Corpus Christi Air Monitoring and Surveillance Camera Project
Sixth Annual Report to the US District Court

by

THE UNIVERSITY OF TEXAS AT AUSTIN

Center for Energy and Environmental Resources

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Today's Presentation

- Introductions
- Project Overview
- Project Budget
- Project Financial Status
- Temporal Trends & Other Data Analysis
- Interactions with the Community
- Statement by Representative of the Project's Voluntary Advisory Board
- Q & A

Project Overview

- Year 1
  - Hired contractors and began construction of 7 sites
  - Established Voluntary Advisory Board
- Year 2
  - Completed construction of sites, acceptance testing of sites & began reporting data April 1, 2005 (collected data for 6 months of Year 2) through TCEQ & project websites
- Years 3 through 6
  - Continued collection & reporting of data; optimized operation of sites to maximize use of project funds
  - Project remains on schedule & within budget

Air Monitoring Network Site Locations

Project Budget

- Of total project costs for first 6 years, only site construction (1.5 years) and 3.5 year of operations & maintenance (O&M) costs have been funded by this project
- Additional funds provided by a Supplemental Environmental Project (SEP) awarded by the TCEQ funded O&M costs for one year
- Beginning October 2, 2006, all O&M costs have been charged to this project.
- Total expenditures for the first 6 years of the project included only 3.5 years of O&M costs

Project Financial Status

Expenditures

Total for prior years	$4,102,965.72
Current year (ending 9/30/09)	$988,842.68
Total* to date (9/30/09)	$5,091,808.40

* Initial budget estimated $2,300,000 for site construction & deployment and $2,664,600 for operations & maintenance after construction for approximately 3.5 years for a total initial estimate of $4,964,600; Actual costs were $5,091,808.40.

Funds Remaining

Initial deposit (10/2/03)	$6,761,718.02
Less expenditures to date (9/30/09)	($5,091,808.40)
Plus interest earned to date (9/30/09)	$726,125.61
Project funds remaining**	$2,396,035.23

**The remaining project funds plus future interest earned are estimated to allow the project to operate for two more years (total of 8 years compared to initial estimate of 7 years) to September 2011, assuming no extraordinary costs arise.

Temporal Trends & Other Data Analysis

Outline

1. Monitoring network background
2. TCEQ toxicological terminology
3. Summary of speciated hydrocarbons measured in residential areas
4. Trends in total non-methane hydrocarbon data
5. Trends in benzene measured in residential areas
6. Three case study analyses of pollution events
7. Update on canister sampling
8. Summary of sulfur compound measurements
9. Conclusions

1. Monitoring Network Background

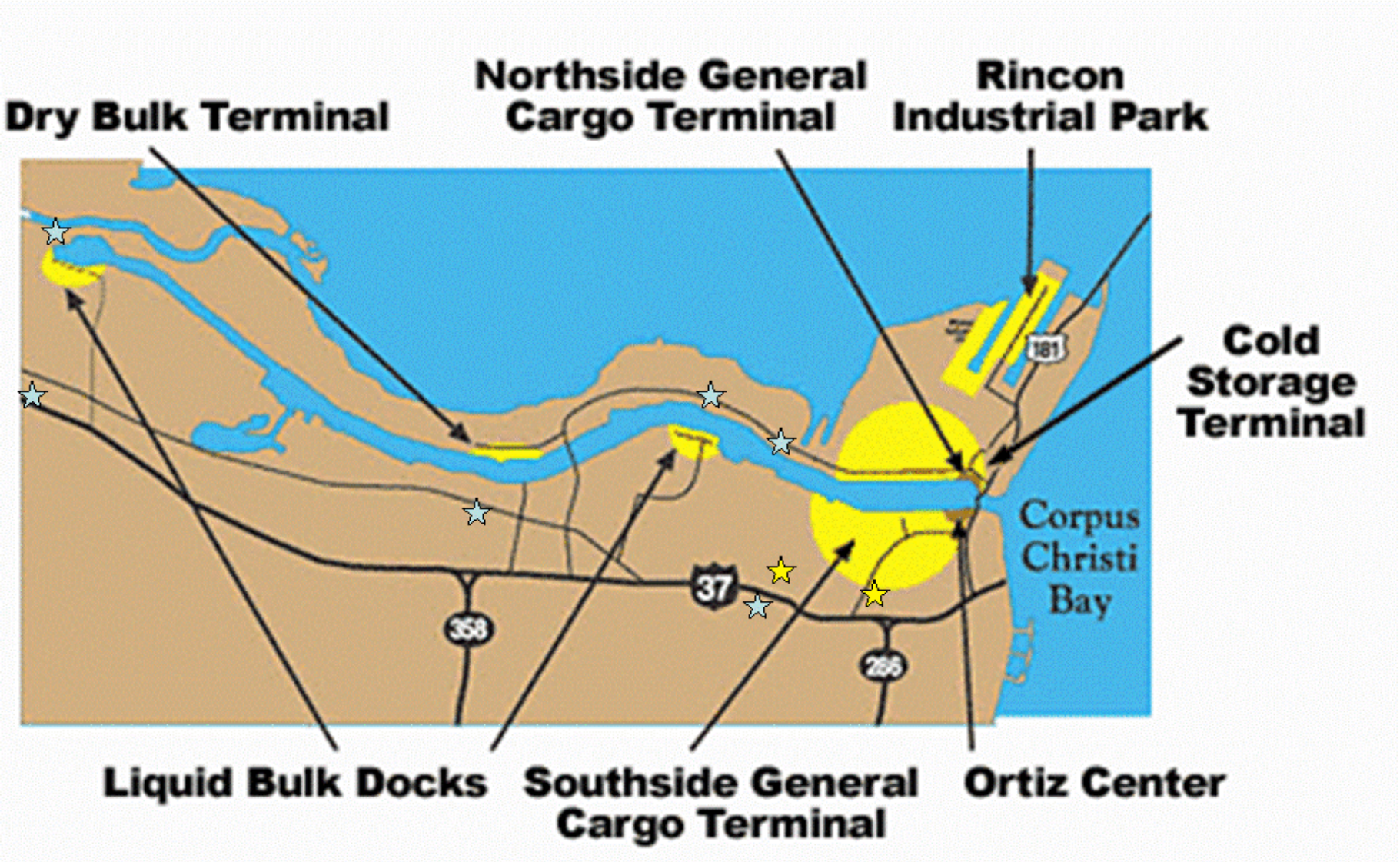
Air Monitoring Sites, Locations, & Instrumentation

TCEQ CAMS Nos.	Description of Site Location	Monitoring Equipment				
		Auto GC	TNMHC(T) & Canister(C)	H2S & SO2	Met Station	Camera
634	Oak Park Recreation Center	Yes	T		Yes	
629	Grain Elevator @ Port of Corpus Christi		T&C	Yes	Yes	
630	J. I. Hailey Site @ Port of Corpus Christi		T&C	Yes	Yes	
635	TCEQ Monitoring Site C199 @ Dona Park		T&C	Yes	Yes	Yes
631	Port of Corpus Christi on West End of CC Inner Harbor		T&C	Yes	Yes	
632	Off Up River Road on Flint Hills Resources Easement		T&C	Yes	Yes	
633	Solar Estates Park at end of Sunshine Road	Yes	T	Yes	Yes	Yes

