APPENDIX F-4

Air Quality Technical Appendix
Greenhouse Gas Emissions Model Methodology and Calculations

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GREENHOUSE GAS EMISSIONS QUANTIFICATION: METHODOLOGY AND CALCULATIONS

For the proposed dairy project Environmental Impact Report (EIR), greenhouse gas (GHG) emissions were estimated using the Dairy Gas Emissions Model, Version 3.3, from the Pasture Systems and Watershed Management Research Unit, Agricultural Research Service (ARS), United States Department of Agriculture (USDA). The Dairy Gas Emissions Model (DairyGEM) was created for the USDA ARS and made available for public use in February 2011. An earlier model, the Dairy Greenhouse Gas Emissions Model, was made available in June 2009 in conjunction with tools and information to help affected producers comply with the Environmental Protection Agency (EPA) Final Mandatory GHG Reporting Rule. Because this model estimates GHG emissions from the entire production system, and some assumptions were made regarding the project operations with best available information, the calculations reported in this EIR are considered a conservative estimate.

The DairyGEM is a software tool for estimating the ammonia, hydrogen sulfide, GHG, and volatile organic compound (VOC) emissions of dairy production systems. A dairy production system generally represents the processes used on a given farm, but the full system extends beyond the farm boundaries. A production system is defined to include emissions during the production of all feeds whether produced on a given farm or elsewhere. It also includes GHG emissions and energy use that occur during the production of resources used on the farm such as machinery, fuel, electricity, and fertilizer. Manure is assumed to be applied to cropland producing feed, but any portion of the manure produced can be exported to other uses external to the system.

DairyGEM also uses process-based relationships and emission factors to predict the primary GHG emissions from the production system. Primary sources include the net emission of carbon dioxide plus all emissions of methane and nitrous oxide occurring from the production system. Emissions are predicted through a daily simulation of feed use and manure handling. Daily emission values of each gas are summed to obtain annual values. For the purposes of this analysis, only the GHG emission results of the modeling are included in the EIR.

Total greenhouse gas emission is determined as the sum of the net emissions of the three GHG where methane and nitrous oxide are converted to carbon dioxide equivalent units (CO_2e)[1]. This net emission is determined through a partial life cycle assessment of the production system. Emissions include both primary and secondary sources. Secondary emissions are those that occur during the manufacture or production of resources used in the production system. These resources include machinery, fuel, electricity, fertilizer, pesticides, plastic, and any replacement animals not raised on the farm. Secondary emissions from the manufacture of equipment are apportioned to the feed produced or manure handled over their useful life.

For more in depth description on modeling equations and rationale, the reference manual can be found at: www.ars.usda.gov/Main/docs.htm?docid=21345

[1] The conversion to CO_2e is done using global warming potentials for methane and nitrous oxide of 25 and 298, respectively. Therefore, each unit of methane is equal to 25 units of carbon dioxide and each unit of nitrous oxide is equal to 298 units of carbon dioxide.

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NUTRIENT CONSTITUENTS OF ALL FEEDS

Feed	Amount (t DM)	CP (%DM)	NEL (Mcal/lb)	NDF (%DM)	TDN (%DM)	DEGR (%CP)	ADIP (%CP)	P (%DM)
High quality silage	2738	22.0	0.60	45.0	59.3	78.0	6.0	0.26
Low quality silage	3212	17.0	0.59	48.0	55.0	78.0	5.0	0.23
High quality hay	1022	21.0	0.65	40.0	63.9	70.0	6.5	0.26
Low quality hay	475	16.0	0.58	50.0	55.0	70.0	5.0	0.23
Dry grain	1497	10.0	0.89	10.0	85.0	48.0	8.0	0.29
Soybean meal, 44%	---	49.0	0.88	14.0	84.0	70.0	3.0	0.68
User defined feed	---	58.0	0.84	8.0	76.8	42.5	5.3	1.78
Purchased grain	---	9.0	0.87	22.8	88.0	55.0	5.0	0.32

