}, ROG, NOX, ammonia, hydrogen sulfide, and methane. PM_{10} emissions are primarily from fugitive dust releases at unpaved corrals and unpaved roadways/areas. Windblown dust across pasture land would also generate very minimal PM_{10} emissions.[34] ROG, ammonia, hydrogen sulfide, and methane emissions result from decomposition of animal waste. Methane emissions are also generated from the digestive process of the dairy animals. In addition, dairy farm equipment exhaust releases ROG and PM_{10} emissions as well as NOx emissions.

PM_{10} Emissions from Fugitive Dust during Cattle Movement in Unpaved Corrals

The generation of fugitive dust at dairies is primarily from cattle movement in unpaved corrals; fugitive dust would also be generated during maintenance activities (e.g., regrading) at the unpaved corrals.[35] Under existing conditions, dry cows, bred heifers, heifers (one year to bred ages), calves, and baby calves are assumed to be housed in unpaved corrals and milk cows in freestall barns.[36]

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[34] Approximately three tons per year of PM_{10} could be emitted from dairy pasture land under existing conditions, conservatively assuming that all of the dairy areas are exclusively for pasture.

[35] Air pollutant emissions from existing dairies were based on the assumptions that: 1) existing dairies handle Holstein-type cows; 2) the ratio of support stock to milk cows is similar to that estimated under Table 5 (Theoretical Dairy Capacity of Kings County); 3) existing dairies house milk cows in freestall barns and support stock in unpaved corrals; and 4) manure is currently not being treated to reduce air pollutant emissions.

[36] Little to no fugitive dust would be expected to be generated from the freestall barns as these facilities are typically paved with concrete.

PM_{10} emission factors from fugitive dust generated at unpaved dairy corrals have not yet been developed by U.S. EPA or CARB (Gaffney, 1999). However, a wide range of particulate emission factors have been published for cattle feedlots. The September 1985 U.S. EPA A.P. 42 Manual publishes a total particulate matter emission factor from fugitive dust at cattle feedlots (U.S. EPA, 1985). Based on this factor, CARB developed a PM_{10} emission factor, which is provided in the Emission Inventory Procedural Manual, Methods for Assessing Area Source Emissions (CARB, 1989a). CARB's PM_{10} emission factor of 134.4 pounds per 1,000 head per day assumes that 48 percent of the total particulate emission factor constitutes PM_{10}.[37]

In 1999, the Department of Agricultural Engineering at Texas A&M University completed a PM_{10} emission inventory study for cattle feedlots in Texas. As part of the study, the AP-42 total particulate emission factor was reexamined and a revised PM_{10} emission factor of 15 pounds per 1,000 head per day from fugitive dust at cattle feedlots was estimated. The revised PM_{10} emission factor was based on sampling, back-calculating the emission factor using the ISC3 air model, and annualizing the estimated emission factor. The revised PM_{10} emissions factor for feedlots was considered in a recent report by the Confined Livestock Air Quality Committee (CLAQC) of the USDA Agriculture Air Quality Task Force (CLAQC, 2000). CLAQC indicated that the PM_{10} emission factor for dairy cattle may be less than 20 percent of the cattle feedlot PM_{10} emission factor developed by Texas A&M (15 pounds per 1,000 head per day), according to personal communication between Mr. Jim Sweeten (Texas A&M University professor) and the Confined Livestock Air Quality Committee of the USDA Agricultural Air Quality Task Force (2000).

Potential PM_{10} emissions from existing unpaved dairy corrals in Kings County were estimated using PM_{10} emission factors published by CARB as well as the Department of Agricultural Engineering at Texas A&M University for cattle feedlots (Table 4.2-5a). However, actual PM_{10} emissions generated could be less than the estimated emissions since cattle feedlots are known to generate more PM_{10} emissions than dairy corrals constructed to current California Department of Food and Agriculture standards.[38] The number of existing support stock (dry cows, heifers, and calves) considered in calculating PM_{10} emissions were estimated using the ratio of milk cow to individual support stock and the number of milk cows currently housed in existing dairies in Kings County provided in Table 5 of the Element (Theoretical Dairy Capacity of Kings County).

[37] As indicated previously, an average of 4,621 tons per year of PM_{10} emissions from farming operations, which included cattle feedlots (but not dairies), was emitted from the entire County in 2000.

[38] PM_{10} emissions from a cattle feedlot are mainly due to the disturbance of the manure pack present in the feedlot. However, manure in unpaved dairy corrals is not common and typically removed frequently. In addition, the spacing of cows in unpaved dairy corrals is typically greater than in cattle feedlots.