Air Monitoring Network Site Locations

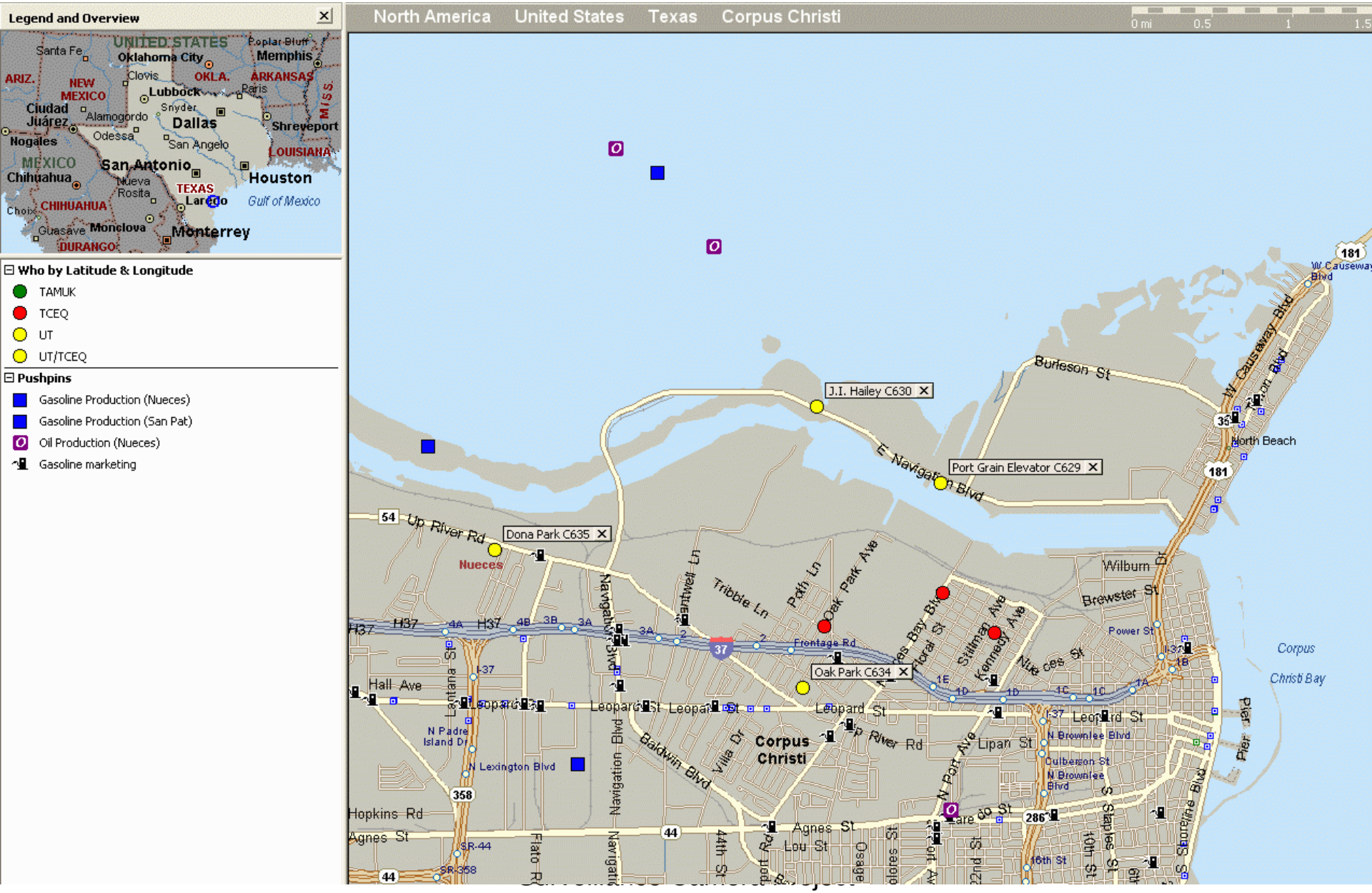
Monitors and Emissions - Industry

Monitors and Emissions - Shipping

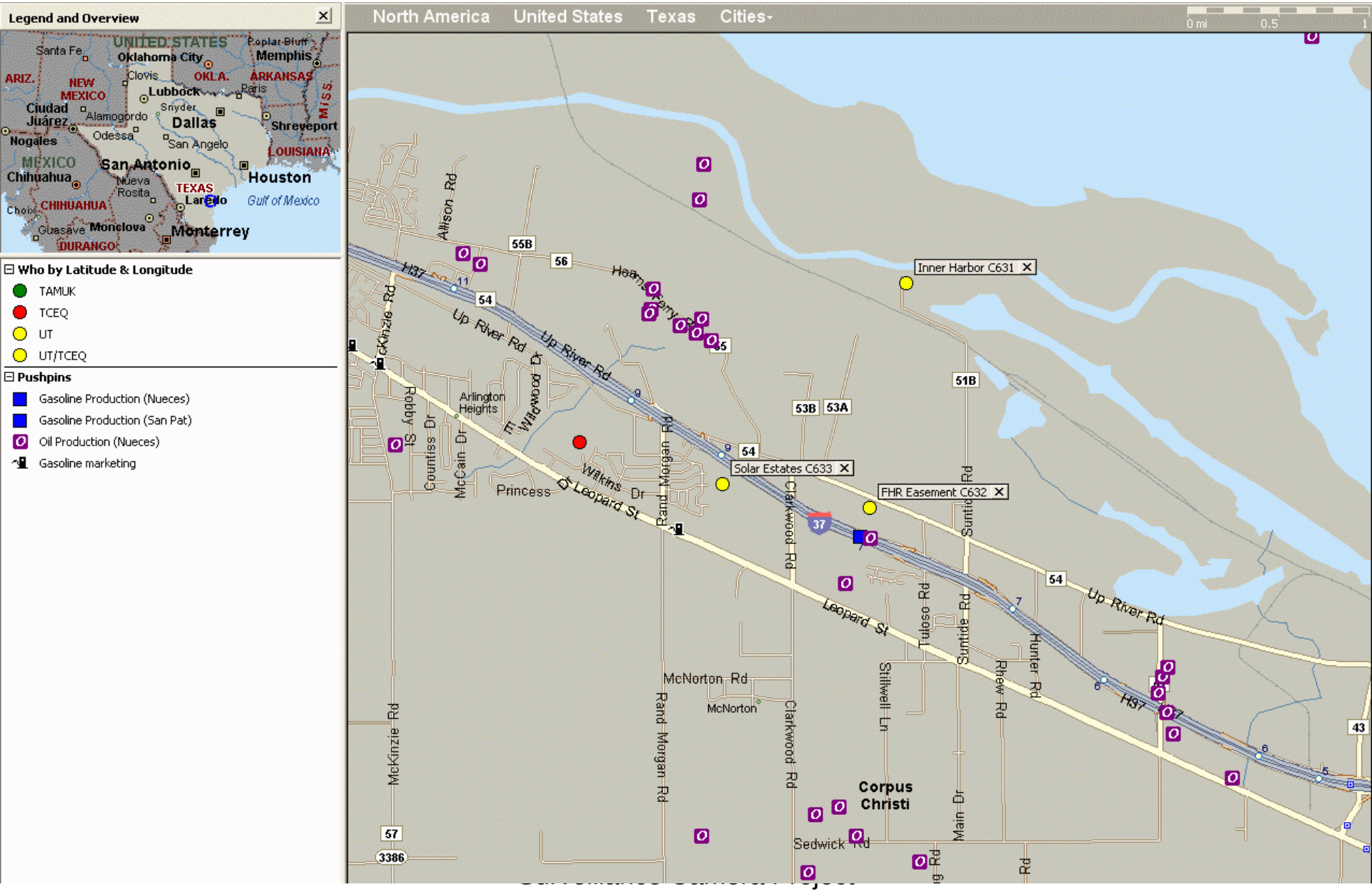


☆ UT CAMS ★ TCEQ CAMS

Small Emission Sources Eastern Network



Small Emission Sources Western Network



Explanation of monitoring terms

- **Pollutant concentrations** –
  - Gravimetric vs volumetric; ppbC vs ppbV
- **Auto-GC** –
  - 40 min sample every hour for 47 hydrocarbon species C2-C11
  - Carcinogens, photochemical compounds
  - Sited in neighborhoods at Solar Estates CAMS 633 & Oak Park CAMS 634.
- **Total non-methane hydrocarbons (TNMHC)** –
  - 5 min time resolution, unspeciated, aside from methane
  - Operate at all 7 UT/CEER sites.
  - Sustained level of 2000 ppbC used to trigger canister samples.
- **Canister** –
  - Stainless steel cans filled when sensor detects elevated TNMHC.
  - 20 minute samples capture chemical make-up of air, some 50 – 55 species.
  - Operated at 5 of 7 UT/CEER sites.
- **"Elevated Concentrations"** – Colloquial term for pollutant above ESL or ReV (e.g., benzene), above a state standard (e.g., H_2S), above a triggering threshold (e.g., TNMHC), or statistically significantly higher than average (e.g., $p<0.01$).

2. TCEQ Toxicological Terminology

Explanation of monitoring terms

- **Effects Screening Levels (ESLs) – "***used to evaluate potential for effects to occur as a result of exposure to concentrations of constituents in the air. ESLs based on data concerning health effects, potential for odors to be a nuisance, effects on vegetation, & corrosive effects. … not ambient air standards. If … levels of a constituent do not exceed screening level, adverse health or welfare effects are not expected. If ambient levels of constituents in air exceed screening levels, it does not necessarily indicate a problem but rather triggers a review in more depth."* *(emphasis added)*

Use of ESLs

- Air permit reviews involve evaluations of BACT & predicted concentrations from proposed new emissions.
- In review of proposed emissions, federal/state standards & chemical-specific Effects Screening Levels (ESLs) are used.

Explanation of monitoring terms

- **Reference Values (ReVs)** - ReVs are health-based toxicity values used in evaluation of ambient air monitoring data and in calculation of health-based ESLs and source media cleanup levels.
- Benzene ReV = 180 ppbV for 1-hour
- Benzene long-term ESL used for long-term exposure = 1.4 ppbV

Use of ReVs

- Reference Values (ReVs) are used
  - to evaluate measured air toxics for potential to cause health/welfare effects, and
  - to help TCEQ prioritize resources in permitting, compliance, enforcement.
- Generally, ESL = 0.3 * ReV

3. Summary of Hydrocarbon Species Measured in Residential Areas

General downward trend over time

All 2009 values below ESL or ReV

Solar Estates Auto-GC annual means

Species -ppbV	Oct 2005-Sep 2006	Oct 2006-Sep 2007	Oct 2007-Sep 2008	Oct 2008-Sep 2009
Ethane	8.44	8.66	6.78	6.74
Ethylene	0.41	0.52	0.37	0.35
Propane	5.39	5.37	3.93	3.98
Propylene	0.32	0.33	0.17	0.19
Isobutane	2.22	1.98	1.38	1.42
n-Butane	2.76	2.92	2.14	2.12
t-2-Butene	0.16	0.12	0.07	0.05
1-Butene	0.05	0.06	0.04	0.04
c-2-Butene	0.07	0.07	0.04	0.03
Isopentane	1.84	1.81	1.25	1.2
n-Pentane	1.07	1.14	0.76	0.73
1,3-Butadiene	0.08	0.08	0.02	0.06
t-2-Pentene	0.04	0.06	0.03	0.03
1-Pentene	0.02	0.04	0.02	0.02
c-2-Pentene	0.02	0.03	0.01	0.01
n-Hexane	0.4	0.44	0.29	0.26
Benzene	**0.32**	**0.39**	**0.24**	**0.21**
Cyclohexane	0.25	0.29	0.2	0.17
Toluene	0.37	0.45	0.29	0.28
Ethyl Benzene	0.05	0.06	0.03	0.03
p-Xylene + m-Xylene	0.32	0.36	0.19	0.17
o-Xylene	0.06	0.07	0.05	0.04
Isopropyl Benzene - Cumene	0.01	0.03	0.01	0.01
1,3,5-Trimethylbenzene	0.02	0.03	0.02	0.01
1,2,4-Trimethylbenzene	0.05	0.07	0.04	0.04
n-Decane	0.03	0.05	0.03	0.03
1,2,3-Trimethylbenzene	0.02	0.03	0.01	0.01

Oak Park Auto-GC annual means

Species -ppbV	Oct 2005-Sep 2006	Oct 2006-Sep 2007	Oct 2007-Sep 2008	Oct 2008-Sep 2009
Ethane	8.06	8.54	7.73	6.53
Ethylene	0.97	0.99	0.77	0.62
Propane	6.48	6.15	5.02	4.2
Propylene	1.03	0.83	0.5	0.34
Isobutane	2.6	2.55	2.21	1.66
n-Butane	3.5	3.71	3.51	2.8
t-2-Butene	0.17	0.2	0.14	0.06
1-Butene	0.15	0.14	0.08	0.05
c-2-Butene	0.13	0.13	0.1	0.04
Isopentane	2.67	3.06	2.78	2.22
n-Pentane	1.72	2.04	1.67	1.4
1,3-Butadiene	0.04	0.08	0.06	0.03
t-2-Pentene	0.09	0.12	0.09	0.05
1-Pentene	0.05	0.07	0.05	0.03
c-2-Pentene	0.05	0.06	0.03	0.02
n-Hexane	0.62	0.62	0.45	0.43
Benzene	**0.74**	**0.73**	**0.38**	**0.38**
Cyclohexane	0.27	0.23	0.19	0.16
Toluene	0.75	0.78	0.56	0.6
Ethyl Benzene	0.07	0.07	0.05	0.05
p-Xylene + m-Xylene	0.25	0.22	0.16	0.15
o-Xylene	0.1	0.08	0.06	0.05
Isopropyl Benzene - Cumene	0.04	0.03	0.03	0.03
1,3,5-Trimethylbenzene	0.04	0.03	0.02	0.02
1,2,4-Trimethylbenzene	0.09	0.08	0.06	0.05
n-Decane	0.04	0.03	0.02	0.02
1,2,3-Trimethylbenzene	0.03	0.03	0.02	0.01

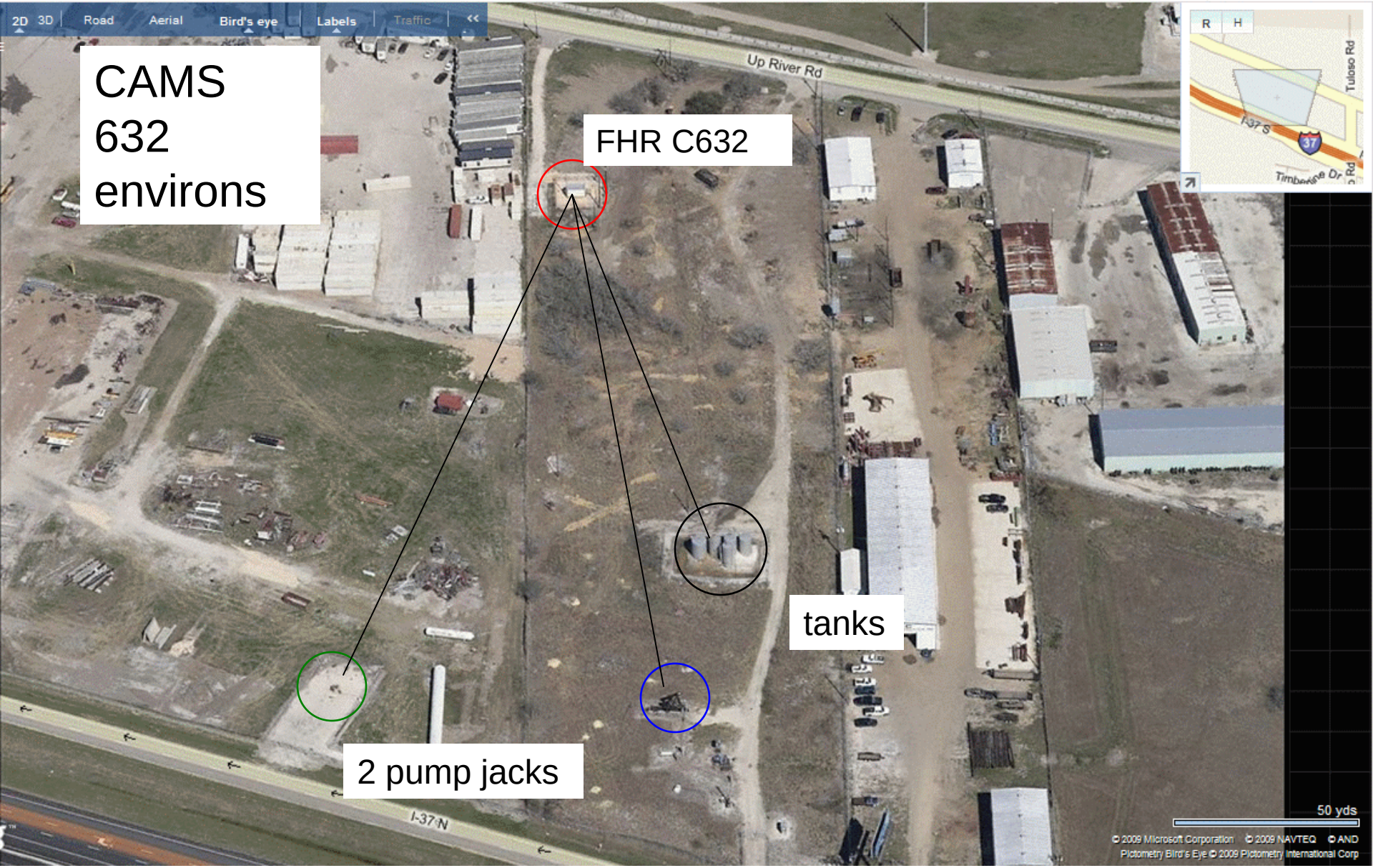
4. Trends in Total Nonmethane Hydrocarbons

