Monitoring and Modeling of ROG at California Dairies

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Sampling and modeling at selected dairies in the San Joaquin Valley

- Select “typical dairies” – about 2000 cows with flush-lane, free stall, lagoon systems

- Determine sampling procedure – collect samples upwind of the diary and downwind of each significant dairy process.

- Analyze samples – Ammonia from filter packs was analyzed by spectro-photometry. ROG analysis was initially for TNMHC at an outside lab and later GCMS utilizing an appropriate standard to identify and determine the quantity of each gas.

- Model emissions – estimate emission rates from each dairy process from the net concentration (upwind-downwind) difference using a Gaussian plume dispersion model (ISC-STv3)

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- 1500 – 2500 milking cows

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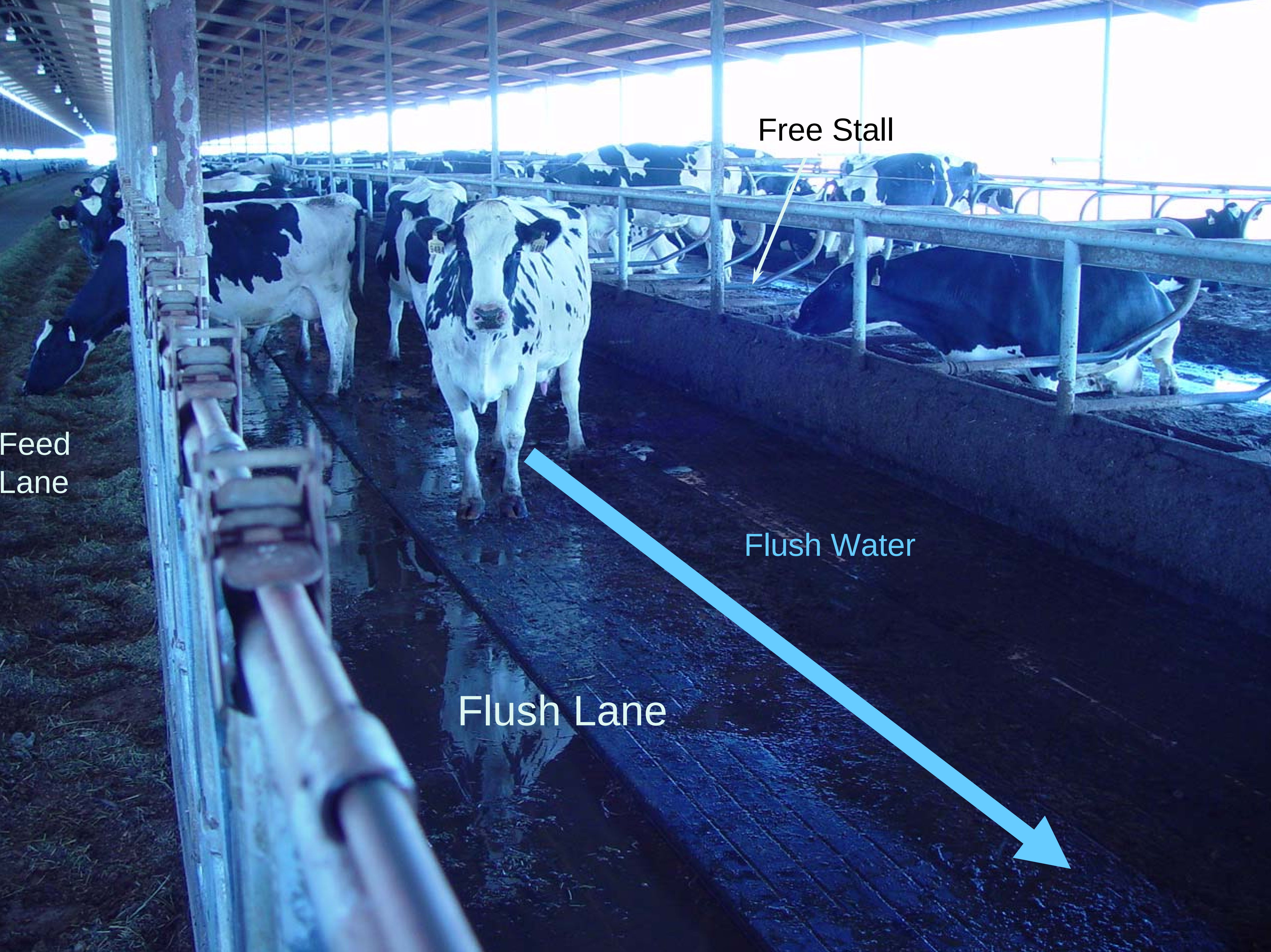

Free Stall
Feed
Lane
Flush Water
Flush Lane

What is a “typical dairy” in California?

- Located in the San Joaquin Valley
- 1500 – 2500 milking cows
- Free stall – flush lane manure collection
- Screen separator and lagoon manure handling system.


Separation Screen
Sand Pit
Large Solids


Lagoon
1. Source of flush-lane water
2. Source of irrigation/fertilizer for surrounding cropland
3. Flood control and runoff capture

What is a “typical dairy” in California?

- Located in the San Joaquin Valley
- 1500 – 2000 milking cows
- Free stall – flush lane manure collection
- Screen separator and lagoon manure handling system.
- Surrounded by cropland on which the effluent is used to recycle nutrients to produce dairy forage.


Irrigation System Standpipe
Lagoon Water
Irrigation Well

Kings County Dairy. A 2000 cow dairy located 10km east of Hanford. The dairy utilizes “free stall” management where the cows are fed on gently sloping concrete that is flushed with a large flow of water several times a day to remove the waste. Solids in the flush water are separated from the liquid which is stored in a series of lagoons for subsequent flushing of the free stalls and eventually is part of the irrigation water for the surrounding cropland.

The dairy is surrounded by sorghum and alfalfa fields that are used to recycle nutrients from the dairy waste and to produce forage for the dairy herd.

Sampling sites at the dairy were: DW1, upwind, DW2-downwind of the lagoon, DW4-downwind of the free stalls and flush lanes, and DW3-300m downwind of DW2 across a field (ammonia sampling only).

Up Wind Fenceline site (DW1). Looking SE, downwind.