SILO PARAMETERS

Forage Type	Storage Type	Width/diameter (ft)	Depth/height (ft)
High quality forage (1)	Pressed bag	9.84	0.00
High quality forage (2)	Pressed bag	9.84	0.00
Low quality forage (1)	Pressed bag	9.84	0.00
Low quality forage (2)	Pressed bag	9.84	0.00
Grain crop silage (1)	Pressed bag	9.84	0.00
Grain crop silage (2)	Pressed bag	9.84	0.00
High moisture grain (1)	Pressed bag	9.84	0.00
High moisture grain (2)	No storage	9.84	0.00

SOIL AND PASTURE PARAMETERS

Parameter	Value
Predominant soil type	Loam
Soil acidity	Moderate
Grazing animals	Older heifers
Pasture available during grazing season	0 ton DM
Pasture growing season	6 months per year
Time on pasture	Full days during grazing season
Expected annual carbon sequestration	0 ton carbon

HERD AND FACILITY PARAMETERS

Herd/Facility Parameters	Value
Animal type	Holstein
Mature body weight	1521 lb
Fat content of milk	3.50 %
Adjustment of fiber intake	1.00
Target milk production	25550 lb/cow/year
First lactation animals	35 %
Number of lactating animals	1063
Number of young stock (over 1 year)	811
Number of young stock (under 1 year)	186

Animal facilities

Cow housing	Free stall barn, naturally ventilated
Heifer housing	Free stalls and open lot

Management options

Calving strategy	Random calving
Relative forage to grain ratio	High
Use of bovine somatotropin	No
Protein feeding adjustment	100 % of NRC recommendation
Sulfur feeding adjustment	100 % of NRC recommendation

MANURE PARAMETERS

Manure Parameters	Value
Manure collection method	Flush system
Field application method	Irrigation
Manure type	Manure type Manure typ
Time between spreading and incorporation	Within two days

Manure storage

Method	4 month storage
Type	Top loaded earthen pit
Storage capacity	24563 ton

Bedding

Type	Manure solids
Amount of bedding per mature animal	3.00 lb/day

Exported manure

Quantity	80 % of that collected
Form	Fresh manure

Oliveira Existing

GASEOUS EMISSIONS

	Average daily		Total annual	
	lb/cow	lb	lb/cow	lb
Methane				
Housed animals	1.047	1113	382.3	406380
Manure storage	0.485	516	177.0	188162
Field applied manure	0.000	0	0.1	65
Total emission	1.533	1629	559.4	594608
Nitrous Oxide				
Housed animals	0.011	11	3.9	4125
Manure storage	0.002	2	0.6	608
Direct and indirect land	0.020	22	7.5	7931
Total emission	0.033	35	11.9	12664
Biogenic Carbon Dioxide				
Housed animals	36.325	38613	13258.6	14093926
Manure storage	1.590	1691	580.5	617034
Assimilated in feed	-58.512	-62198	-21356.9	-22702390
Net emission	-20.597	-21894	-7517.8	-7991458
Anthropogenic Carbon Dioxide	2.517	2676	918.8	976673

ANNUAL ENVIRONMENTAL FOOTPRINTS

	Unit	Mean	SD
Greenhouse Gas Emissions (CO2e)			
Animal emissions	lb	10967348	18456
Manure emissions	lb	6935943	657064
Direct and indirect land emissions	lb	2101586	43236
Net biogenic carbon dioxide emission	lb	-8608473	14890
Anthropogenic carbon dioxide emission	lb	976673	1805
Production of resource inputs	lb	4900387	13566
Not allocated to milk production	lb	-37812724	991992
Carbon footprint without biogenic CO2	lb/lb FPCM	-4.77	0.11
Carbon footprint with biogenic CO2	lb/lb FPCM	-3.42	0.11

FPCM is fat and protein corrected milk (4.0% fat and 3.3% protein)

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NUTRIENT CONSTITUENTS OF ALL FEEDS

Feed	Amount (t DM)	CP (%DM)	NEL (Mcal/lb)	NDF (%DM)	TDN (%DM)	DEGR (%CP)	ADIP (%CP)	P (%DM)
High quality silage	4782	22.0	0.60	45.0	59.3	78.0	6.0	0.26
Low quality silage	5767	17.0	0.59	48.0	55.0	78.0	5.0	0.23
High quality hay	2409	21.0	0.65	40.0	63.9	70.0	6.5	0.26
Low quality hay	548	16.0	0.58	50.0	55.0	70.0	5.0	0.23
Dry grain	2701	10.0	0.89	10.0	85.0	48.0	8.0	0.29
Soybean meal, 44%	---	49.0	0.88	14.0	84.0	70.0	3.0	0.68
User defined feed	---	58.0	0.84	8.0	76.8	42.5	5.3	1.78
Purchased grain	---	9.0	0.87	22.8	88.0	55.0	5.0	0.32