Significant declines area-wide

Especially noteworthy decline at one site

FHR CAMS 632 TNMHC

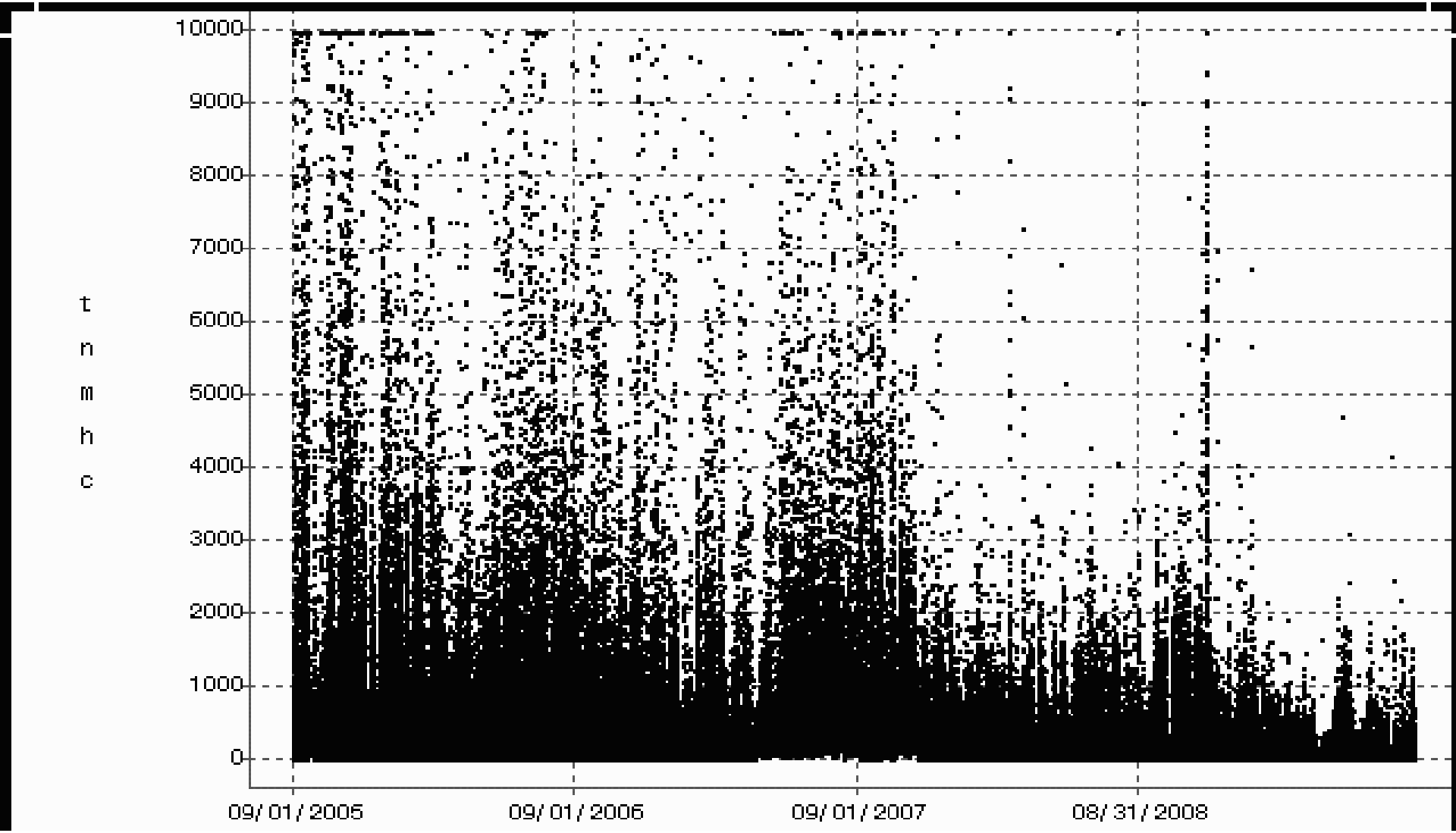
- Formerly measured the highest concentrations in the area
- Concentrations have dropped significantly
- Likely cause is reduced emissions from “small” nearby sources


CAMS 632 environs
FHR C632
tanks
2 pump jacks
Up River Rd
I-37 N
2D 3D Road Aerial Bird's eye Labels Traffic
50 yds
© 2009 Microsoft Corporation © 2009 NAVTEQ © AND
Pictometry Bird's Eye © 2009 Pictometry International Corp

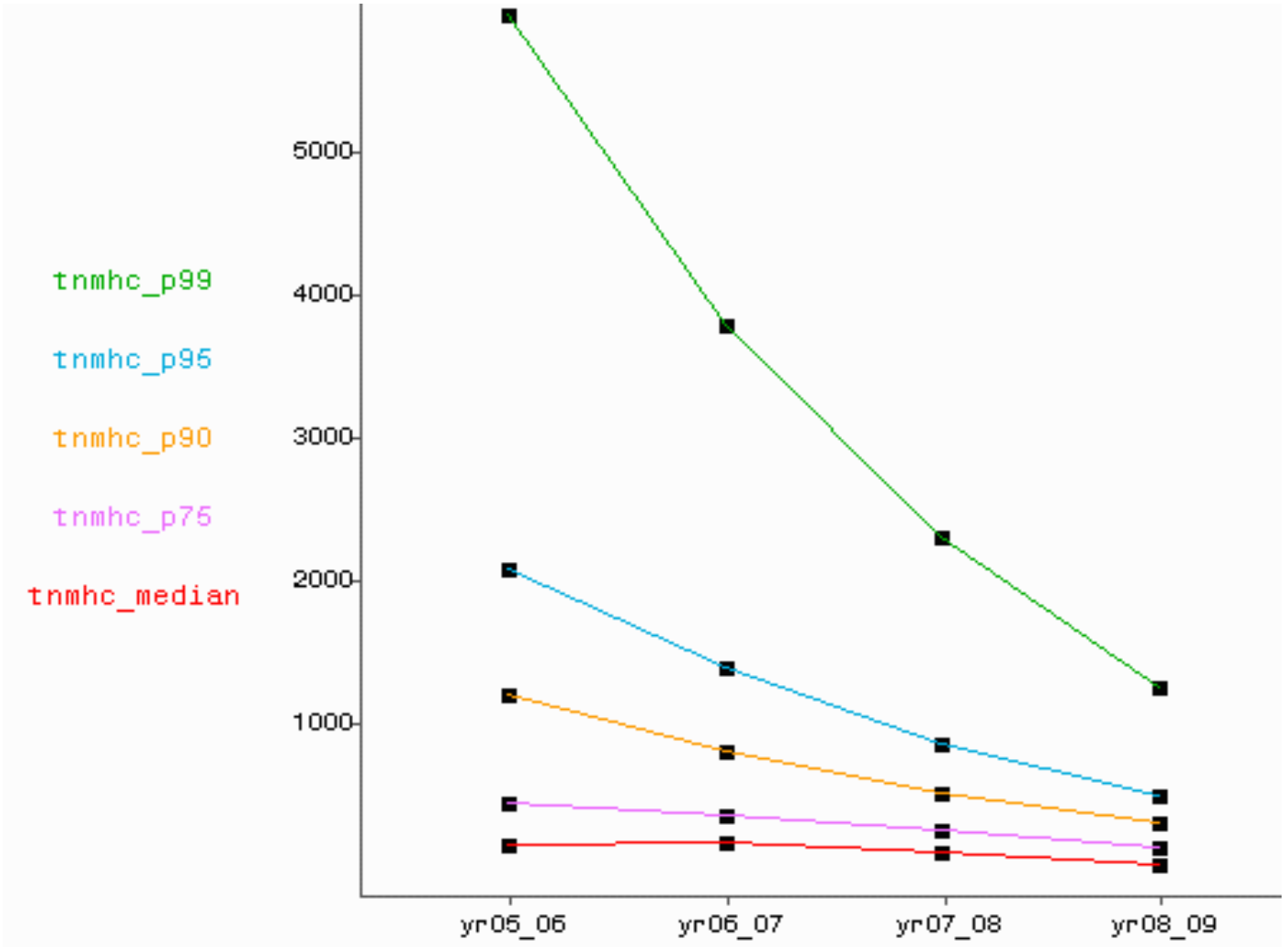
CAMS
632
environs

5-min TNMHC ppbC FHR C632 Sept 05 – Aug 09

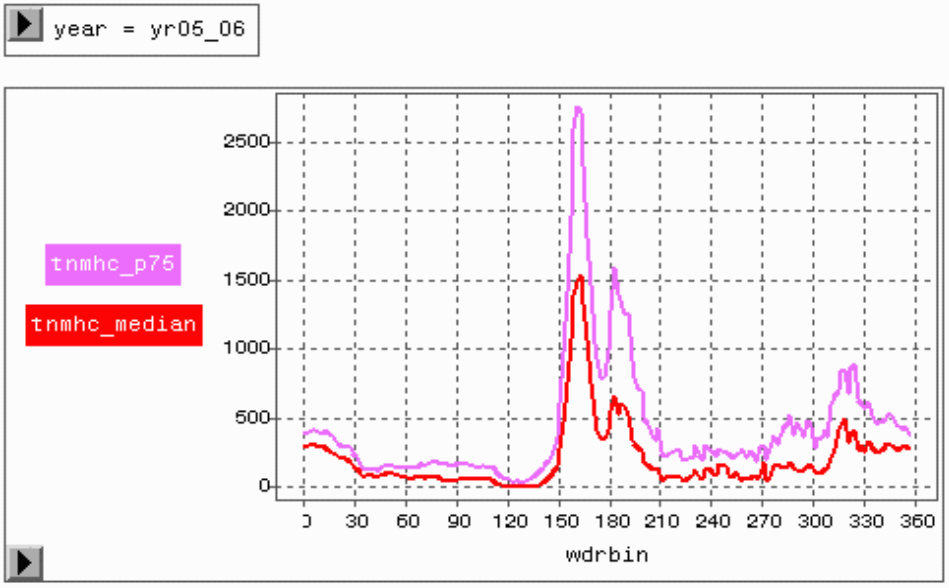
(omit 110 values not cropped at 10,000 ppbC)

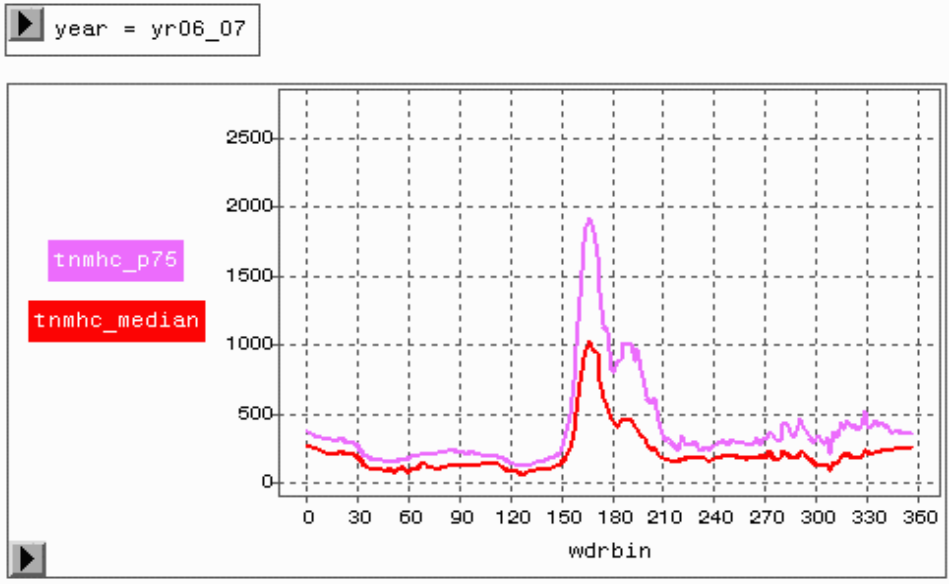


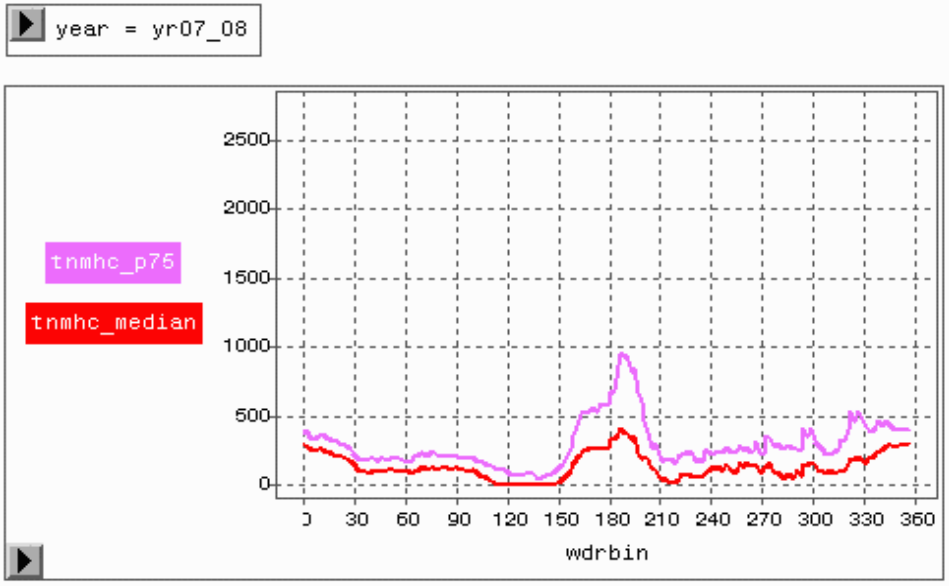
FHR C632 TNMHC Sept. – Aug. median, 75th, 90th, 95th, 99th p-tiles 5-min data