Kings Co. Dairy

Kings County Dairy
Sampling Locations:

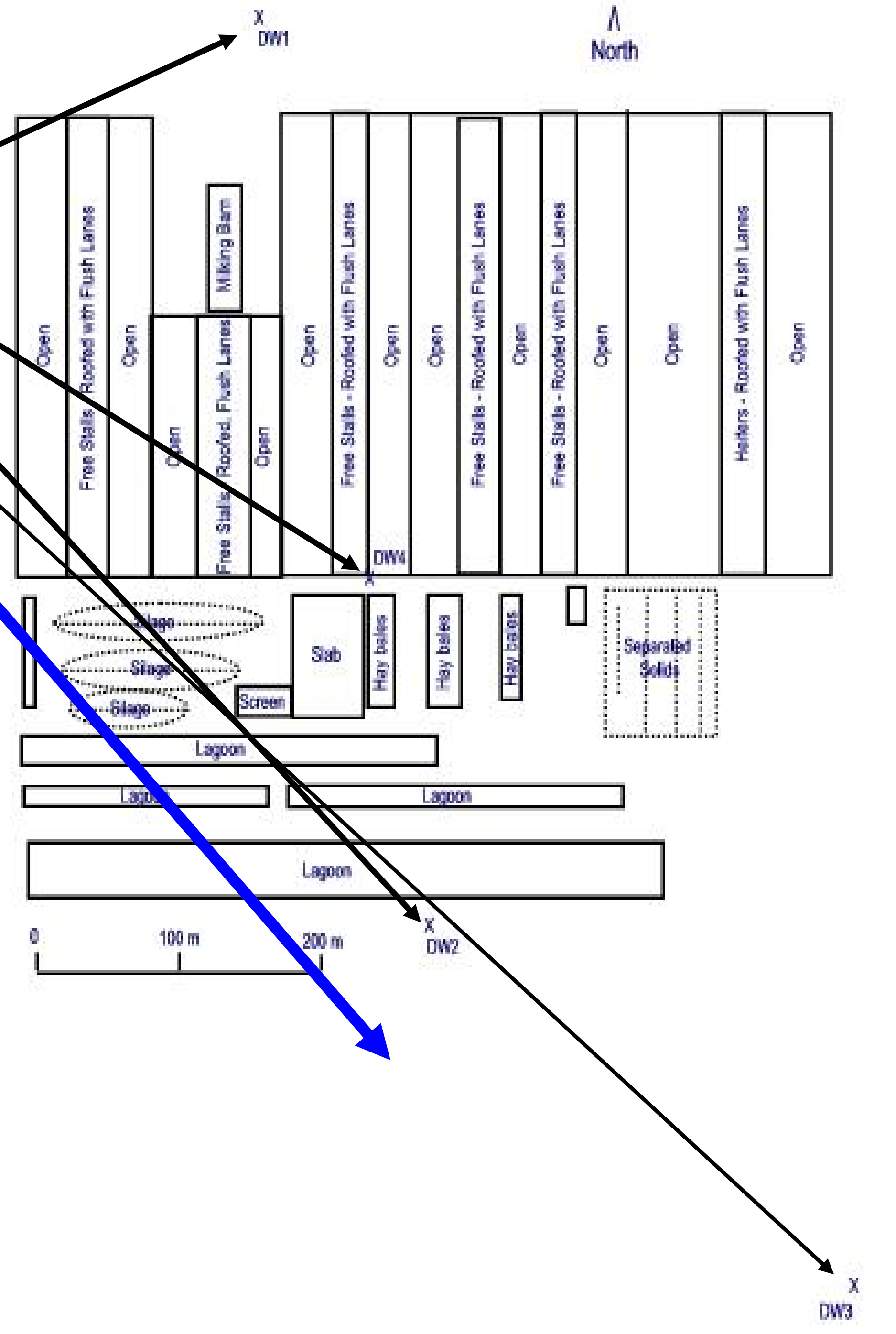
Upwind

Downwind of the Free Stalls

Downwind of the Lagoon System

Far Downwind for NH_3 only

Prevailing wind = 320 degrees



Initial sampling for ROG (ozone precursors) at the Kings County dairy was done in October, ‘02. Sampling canisters and regulators were rented from Dr. Rasmussen at the Oregon Graduate Research Institute. Analysis of the samples was also done by Rasmussen at OGRI.

First samples were collected at the Kings County Dairy in October, 2002.

Total Non-Methane Hydro-Carbons (TNMHC) analysis by Dr. Rasmussen at the Oregon Graduate Research Institute

DATE	Sample	Start	End	CH_4 ppbv	Total Non-methane Hydrocarbons ug/m3	Total Identified Hydrocarbons ug/m3	Alkanes ug/m3	Alkenes ug/m3	Aromatics ug/m3	Total Unidentified Hydrocarbons ug/m3	REMARKS
18-Oct-02	1	1243	1416	2283	60	21	13	3	4	39	Up-Wind
18-Oct-02	4	1554	1754	2410	55	22	15	3	4	32	Up-Wind
18-Oct-02	7	1815	2005	2819	108	44	33	4	8	63	Up-Wind
18-Oct-02	10	2030	2225	2662	78	31	22	4	5	47	Up-Wind
21-Oct-02	13	1248	1440	2375	45	18	13	3	2	26	Up-Wind
21-Oct-02	16	1522	1722	2178	51	14	10	3	2	37	Up-Wind
21-Oct-02	19	1737	1940	5171	140	23	15	4	4	117	Up-Wind
21-Oct-02	22	2005	2135	2721	76	28	19	4	5	48	Up-Wind
23-Oct-02	25	1205	1347	2162	83	42	22	13	7	40	Up-Wind
23-Oct-02	28	1428	1630	2144	47	16	11	2	3	31	Up-Wind
23-Oct-02	31	1737	1940	2316	63	24	15	5	4	39	Up-Wind
23-Oct-02	34	2010	2210	2302	55	21	14	3	4	34	Up-Wind
18-Oct-02	2	1243	1412	4829	54	28	14	3	12	26	Down- Wind of the Lagoon
18-Oct-02	5	1554	1754	7142	115	35	13	3	20	80	Down- Wind of the Lagoon
18-Oct-02	8	1815	2005	16536	275	94	23	5	66	182	Down- Wind of the Lagoon
18-Oct-02	11	2025	2230	11988	169	68	24	5	39	101	Down- Wind of the Lagoon
21-Oct-02	14	1248	1440	5373	64	23	13	2	8	41	Down- Wind of the Lagoon
21-Oct-02	17	1522	1722	6579	99	26	12	2	13	73	Down- Wind of the Lagoon
21-Oct-02	20	1737	1940								
21-Oct-02	23	2005	2155	32660	251	102	21	5	77	149	Down- Wind of the Lagoon
23-Oct-02	26	1210	1347	4519	85	58	30	13	15	28	Down- Wind of the Lagoon
23-Oct-02	29	1428	1630	4920	47	19	10	2	7	29	Down- Wind of the Lagoon
23-Oct-02	32	1737	1940	15187	79	32	18	3	11	47	Down- Wind of the Lagoon
23-Oct-02	35	2010	2225	7127	117	33	12	3	18	84	Down- Wind of the Lagoon
18-Oct-02	3	1243	1412	4784	64	27	13	3	12	38	Co-located with 2m sample at DV
18-Oct-02	6	1554	1754	3960	77	24	11	3	10	53	DW2 tower, 10m elevation
18-Oct-02	9	1815	2005	19977	235	99	28	6	66	136	Co-located with 2m sample at DV
18-Oct-02	12	2025	2230	4185	330	295	254	6	35	35	DW2 tower, 10m elevation
21-Oct-02	15	1248	1440	3718	173	16	12	2	2	157	These 4 sampled at Point B,
21-Oct-02	18	1522	1722	5971	234	20	14	3	3	214	S (downwind) of stall area,
21-Oct-02	21	1737	1940	18005	403	35	22	9	4	368	N (upwind) of feed storage,
21-Oct-02	24	2005	2155	14294	227	34	23	6	5	193	midway between DW! & DW2
23-Oct-02	27	1200	1355	2226	72	40	21	12	7	32	300m Down-Wind of the Lagoon
23-Oct-02	30	1423	1635	2249	57	14	9	2	3	43	300m Down-Wind of the Lagoon
23-Oct-02	33	1742	1945	3554	111	26	16	6	4	85	300m Down-Wind of the Lagoon
23-Oct-02	36	2015	2235	5425	97	26	15	3	9	71	300m Down-Wind of the Lagoon