CARB's PM_{10} emission factor is based on dry season conditions and where dust control measures are not regularly employed. In addition, the emission factor appears to be based on adult steers and heifers that are placed in feedlots and calves (weighing 320 to 700 pounds) that are placed in feedlots during part of their growth period (Monsanto, 1977). Therefore, CARB's PM_{10} emission factor would not be expected to account for PM_{10} emissions generated from new born calves and only partially considers PM_{10} emissions generated from calves weighing between 320 to 700 pounds.[39]

PM_{10} emissions using CARB's emission factor were estimated under the following two scenarios to account for PM_{10} emission reduction from the wet season (rainfall effects) and for potential additional PM_{10} emissions generated from new born calves and calves between 320 to 700 pounds:

- Scenario 1: Exclude all calves in PM_{10} emission estimate and account for potential PM_{10} emission reduction during wet season;[40] and

- Scenario 2: Conservatively include all calves in PM_{10} emission estimate (assuming that PM_{10} emission rates for calves are equivalent to those for the heavier and larger dry cattle and heifers),[41] and ignore potential PM_{10} emission reduction during wet season.

The PM_{10} emission factor developed by the Department of Agricultural Engineering at Texas A&M University is an annualized value that accounts for rainfall effects observed in Texas. However, the PM_{10} emissions for existing conditions used a non-annualized emission factor of 20 pounds per 1,000 head per day since the rainfall effects observed in Texas would not be applicable to California. The PM_{10} emission factor was assumed not to account for calves in the cattle feedlots. Therefore, PM_{10} emissions using the University's emission factor were estimated under the following two scenarios:

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[39] PM_{10} emissions from cattle movement vary depending on the cattle type, as movement from dry cattle and heifers would likely generate more PM_{10} emissions from fugitive dust compared to calves because of weight and hoof size differences between the older (dry cattle and heifers) and younger (calves) cattle.

[40] PM_{10} emission reductions from rainfall were based on guidance from CARB (Gaffney, 1999).

[41] The emission factor used to estimate PM_{10} emissions was based on beef cattle feedlots. Production of beef calves usually consists of raising calves to weaning weights of 480 pounds as part of a range-pasture program; calves from weaning to weights between 550 to 700 pounds are typically grazed on pastures and also maintained in cattle feedlots. Therefore, the emission factor would not be expected to account for PM_{10} emissions generated from baby calves or from partial raising of calves from weaning to weights of 550 to 700 pounds.

- Scenario 3: Exclude all calves in PM_{10} emission estimate and account for potential PM_{10} emission reduction during wet season using approach consistent with Scenario 1;[42] and

- Scenario 4: Conservatively include all calves in PM_{10} emission estimate, and ignore potential PM_{10} emission reduction during wet season.

The PM_{10} emissions for the four scenarios were estimated to be 1,681, 3,394, 251, and 505 tons per year for Scenarios 1, 2, 3, and 4, respectively (Tables 4.2-5a). CARB's November 2000 study indicated that 90 tons per year of PM_{10} were generated from dairy operations in Kings County. However, CARB's estimate only reflects PM_{10} emissions released from windblown dust along dairy pasture land. In addition, CARB's study was based on a rough assumption on the fraction of pasture land occupied by dairy cattle (Benjamin, 2001a). If the entire 4,756 acres that are currently occupied by dairies in Kings County were conservatively assumed to constitute all pasture land, the estimated PM_{10} emissions generated from windblown dust on the pasture land would be approximately three tons per year, which is a relatively insignificant amount compared to PM_{10} emissions expected to be released from unpaved dairy corrals.[43]

PM_{10} Emissions from Fugitive Dust during Vehicular Use along Unpaved/Gravel Paved Roadways and Other Unpaved Areas

PM_{10} emissions are also generated from fugitive dust during vehicular use along unpaved or gravel paved roadways and from other unpaved areas within a dairy facility. The amount of PM_{10} emissions that could be generated from vehicular use along roadways at existing dairies would be dependent on various factors including the road type, vehicle miles traveled along the roadway, number of vehicular trips, vehicle type (number or wheels and weight), travel speed, silt content of the roadway, and vehicle weight. Similarly, the amount of PM_{10} emissions that could be generated from unpaved areas throughout a dairy facility would be dependent on several factors including area size and silt content of the area.

Since these factors vary widely with each dairy, PM_{10} emissions from vehicular use along unpaved or gravel paved roadways were not estimated. In addition, PM_{10} emissions from vehicular use are generally minimal, compared to PM_{10} emissions generated from unpaved corrals (Kings County, 1999). However, according to CARB's 2000 Emission Inventory, an estimated 7.51 tons per day (2,741 tons per year) of PM_{10} were emitted in 2000 from

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[42] PM_{10} emission reductions from rainfall were based on guidance from CARB (Gaffney, 1999).

[43] This estimate is based on an the actual acreage currently occupied by dairies within the County and an emission factor for pasture land in Kings County, which is published in the August 1997 CARB Emission Inventory Manual, Volume III, Section 7.12, Wind Blown Dust, Agricultural Land.