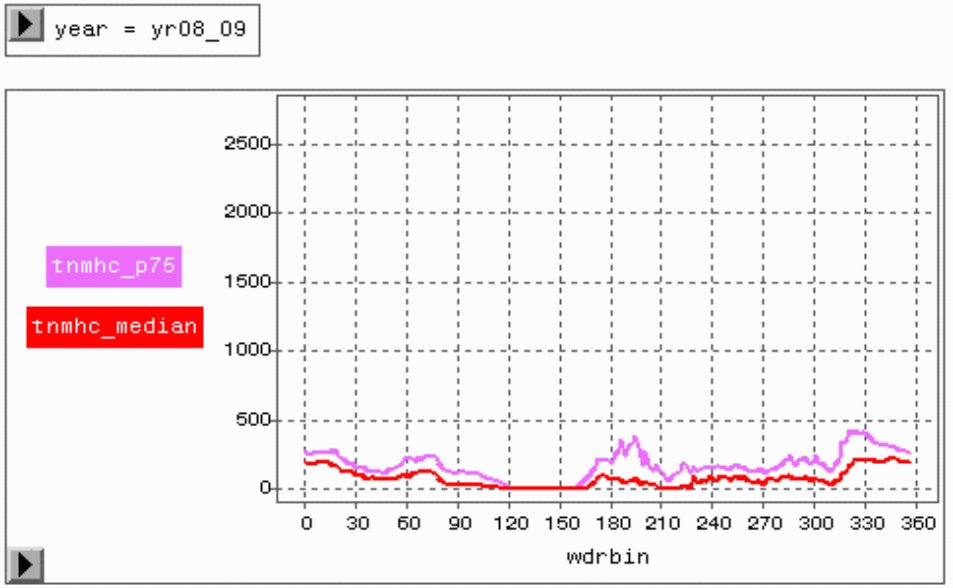


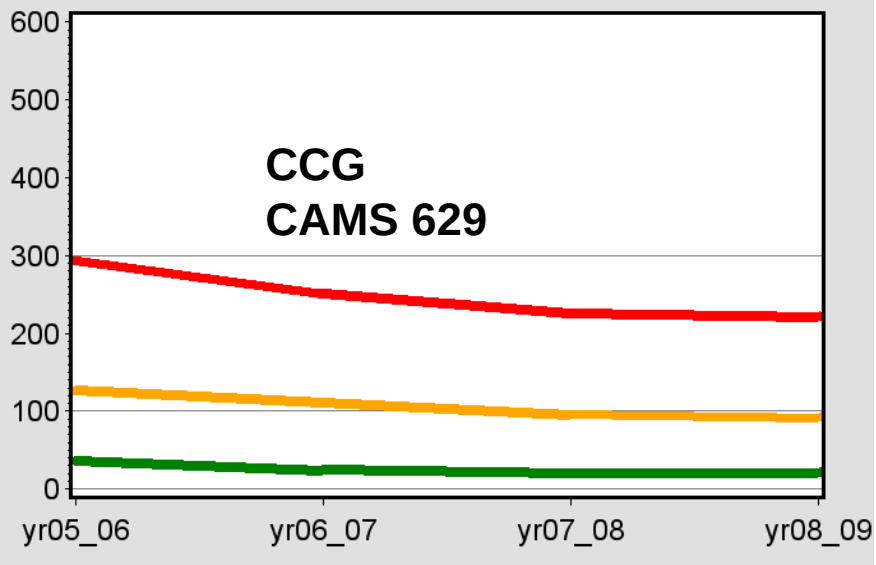
TNMHC ppbC median & 75th p-tile concentrations 2-deg. wind dir bins, by Sept – Aug periods

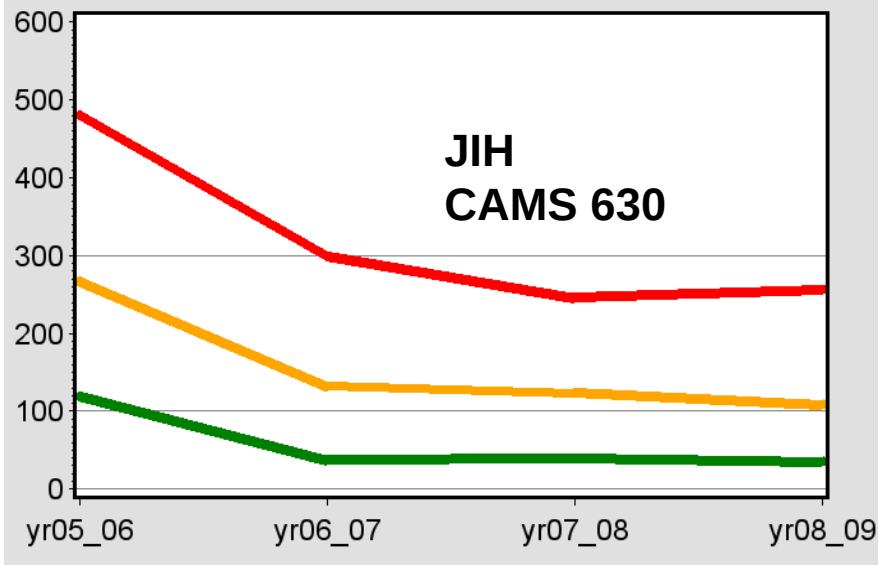


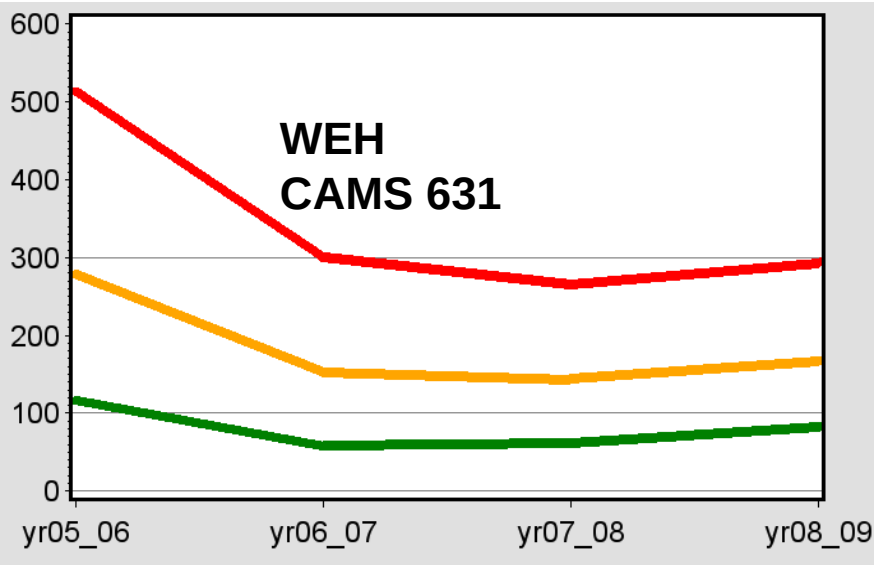










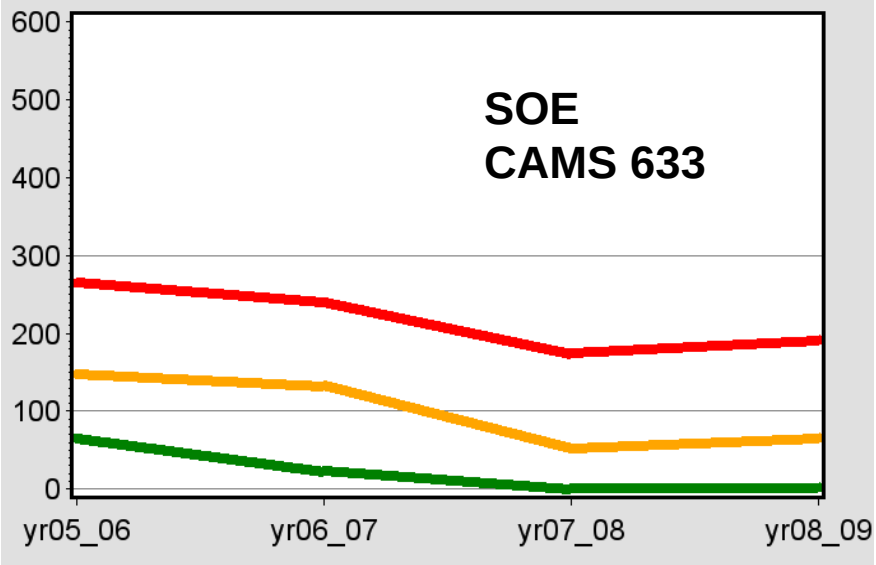


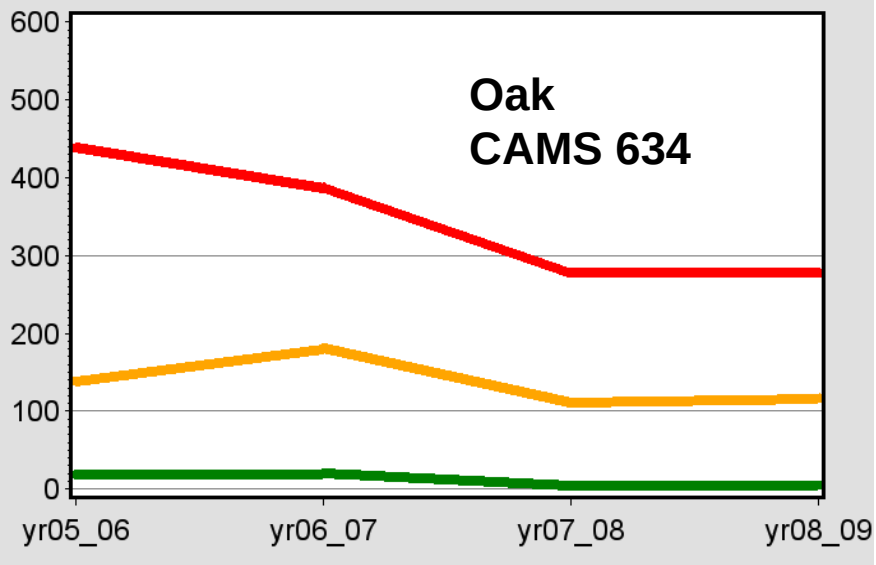
median
75th p-tile
90th p-tile

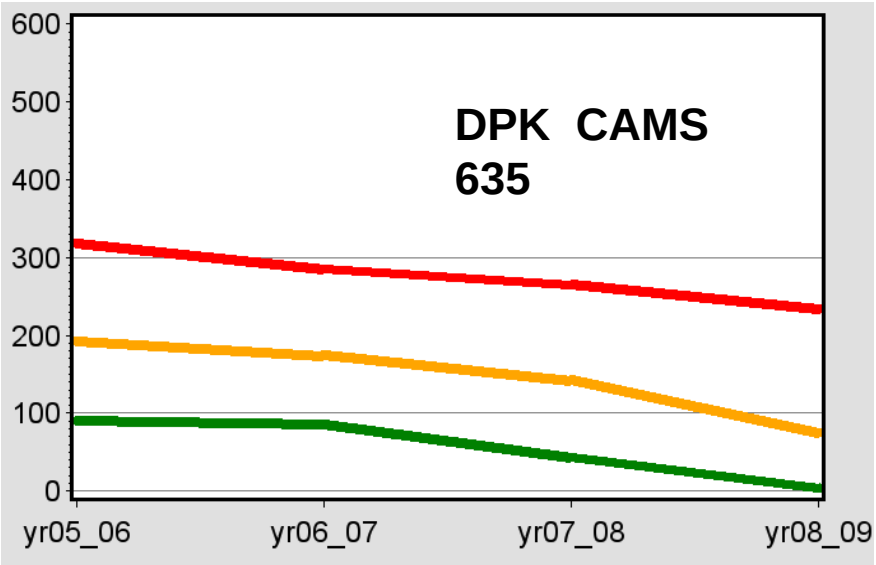
Trends at other TNMHC sites

ppbC units

Sept.-Aug. years (State FY)