The locations of the sampling sites at the Kings County dairy were suited to modeling with the ISC-STv3 dispersion model only on October 21. The wind conditions were typical for this area and season. A thermal wind began about noon and increased until evening, after which it decreased until it was calm at about 2200.

Modeling of ROG emission rates for the animal housing area (between DW1 and DW4) produced a significantly higher ROG emission rate in the afternoon compared to the evening sampling periods.

Modeling of the ROG emission rates for the lagoon system (between DW4 and DW2) produced similar ROG emission rates for all three sampling periods on 10/21/02. The 1737-1940 sample was lost during the analytical process.

Adding the emission rates for the animal housing area to that of the lagoon system for each sampling period produces an estimate of the TNMHC-ROG emission rate for the whole dairy operation. The consistency of the lagoon emission rates may permit an estimate for the whole dairy rate for the missing sample to be calculated as approximately 8.6 lb/hd/yr.

Sampling Conditions, Kings Dairy

Sampling Periods			Up-wind Conditions					
Date	Start	End	CH4 $\mu g/m^3$	TNMHC $\mu g/m^3$	Wind Speed (m/s)	WD degrees	Stablility Class	Air Temp. Degree F
21-Oct-02	1248	1440	1560	44.5	1.26	343.5	2	74.5
21-Oct-02	1522	1722	1428	51.4	2.20	320.0	4	75.5
21-Oct-02	1737	1940	3443	139.7	0.95	312.1	6	67.4
21-Oct-02	2005	2155	1830	75.7	0.23	318.4	6	62.1
Average			2066	77.8	1.2	323.5		69.9

Modeled Emissions from Animal Housing Area (Freestall/corral)

Sampling Periods			Methane	Methane	ROG TNMHC	ROG TNMHC
Date	Start	End	kg/hd/yr	lb./hd/yr	kg/hd/yr	lb./hd/yr
21-Oct-02	1248	1440	53.9	118.6	7.8	17.3
21-Oct-02	1522	1722	118.9	261.6	8.8	19.3
21-Oct-02	1737	1940	94.5	207.9	2.9	6.4
21-Oct-02	2005	2155	85.5	188.1	1.7	3.7
Average			88.2	194.0	5.3	11.7

Modeled Emissions from Lagoon System

Sampling Periods			Methane	Methane	ROG TNMHC	ROG TNMHC
Date	Start	End	kg/hd/yr	lb./hd/yr	kg/hd/yr	lb./hd/yr
21-Oct-02	1248	1440	6.7	14.7	0.5	2.3
21-Oct-02	1522	1722	5.9	13.0	1.0	2.3
21-Oct-02	1737	1940	N/A	N/A	N/A	N/A
21-Oct-02	2005	2135	4.0	8.7	0.9	2.1
Average			5.5	12.1	0.8	2.2

Modeled Emissions Estimated for Total Dairy

Sampling Periods			Methane	Methane	ROG TNMHC	ROG TNMHC
Date	Start	End	kg/hd/yr	lb./hd/yr	kg/hd/yr	lb./hd/yr
21-Oct-02	1248	1440	60.6	133.3	8.4	19.6
21-Oct-02	1522	1722	124.8	274.5	9.8	21.6
21-Oct-02	1737	1940	N/A	N/A	N/A	N/A
21-Oct-02	2005	2135	89.5	196.8	2.6	5.8
Average			93.7	206.2	6.1	13.9

CSU Fresno Sampling and Analysis for ROG

- **Selected a standard EPA method for sampling and analytical procedures. (EPA-TO-15)**

- **EPA-TO-15 utilizes Gas Chromatography to separate the ROG compounds and a Mass Spectrometer to identify them by their molecular weight.**

- **EPA-TO-15 requires the use of a standard gas to compare with the sampled gas. Identification and quantification of species in the sampled gas can only be done for those compounds in the standard gas.**

- **The GC-MS can identify other compounds not present in the standard gas but cannot accurately quantify them.**

- **Selected an EPA recommended dispersion modeling program (ISC-STv3) to model emissions from the concentration difference (downwind – upwind) to estimate ROG emissions.**