SILO PARAMETERS

Forage Type	Storage Type	Width/diameter (ft)	Depth/height (ft)
High quality forage (1)	Pressed bag	9.84	0.00
High quality forage (2)	Pressed bag	9.84	0.00
Low quality forage (1)	Pressed bag	9.84	0.00
Low quality forage (2)	Pressed bag	9.84	0.00
Grain crop silage (1)	Pressed bag	9.84	0.00
Grain crop silage (2)	Pressed bag	9.84	0.00
High moisture grain (1)	Pressed bag	9.84	0.00
High moisture grain (2)	Pressed bag	9.84	0.00

SOIL AND PASTURE PARAMETERS

Parameter	Value
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Pasture growing season	6 months per year
Time on pasture	Full days during grazing season
Expected annual carbon sequestration	0 ton carbon

HERD AND FACILITY PARAMETERS

Herd/Facility Parameters	Value
Animal type	Holstein
Mature body weight	1521 lb
Fat content of milk	3.50 %
Adjustment of fiber intake	1.00
Target milk production	23725 lb/cow/year
First laction animals	35 %
Number of lactating animals	2500
Number of young stock (over 1 year)	750
Number of young stock (under 1 year)	750

Animal facilities

Cow housing	Free stall barn, naturally ventilated
Heifer housing	Free stalls and open lot

Management options

Calving strategy	Random calving
Relative forage to grain ratio	High
Use of bovine somatotropin	No
Protein feeding adjustment	100 % of NRC recommendation
Sulfur feeding adjustment	100 % of NRC recommendation

MANURE PARAMETERS

Manure Parameters	Value
Manure collection method	Flush system
Field application method	Irrigation
Manure type	Manure type Manure typ
Time between spreading and incorporation	Within two days

Manure storage

Method	4 month storage
Type	Top loaded earthen pit
Storage capacity	24567 ton

Bedding

Type	Manure solids
Amount of bedding per mature animal	3.00 lb/day

Exported manure

Quantity	90 % of that collected
Form	Fresh manure

Oliveira Proposed

GASEOUS EMISSIONS

	Average daily		Total annual	
	lb/cow	lb	lb/cow	lb
Methane				
Housed animals	1.074	2685	392.0	979986
Manure storage	0.513	1282	187.1	467846
Field applied manure	0.000	0	0.0	82
Total emission	1.587	3967	579.2	1447914
Nitrous Oxide				
Housed animals	0.008	21	3.0	7576
Manure storage	0.001	3	0.4	948
Direct and indirect land	0.019	47	6.8	17051
Total emission	0.028	70	10.2	25576
Biogenic Carbon Dioxide				
Housed animals	38.174	95435	13933.5	34833848
Manure storage	1.665	4162	607.7	1519163
Assimilated in feed	-76.051	-190127	-27758.5	-69396176
Net emission	-36.212	-90529	-13217.3	-33043184
Anthropogenic Carbon Dioxide	2.624	6560	957.8	2394424

ANNUAL ENVIRONMENTAL FOOTPRINTS

	Unit	Mean	SD
Greenhouse Gas Emissions (CO_2e)			
Animal emissions	lb	26468162	12528
Manure emissions	lb	16332323	1351129
Direct and indirect land emissions	lb	4518623	70568
Net biogenic carbon dioxide emission	lb	-34562332	108533
Anthropogenic carbon dioxide emission	lb	2394424	960
Production of resource inputs	lb	17961396	18871
Not allocated to milk production	lb	-11786719	259099
Carbon footprint without biogenic CO_2	lb/lb FPCM	1.21	0.03
Carbon footprint with biogenic CO_2	lb/lb FPCM	0.59	0.03

FPCM is fat and protein corrected milk (4.0% fat and 3.3% protein)