median
75th p-tile
90th p-tile

Trends at other TNMHC sites

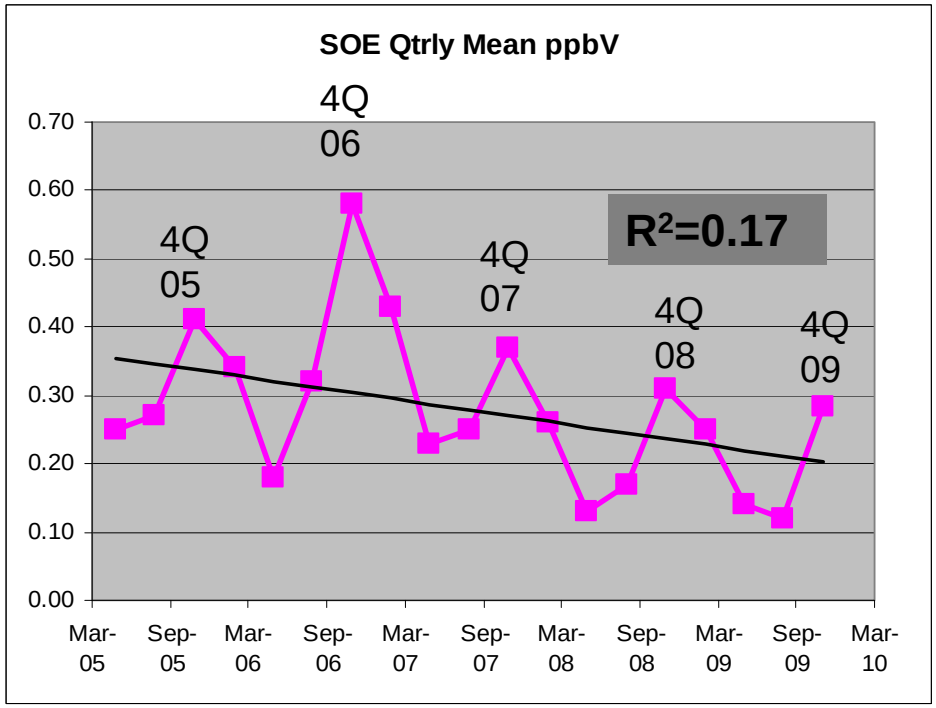
ppbC units

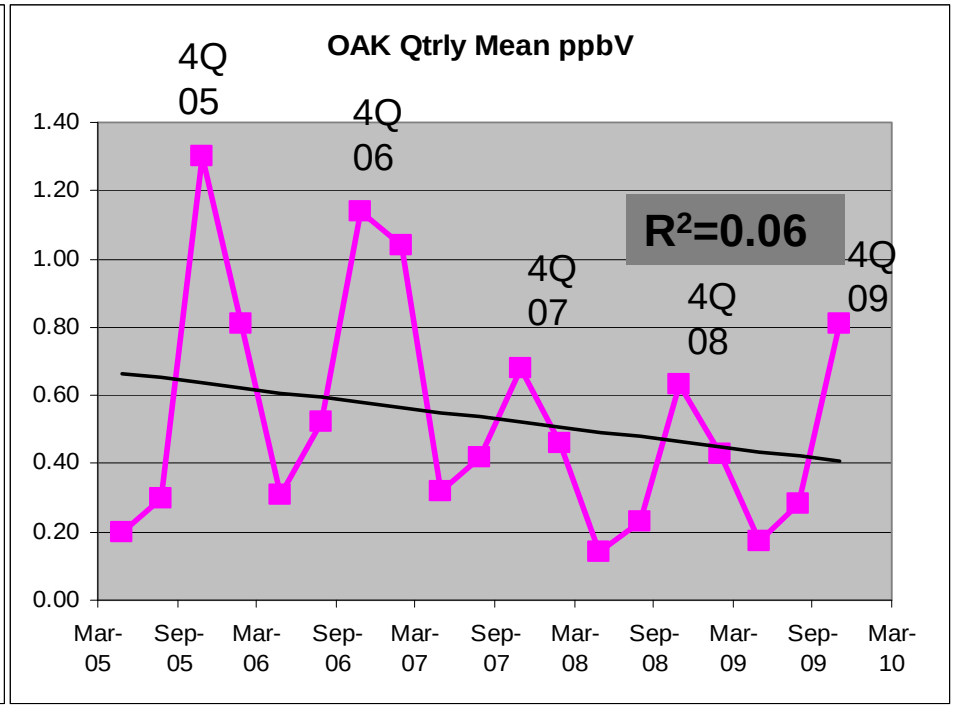
Sept.-Aug. years (State FY)

5. Benzene Trends

Seasonally-adjusted quarterly means show clear decline

2005-2009 Quarterly Benzene from Auto-GCs in Corpus Christi

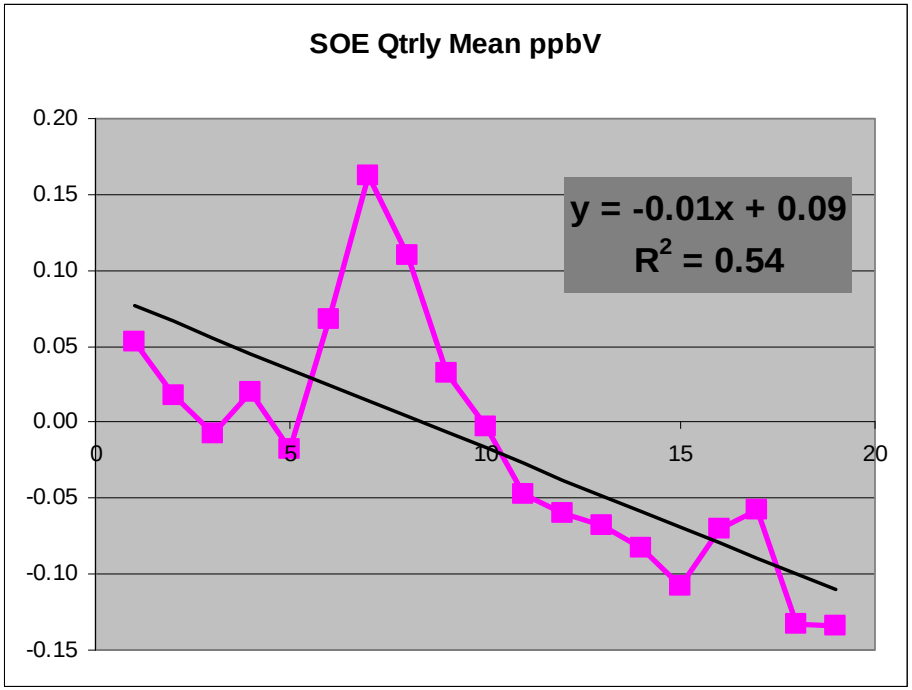


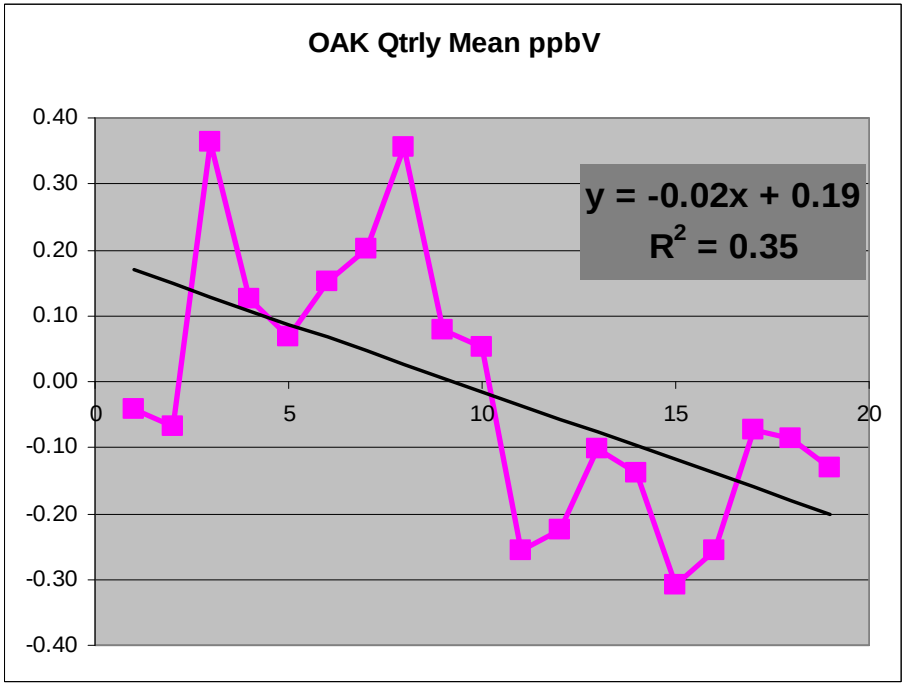


General downward trend, significant seasonality

Slight up-tick at Oak Park in 4Q09

Seasonally-adjusted benzene trends





After adjusting for seasonality, downward trend is more significant

Trend suggests **0.01**
ppb/qtr average decline at Solar Estates (0.04 ppb/yr) and
0.02 ppb/qtr average decline at Oak Park (0.08 ppb/yr)

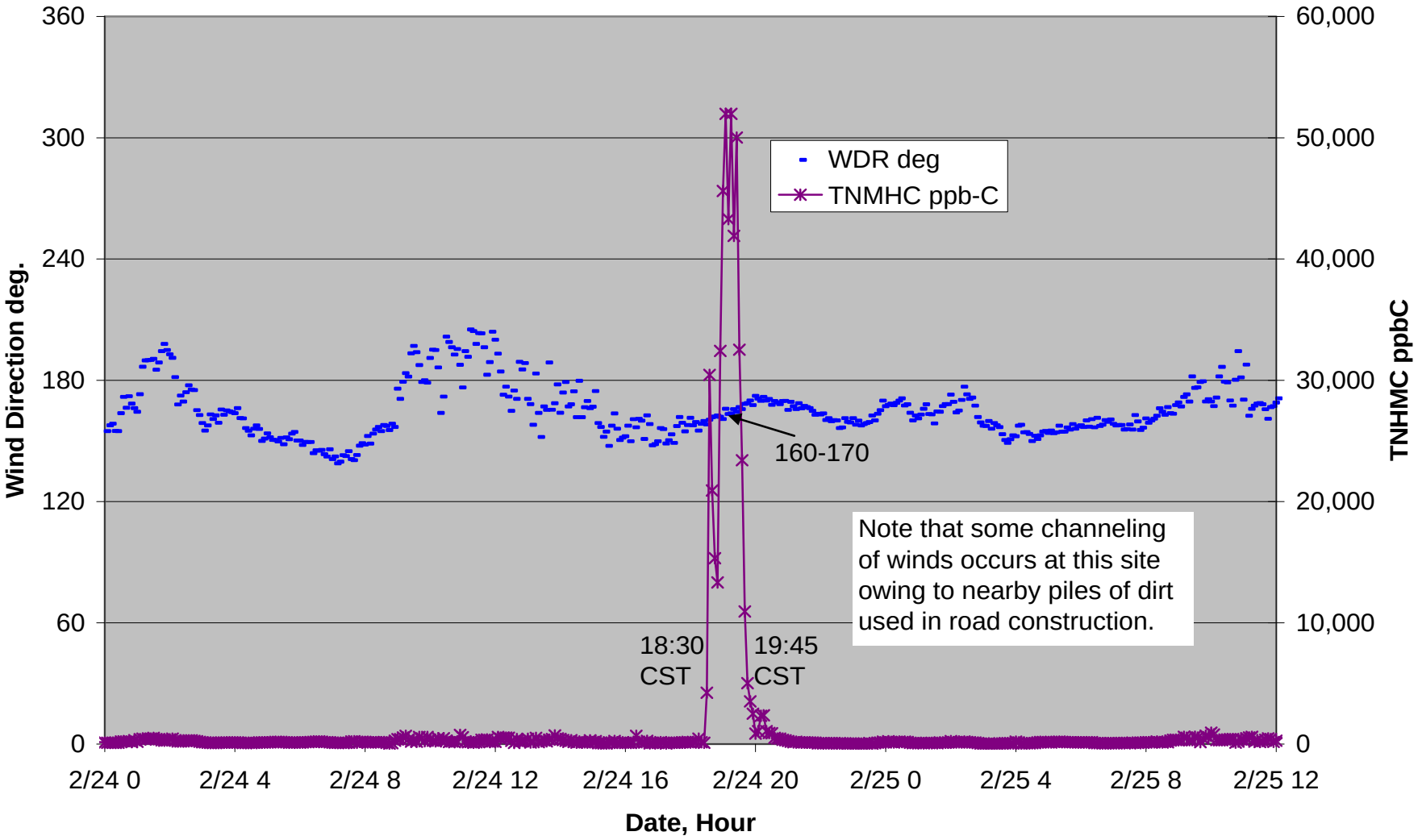
6. Three Case Studies

- TNMHC at WEH 2/24/09
- 1,3-Butadiene at Solar Estates 9/26/09
- White Point emissions study