Kings Co. Dairy, 7/22/04. TO-15

name	MW	MDL	units	DWFS raw	DWFS corrected	DWFS µg/m3	DWFS Net C	DWLN-1 raw	DWLN-1 corrected	DWLN-1 µg/m3	DWLN-1 Net C	DWLN-2 raw	DWLN-2 corrected	DWLN-2 µg/m3	DWLN-2 Net C	DWOL raw	DWOL corrected	DWOL µg/m3	DWOL Net C	UW raw	UW corrected	UW µg/m3
propylene	42	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Dichlorodifluoromethane	120	0.1	ppbv	0.958	1.36	6.67	1.33	0.793	1.24	6.10	0.77	0.972	1.29	6.33	0.99	0	0.00	0.00	0.00	0.8	1.09	5.34
chloromethane	50	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Dichlorotetrafluoroethane	170	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0.382	0.52	3.61
vinyl chloride	62	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
1,3-Butadiene	54	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0.357	0.47	1.05	1.05	0	0.00	0.00	0.00	0	0.00	0.00
Methane,bromo-	94	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
ethanol	46	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
chloroethane	64	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Trichloromonofluoromethane	136	0.1	ppbv	0.26	0.37	2.05	0.00	0.316	0.50	2.76	0.31	0.388	0.51	2.86	0.41	0	0.00	0.00	0.00	0.324	0.44	2.45
acetone	58	0.1	ppbv	0	0.00	0.00	0.00	2.173	3.41	8.08	3.85	2.715	3.60	8.54	4.30	0	0.00	0.00	0.00	1.314	1.79	4.24
isopropylalcohol	60	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Ethene,1,1-dichloro-	96	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Ethane,1,1,2-trichloro-1,2,2-trifluoro-	186	0.1	ppbv	0.262	0.37	2.83	0.41	0.246	0.39	2.93	0.52	0.287	0.38	2.89	0.48	0.283	0.40	3.03	0.61	0.234	0.32	2.42
Carbondisulfide	76	0.1	ppbv	0.188	0.27	0.83	0.04	0.153	0.24	0.75	0.00	0.215	0.29	0.89	0.10	0	0.00	0.00	0.00	0.186	0.25	0.79
methylenechloride	84	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0.143	0.20	0.69	0.69	0	0.00	0.00
trans1,2-dichloroethylene	96	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
tert-butylmethylether(MTBE)	88	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
n-hexane	86	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Ethane,1,1-dichloro-	98	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
vinylacetate	86	0.1	ppbv	1.526	2.17	7.62	7.62	0	0.00	0.00	0.00	1.37	1.82	6.39	6.39	0	0.00	0.00	0.00	0	0.00	0.00
MEK$$2-butanone	72	0.1	ppbv	1.602	2.27	6.69	0.51	1.573	2.47	7.26	1.08	1.343	1.78	5.24	0.00	4.307	6.07	17.87	11.68	1.546	2.10	6.19
cis-1,2-dichloroethene	96	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
ethylacetate	88	0.1	ppbv	2.062	2.93	10.53	10.53	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0.053	0.07	0.27	0.27	0	0.00	0.00
Chloroform	118	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0.129	0.18	0.88	0.88	0	0.00	0.00
tetrahydrofuran	72	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Ethane,1,1,1-trichloro-	132	0.1	ppbv	0	0.00	0.00	0.00	0.261	0.41	2.21	2.21	0.248	0.33	1.78	1.78	0.248	0.35	1.89	1.89	0	0.00	0.00
Ethane,1,2-dichloro-	98	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Benzene	78	0.1	ppbv	0.292	0.41	1.32	0.26	0.31	0.49	1.55	0.48	0.245	0.32	1.04	0.00	0.289	0.41	1.30	0.23	0.246	0.33	1.07
carbontetrachloride	152	0.1	ppbv	0.428	0.61	3.78	0.36	0.435	0.68	4.24	0.83	0.425	0.56	3.50	0.09	0.428	0.60	3.75	0.34	0.404	0.55	3.41
Cyclohexane	84	0.1	ppbv	0	0.00	0.00	0.00	0.216	0.34	1.16	1.16	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
n-heptane	100	0.1	ppbv	0.232	0.33	1.35	1.35	0.307	0.48	1.97	1.97	0	0.00	0.00	0.00	0.238	0.34	1.37	1.37	0	0.00	0.00
Trichloroethylene	130	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Propane,1,2-dichloro-	112	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
1,4-dioxane	88	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Methane,bromodichloro-	162	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
MethylIsobutylKetone	100	0.1	ppbv	1.074	1.52	6.23	0.27	0	0.00	0.00	0.00	0	0.00	0.00	0.00	1.051	1.48	6.06	0.09	1.073	1.46	5.97
1-Propene,cis-1,3-dichloro-	110	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
1-Propene,trans-1,3-dichloro-	110	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Toluene	92	0.1	ppbv	0.336	0.48	1.79	0.37	3.795	5.95	22.40	20.97	1.39	1.84	6.94	5.51	0.273	0.38	1.45	0.02	0.279	0.38	1.43
Ethane,1,1,2-trichloro-	132	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
methyln-butylketone$$2-hexanone	100	0.1	ppbv	1.39	1.97	8.07	0.00	1.363	2.14	8.74	0.55	1.314	1.74	7.13	0.00	1.258	1.77	7.25	0.00	1.473	2.00	8.19
Methane,dibromochloro-	206	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Tetrachloroethylene	164	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Ethane,1,2-dibromo-	186	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Benzene,chloro-	112	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Ethylbenzene	106	0.1	ppbv	0.191	0.27	1.17	0.04	0.189	0.30	1.29	0.15	0.177	0.23	1.02	0.00	0.174	0.25	1.06	0.00	0.192	0.26	1.13
m&p-xylene	106	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Styrene	104	0.1	ppbv	1.009	1.43	6.09	0.27	1.06	1.66	7.07	1.26	0	0.00	0.00	0.00	0.981	1.38	5.88	0.06	1.006	1.37	5.82
o-xylene	106	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Methane,tribromo-	250	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Ethane,1,1,2,2-tetrachloro-	166	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
Benzene,1-ethyl-4-methyl-	120	0.1	ppbv	0.19	0.27	1.32	0.10	0.186	0.29	1.43	0.21	0.217	0.29	1.41	0.19	0.175	0.25	1.21	0.00	0.183	0.25	1.22
Benzene,1,3,5-trimethyl-	120	0.1	ppbv	0.327	0.46	2.28	0.84	0.221	0.35	1.70	0.27	0.253	0.34	1.65	0.21	0.295	0.42	2.04	0.61	0.215	0.29	1.43
Benzene,1,2,4-trimethyl-	120	0.1	ppbv	0.258	0.37	1.80	0.15	0.245	0.38	1.89	0.24	0.234	0.31	1.52	0.00	0.227	0.32	1.57	0.00	0.247	0.34	1.65
Benzene,1,3-dichloro-	146	0.1	ppbv	0.24	0.34	2.03	0.09	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0.236	0.33	1.99	0.04	0.24	0.33	1.95
Benzene,1-chloro-3-methyl-	126	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0.436	0.61	3.17	3.17	0	0.00	0.00
Benzene,1,4-dichloro-	146	0.1	ppbv	0.228	0.32	1.93	0.09	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0.223	0.31	1.88	0.03	0.227	0.31	1.84
Benzene,1,2-dichloro-	146	0.1	ppbv	0.276	0.39	2.34	0.00	0.207	0.32	1.94	0.00	0.202	0.27	1.60	0.00	0.199	0.28	1.67	0.00	0.352	0.48	2.86
Benzene,1,2,4-trichloro-	180	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
1,3-Butadiene,1,1,2,3,4,4-hexachloro-	258	0.1	ppbv	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00
						78.7	**24.6**			**85.5**	**36.8**			**61.8**	**21.5**			**66.3**	**22.0**			**63.0**

TO-15 analysis of various sampling sites at the Kings Co. dairy for 7/22/04.

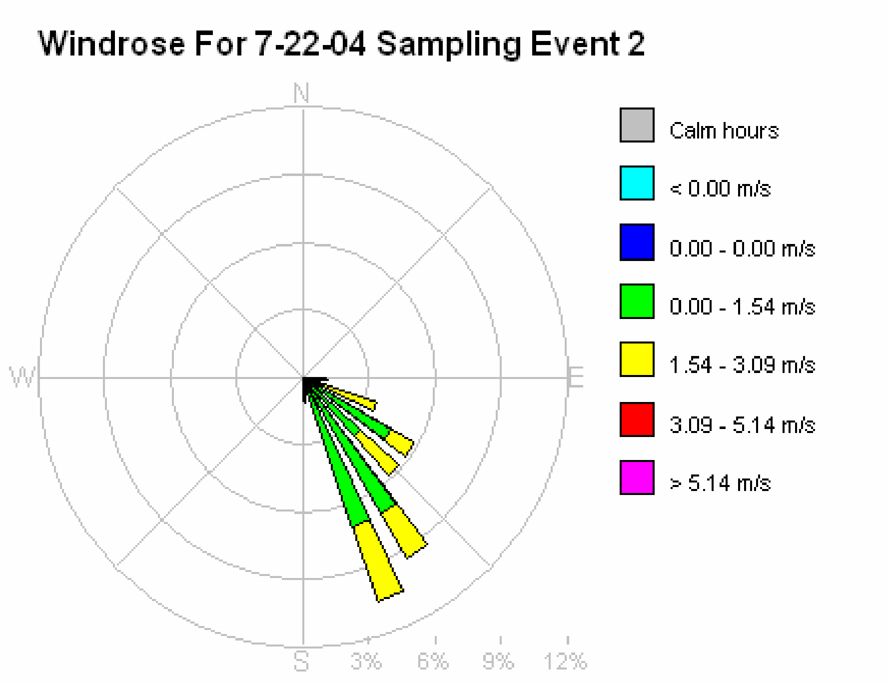
Kings Co. Dairy, 7/22/04

Gas Species	MW	MDL	units	FreeStall		Lagoon-1		Lagoon-2		Up Wind
				µg/m3	Net C	µg/m3	Net C	µg/m3	Net C	µg/m3
Benzene	**78**	**0.1**	**ppbv**	**1.32**	**0.26**	**1.55**	**0.48**	**1.04**	**0.00**	**1.07**
carbontetrachloride	**152**	**0.1**	**ppbv**	**3.78**	**0.36**	**4.24**	**0.83**	**3.50**	**0.09**	**3.41**
Cyclohexane	84	0.1	ppbv	0.00	0.00	1.16	1.16	0.00	0.00	0.00
n-heptane	**100**	**0.1**	**ppbv**	**1.35**	**1.35**	**1.97**	**1.97**	**0.00**	**0.00**	**0.00**
Trichloroethylene	130	0.1	ppbv	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Propane,1,2-dichloro-	112	0.1	ppbv	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1,4-dioxane	88	0.1	ppbv	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Methane,bromodichloro-	162	0.1	ppbv	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MethylIsobutylKetone	**100**	**0.1**	**ppbv**	**6.23**	**0.27**	**0.00**	**0.00**	**0.00**	**0.00**	**5.97**
1-Propene,cis-1,3-dichloro-	110	0.1	ppbv	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-Propene,trans-1,3-dichloro	110	0.1	ppbv	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	**92**	**0.1**	**ppbv**	**1.79**	**0.37**	**22.40**	**20.97**	**6.94**	**5.51**	**1.43**

Examples of selected TO-15 results showing calculation of net concentration (Net C) from the Downwind – Upwind values monitored during a sampling period (Kings Dairy, test 2, 1330-1600 on July 22, 2004). Concentrations of each gas in µgrams/m^3 at each sampling point are shown in **violet** for those gasses where significant enrichment was found and **green** where the ambient concentrations were not enriched across the dairy. The net concentrations used for modeling are shown in **blue** for enriched gasses and **yellow** where enrichment of ambient concentrations did not occur.

Kings County Dairy

7-22-04 test 2		1330 to 1600	
Summer Dairy 2	Measured TO-15 Concentration	Net TO-15 Concentration	Emission Rate
	µg/m³	µg/m³	#/hd/yr
Freestall	78.7	24.6	1.5
Primary Lgn	85.5	36.8	0.3
Storage Lgn	61.8	21.5	0.9
		Sum =	2.7