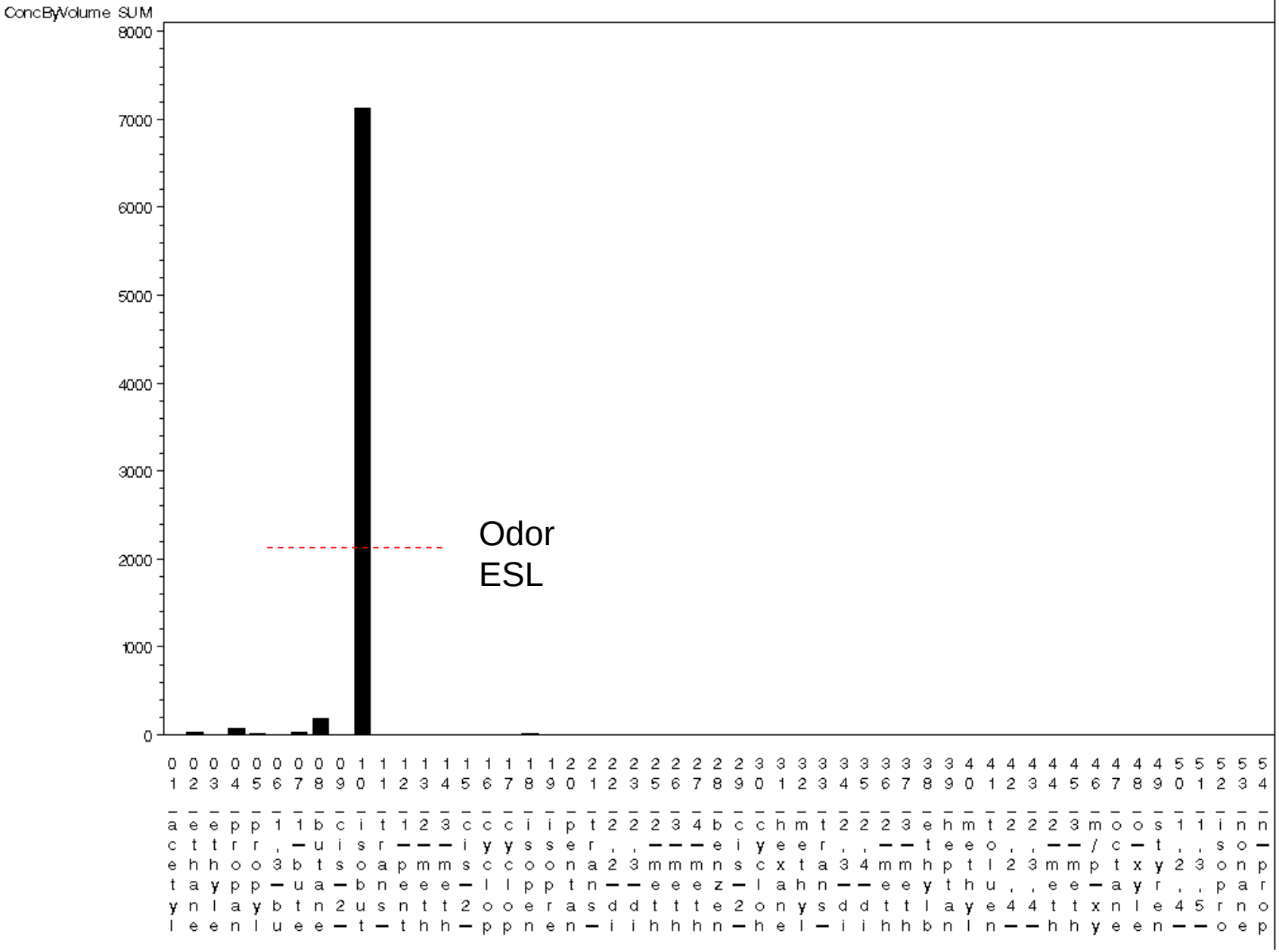
Case Study 1: TNMHC at WEH 2/24/09

- Email alert at WEH, 6:35 pm, 16 mph SE winds.
- TNMHC at 52,000 ppbC, one of the highest recorded values ever.
- FHR representative told TCEQ they had found a ¼" hole in a hose at the railcar loading rack where isobutane was being loaded. FHR estimated 12 pounds had leaked from 6 pm to 7:30 pm.

TNMHC data and wind direction 2/24/09



Canister contents: Isobutane



Surface back-trajectory from time of maximum TNMHC

Case Study 2: Solar Estates 1,3-Butadiene

- Unusually high values measured Sept. 27, 2009
- Strong directionality present in data since 2005
- No apparent health risk at Solar Estates; however, *uncertainty exists regarding concentrations closer to the source*.

1,3-Butadiene
http://www.atsdr.cdc.gov/tfacts28.html

- Made via processing petroleum.
- Colorless gas with mild gasoline-like odor.
- About 75% used to make synthetic rubber, widely used for tires.
- Also used to make plastics, acrylics.
- Small amounts are found in gasoline.

TCEQ Reference Value & ESL for 1,3 Butadiene

Table 1. Health- and Welfare-Based Values		
Short-Term Values	**Concentration**	**Notes**
^{acute}ESL [6 h] (HQ = 0.3)	1,100 µg/m^3 (510 ppb)	**Critical Effect:** Developmental toxicity; reduction in extragestational weight gain and in fetal body weight in CD-1 mice
Acute ReV [6 h] (HQ = 1.0)	3,700 µg/m^3 (1,700 ppb) [a]	
^{acute}ESL$_{odor}$	510 µg/m^3 (230 ppb) [a] **Short-Term ESL for Air Permit Reviews**	50% detection threshold, mild aromatic odor

[a] Values that may be used for evaluation of air monitoring data

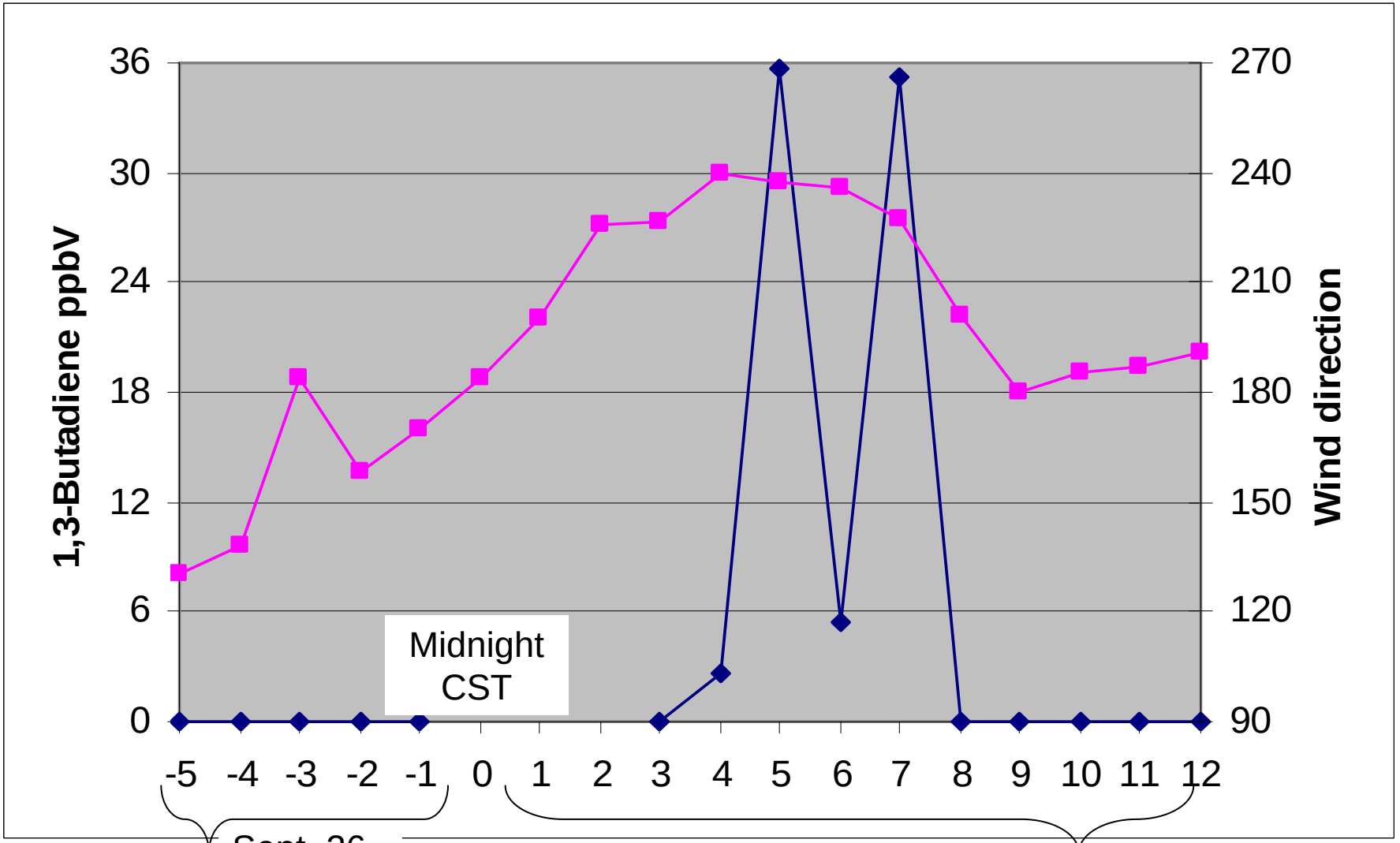
See http://www.tceq.state.tx.us/implementation/tox/dsd/final.html

"HRVOC" -- Effect on Ozone Formation -- 1,3-Butadiene ranks 3rd or 4th among 58 species we measure in terms of photochemical reactivity