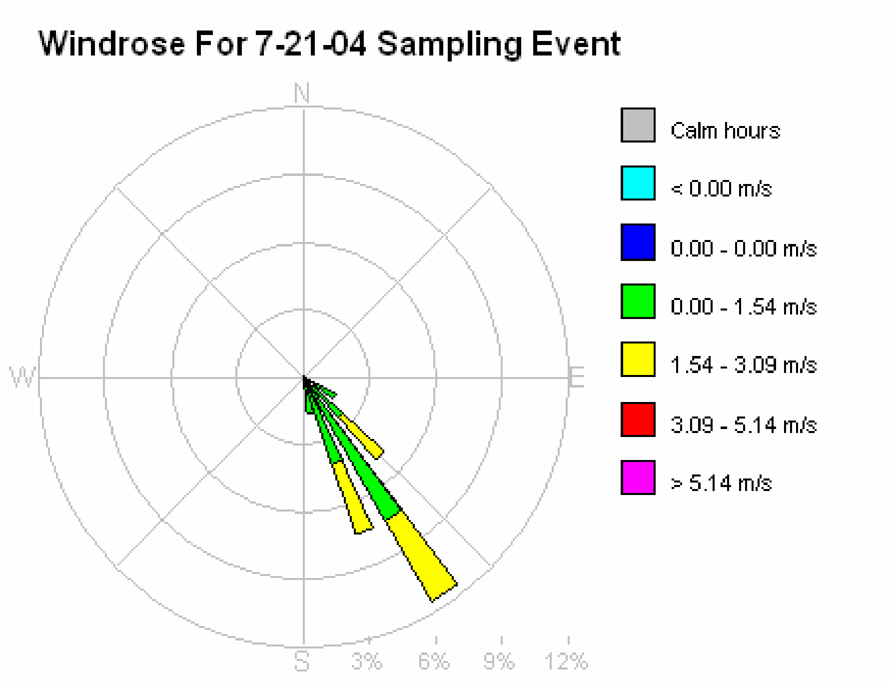
Comments:

Summer wind direction and speed were typical for this location. Wind speed in the early afternoon was less than at other locations but the direction was sufficiently consistent for modeling.

Kings County Dairy

7/21/2004		1300 to 1530	
Summer Dairy 2	Measured TO-15 Concentration	Net TO-15 Concentration	Emission Rate
	µg/m³	µg/m³	#/hd/yr
Freestall	72.7	21.5	1.3
Trt Lgn	55.9	27.7	0.2
Storage Lgn	52.4	10.3	0.4

Sum = 1.9



Comments:

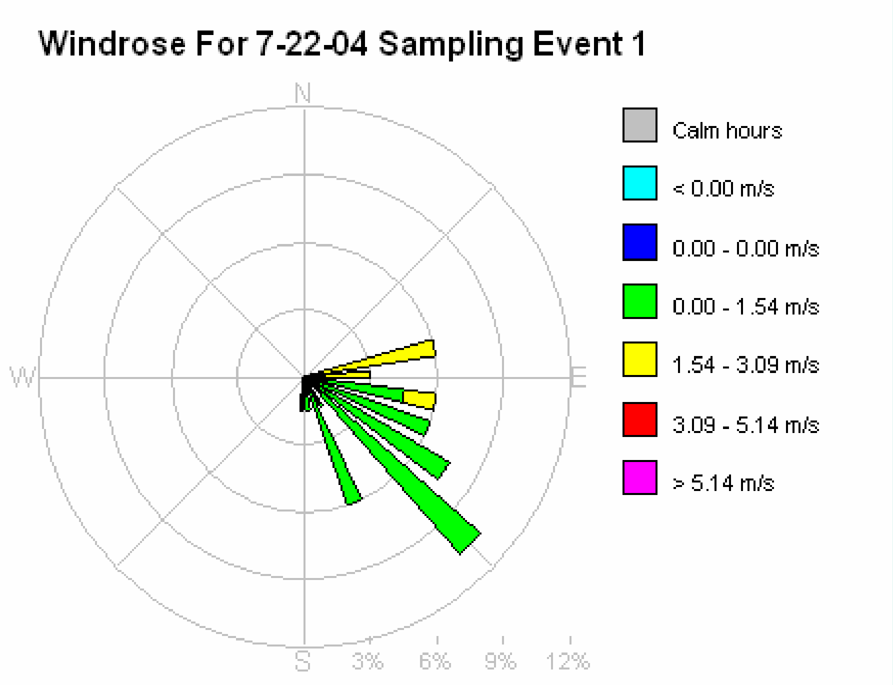
Summer wind direction and speed were typical for this location. Wind speed in the early afternoon was less than at other locations but the direction was sufficiently consistent for modeling.

Kings County Dairy

7-22-04 test 1 — 1100 to 1330

Summer Dairy 2	Measured TO-15 Concentration	Net TO-15 Concentration	Emission Rate
	µg/m³	µg/m³	#/hd/yr
Freestall	64.3	12.4	0.9
Trt Lgn	219.3	161.5	1.7
Storage Lgn	69.7	19.3	1.1