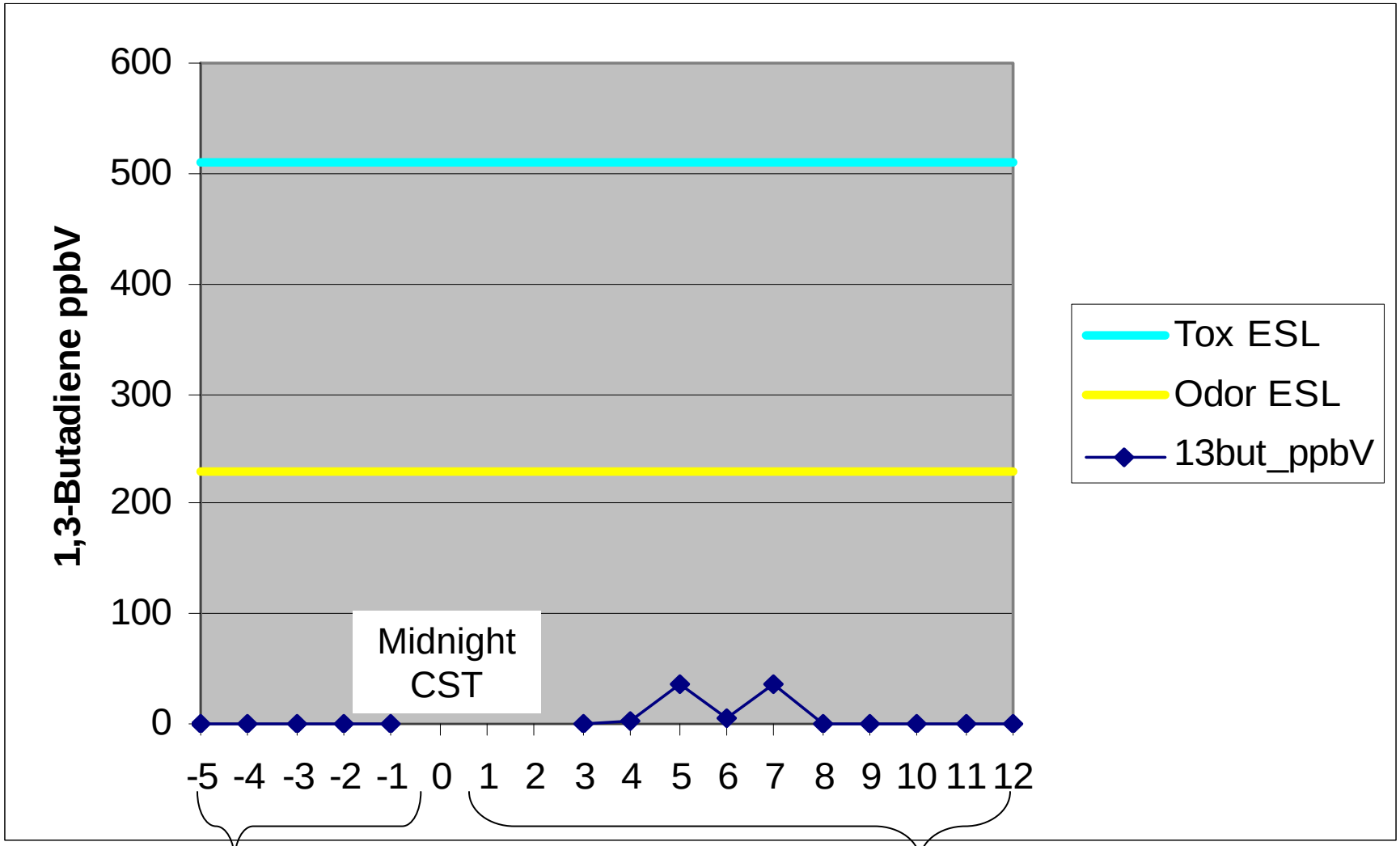
1,3-Butadiene at Solar Estates

- No short-term value or long-term average is close to an ESL or ReV.
- However, data from Solar Estates suggests short & long-term concentrations may be higher at other locations in the area.
- Max values measured to date were taken on Sunday Sept. 27, 2009 at 5 and 7 CST (6 a.m. and 8 a.m. CDT)

1,3-Butadiene and Wind Direction by Hour (CST) nighttime 9/26 and morning 9/27



9/26-27 1,3-Butadiene ppbV and Health Effects Screening Levels



Possible emission source

- Only one industrial facility upwind on 9/27 (Equistar on McKinzie Rd)
- No upsets reported in that area on 9/27

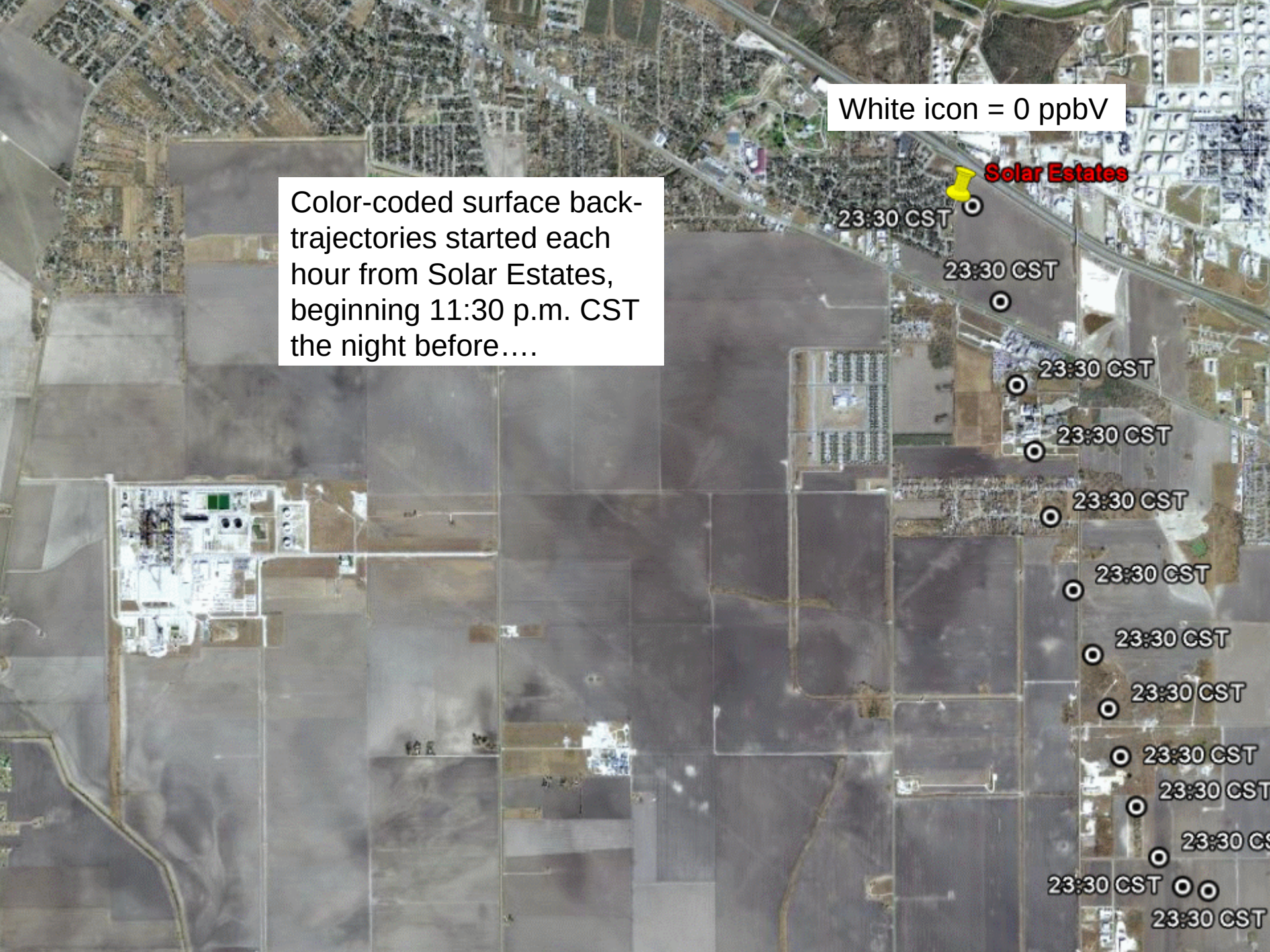
Search Results - Air Emission Event Reports

You asked about air emissions in NUECES County, with a start date between 09/15/2009 and 10/04/2009.

The list below is not sorted.

Click the Tracking Number to see the detailed information for that air emission report.

Tracking Number	Air emission event at:	Began:	Ended:	Type of event
129628	FLINT HILLS RESOURCES CORPUS CHRISTI WEST PLANT	09/19/2009	09/19/2009	emissions event
129826	VALERO CORPUS CHRISTI REFINERY EAST PLANT	09/24/2009	09/25/2009	emissions event
129658	HYDROGEN PLANT INDUST GAS	09/24/2009	09/24/2009	emissions event
130159	VALERO CORPUS CHRISTI REFINERY WEST PLANT	10/02/2009	10/04/2009	maintenance
129697	VALERO CORPUS CHRISTI REFINERY WEST PLANT	09/21/2009	10/04/2009	maintenance
129432	FLINT HILLS RESOURCES CORPUS CHRISTI WEST PLANT	09/15/2009	09/15/2009	maintenance
129182	BARNEY M DAVIS POWER STATION	09/26/2009	09/26/2009	maintenance
130157	VALERO CORPUS CHRISTI REFINERY WEST PLANT	10/02/2009	10/02/2009	air shutdown
129319	VALERO CORPUS CHRISTI REFINERY EAST PLANT	09/15/2009	09/18/2009	air shutdown
129849	VALERO CORPUS CHRISTI REFINERY EAST PLANT	09/25/2009	09/27/2009	air startup