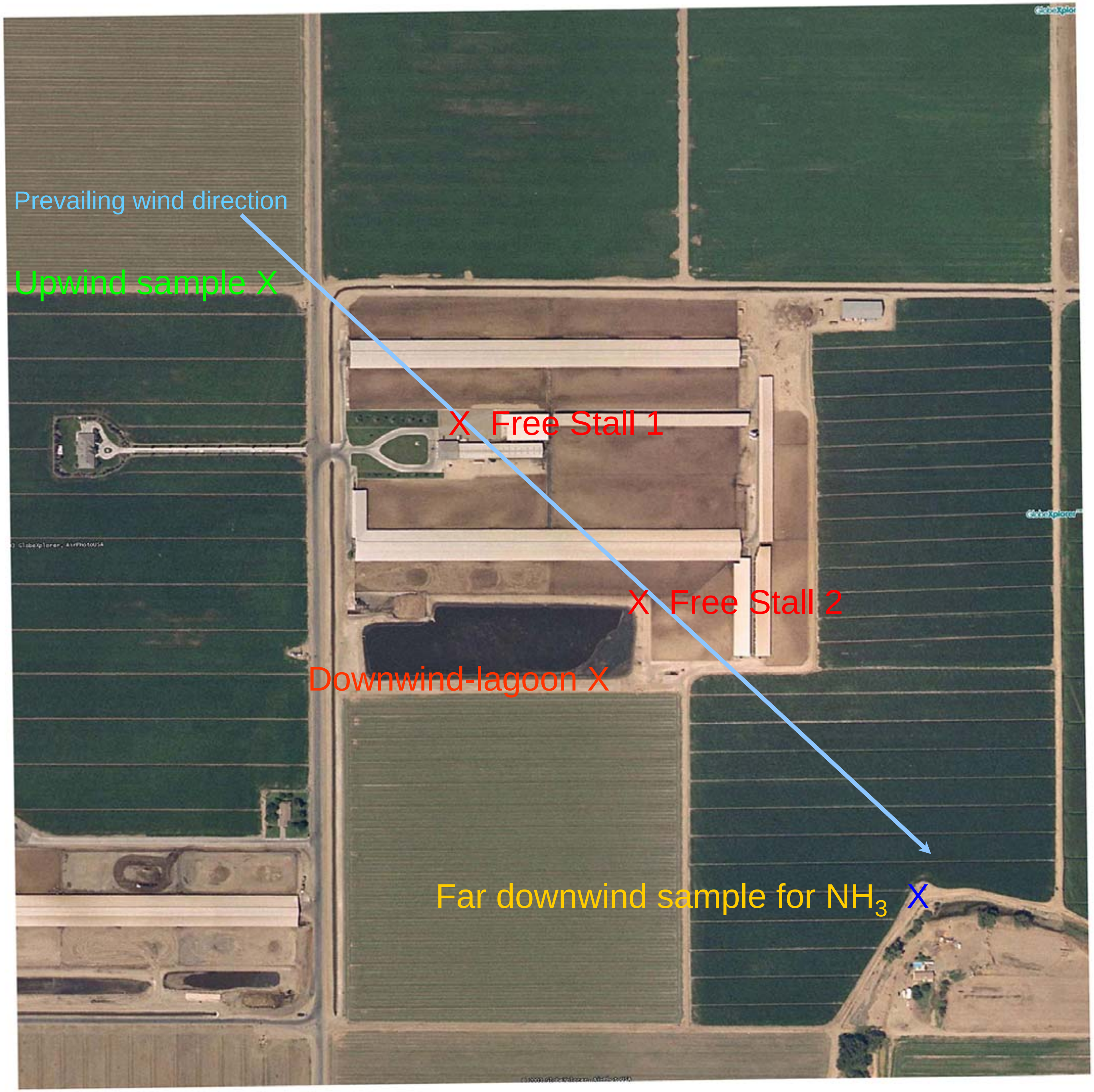
Sum = 3.7



Comments:

Summer wind direction and speed were typical for this location. Wind speed in the late morning was less than at other locations. There was more variability in the direction so modeled emissions are less accurate than other sampling episodes.

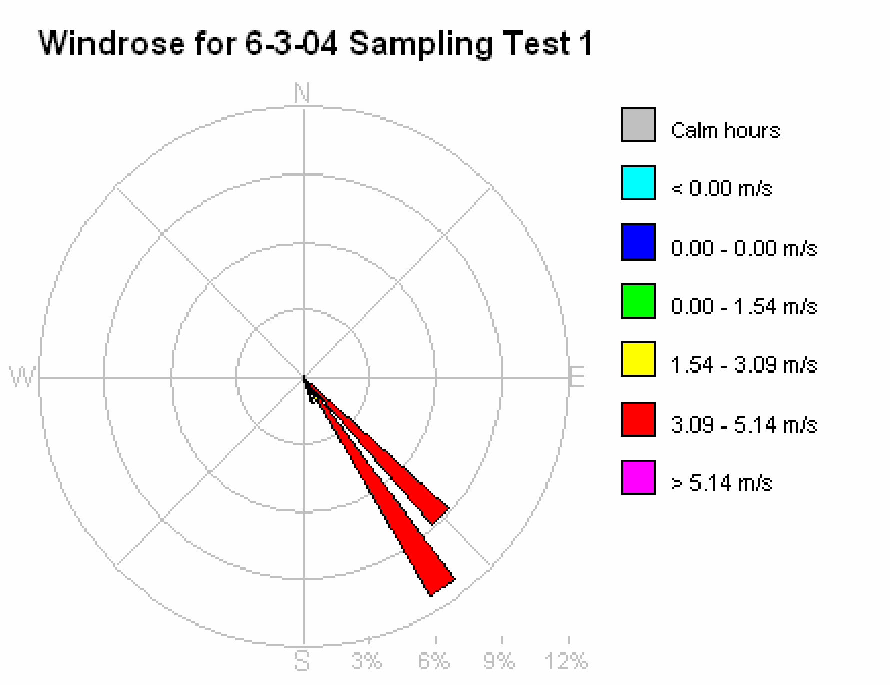
Merced Co. Dairy
Sampling locations
for 6/3/04



Merced County Dairy

6-3-04 test 1 — 945 to 1230

Summer Dairy 1	Measured TO-15 Concentration	Net TO-15 Concentration	Emission Rate
	µg/m³	µg/m³	#/hd/yr
Lagoon	79.2	16.2	2.4
Freestall 1	101.1	21.3	6.3
Freestall 2	73.5	14.4	3.6



Comments:

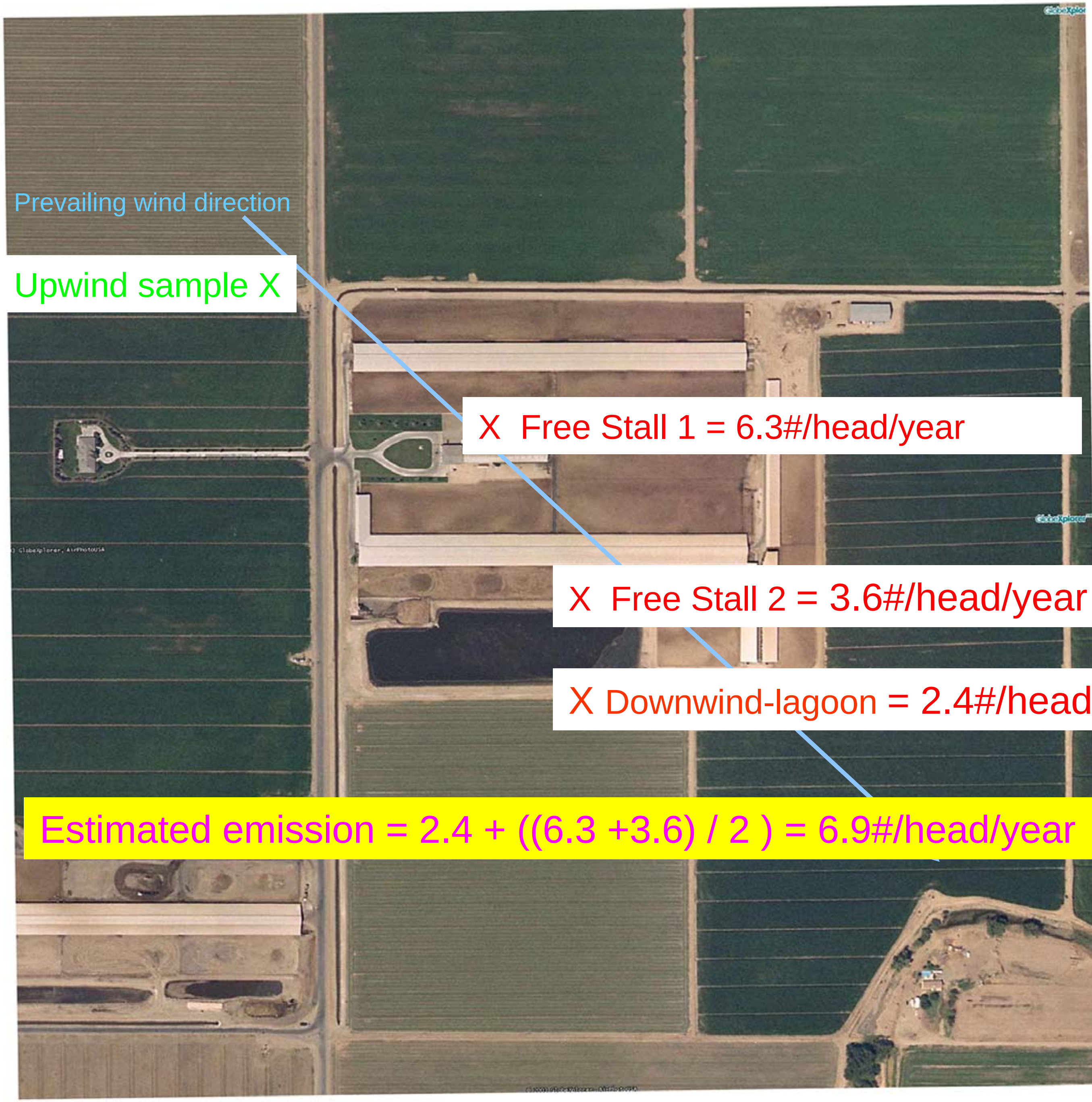
Summer wind conditions provided for almost a 3 hour sampling period in the late morning. Wind direction and speed were very consistent.

Locations for Animal Housing samples (Freestall 1 & 2) do not permit summing to determine the total ROG emissions from the dairy.

Merced County Dairy.

Sampled:

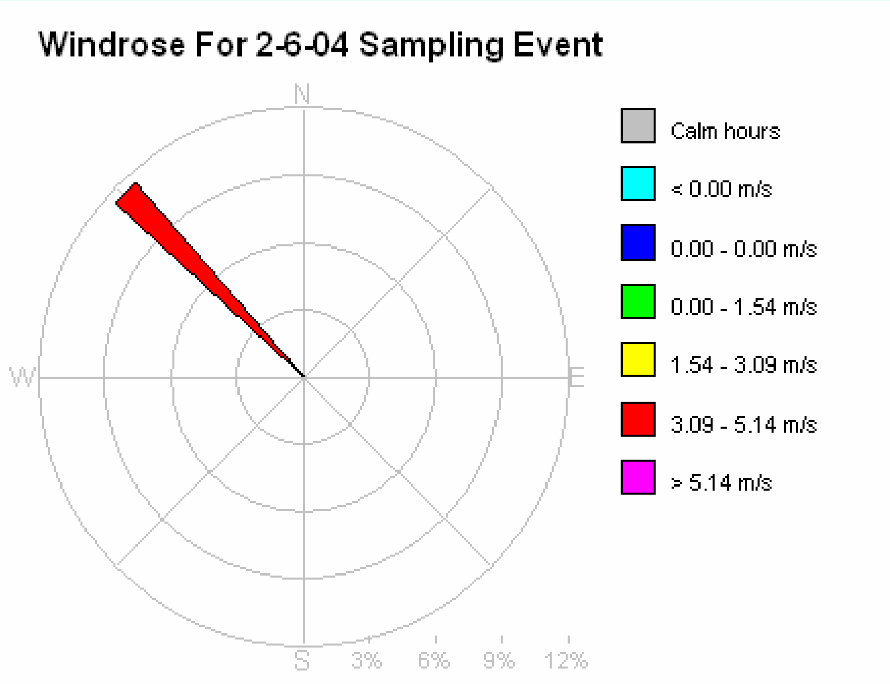
June 3, 2004



Merced County Dairy

2/6/2004 1100 to 1105

Winter Dairy 1	Measured TO-15 Concentration	Net TO-15 Concentration	Emission Rate
	µg/m³	µg/m³	#/hd/yr
Lagoon	139.6	39.4	1.5
Freestall 1	118.6	17.1	4.2
Freestall 2	109.7	20.1	3.8



Comments:

Winter wind conditions precluded the usual 2 hour sampling period with the wind from the NW. This was a 5 minute sample with the wind from the SE.

Estimating ROG emissions by averaging the Freestall values and adding the lagoon value = ((4.2 + 3.8)/2) + 1.5 = 5.5

Uncertainty Factors

- **Primary questionable factor is the analytical problem.**

- **No analytical procedure or standard for ozone precursors from ag operations exists. The GC-MS (EPA TO-15) method and standard is commonly used for other air quality analysis, provides speciation and it is consistent from lab to lab. This method may underestimate or overestimate ROG's from dairies because the standard probably does not precisely match the gasses emitted from the dairy operations.**

- **Recently, a standard gas for PAM (Photo-chemical Assessment Monitoring) analysis was found that appears to be closer to an ozone precursor standard for analysis of samples from dairies and other animal operations. Some recent published data from ARB funded projects supports the use of this standard to evaluate ROG's. That PAM standard has been ordered for use in evaluating samples to be collected in the future.**

- **TNMHC analysis from GC-FID is an overestimation since many measured gasses are not ROG's and contaminants cannot be easily identified and separated from the sample gasses. There are a number of different methods of detecting and reporting TNMHC that do not provide consistent results**

Additional Uncertainty Factors

- Requirement for consistent wind direction and speed for modeling of results.
- Wide range of management levels at dairies.
- Sampling problems related to the analytical difficulties.
- Seasonal variability
- Influence of upwind and surrounding agricultural operations.

Very Preliminary Conclusions

- **Hypotheses supported or contradicted by these initial results:**

- The animal holding areas (free-stalls and exercise corrals) are a larger source of ROG than lagoons by a factor of 2-4.

- The seasonal variability may not be as large as expected.

- The level of management may affect emissions. The Kings Co. dairy was flushed, scraped and had a series of lagoons. That dairy had lower ROG emissions from both the animal areas and the lagoon.

QUESTIONS?

Monitoring and Modeling of ROG at California Dairies

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