White icon = 0 ppbV
Color-coded surface back-trajectories started each hour from Solar Estates, beginning 11:30 p.m. CST the night before….
Solar Estates
23:30 CST
23:30 CST
23:30 CST
23:30 CST
23:30 CST
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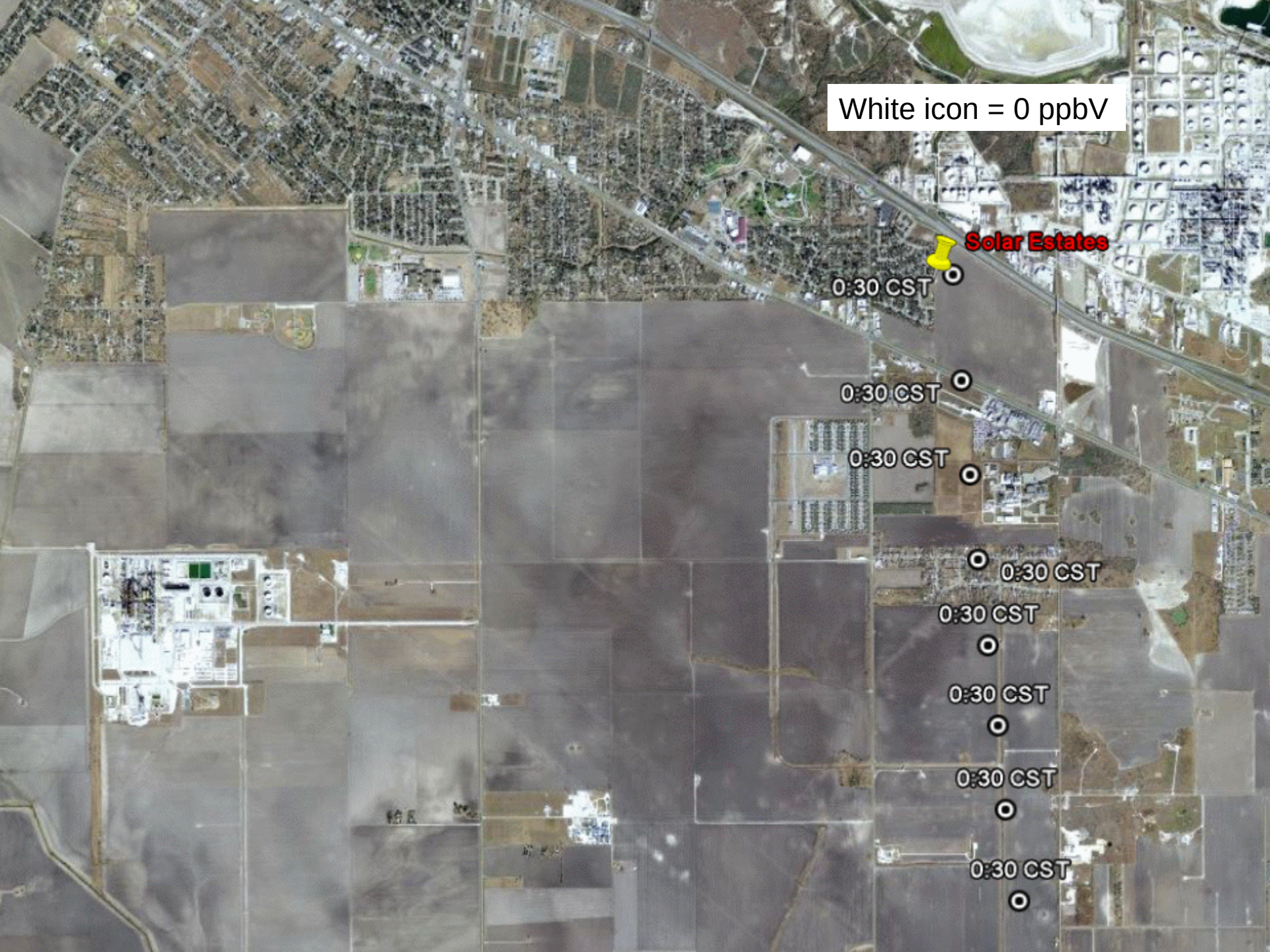
White icon = 0 ppbV
Solar Estates
0:30 CST
0:30 CST
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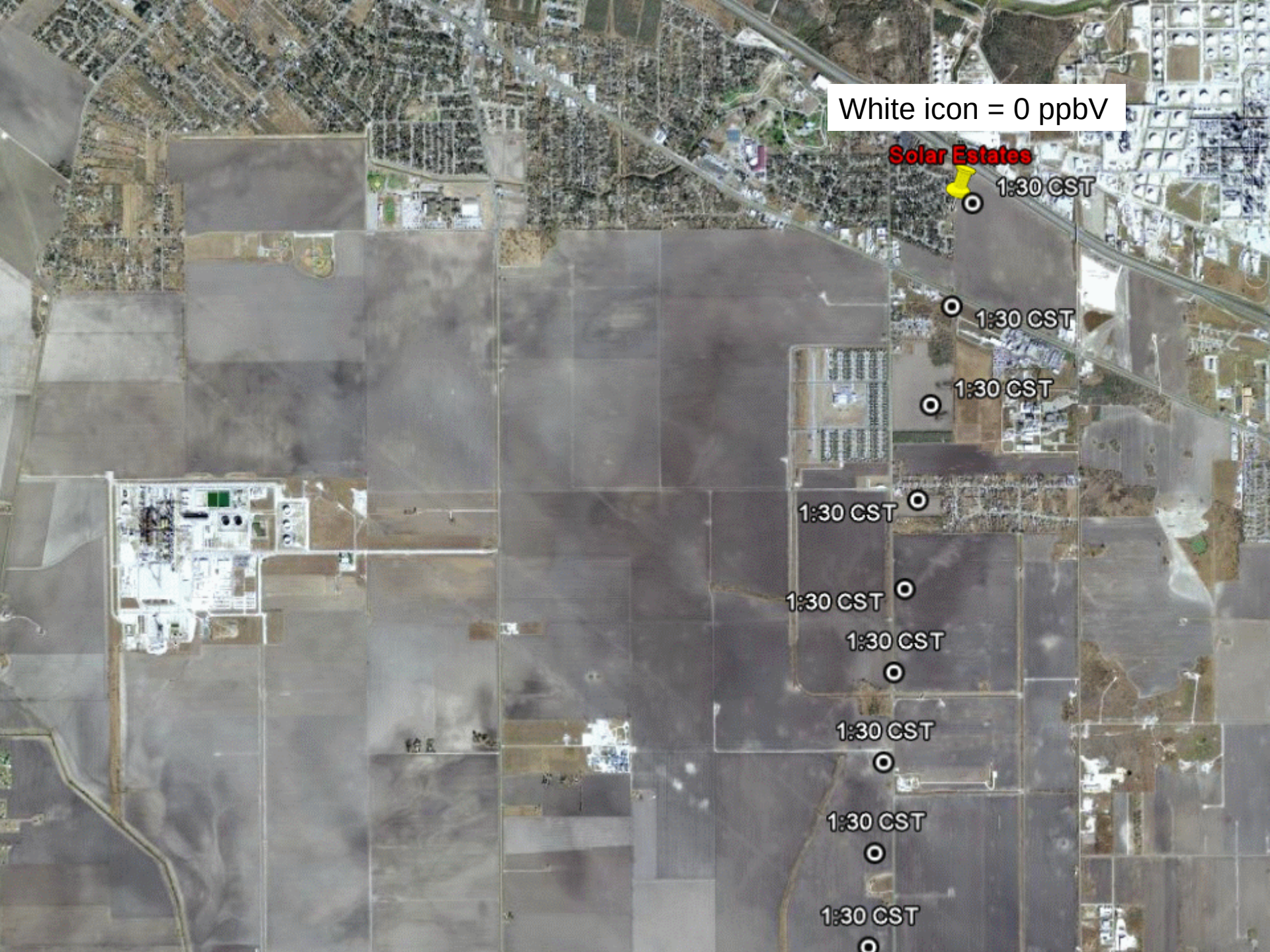
0:30 CST


White icon = 0 ppbV
Solar Estates
1:30 CST
1:30 CST
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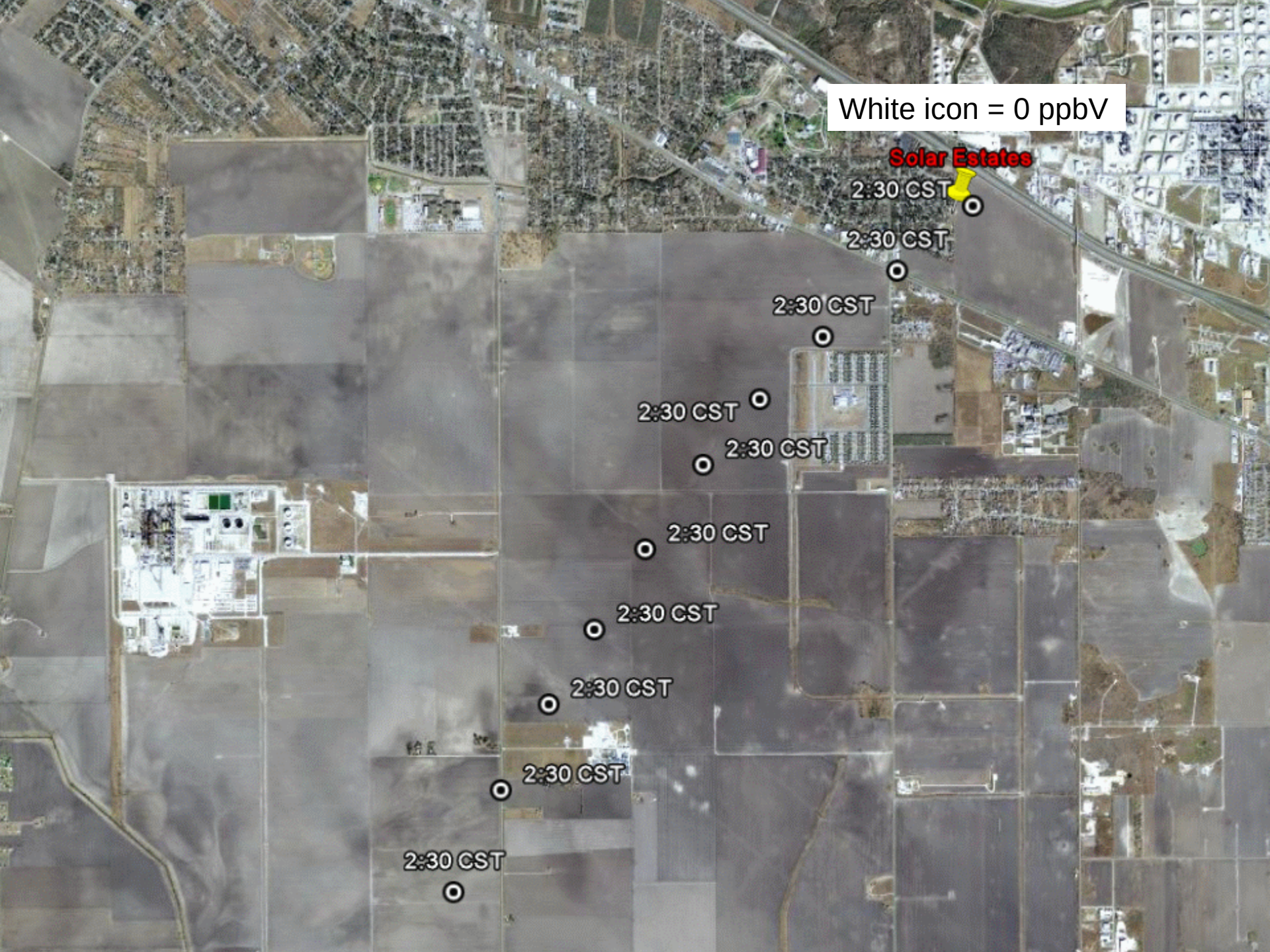
White icon = 0 ppbV
Solar Estates
2:30 CST
2:30 CST
2:30 CST
2:30 CST
2:30 CST
2:30 CST
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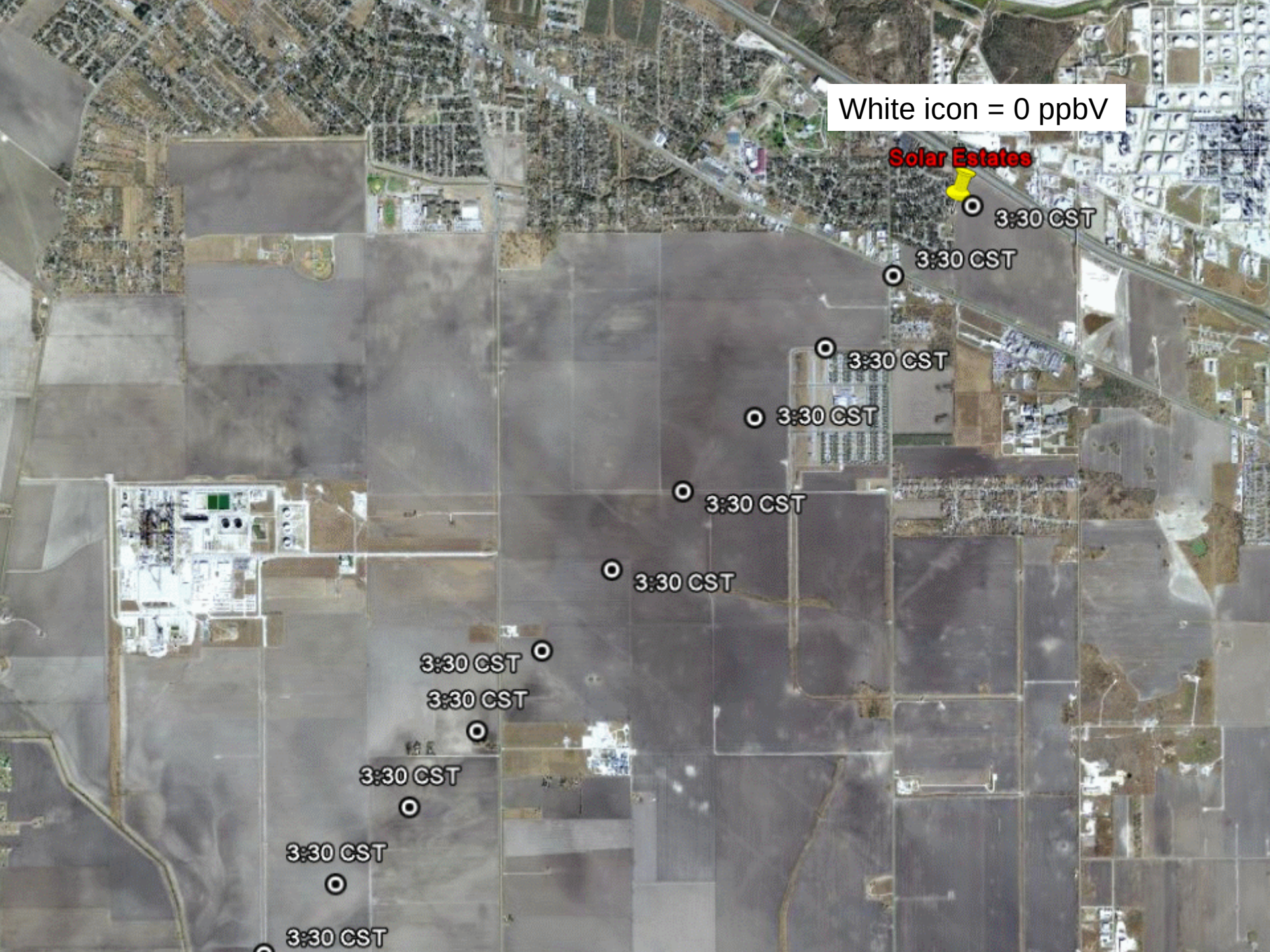
2:30 CST
2:30 CST
2:30 CST


White icon = 0 ppbV
Solar Estates
3:30 CST
3:30 CST
3:30 CST
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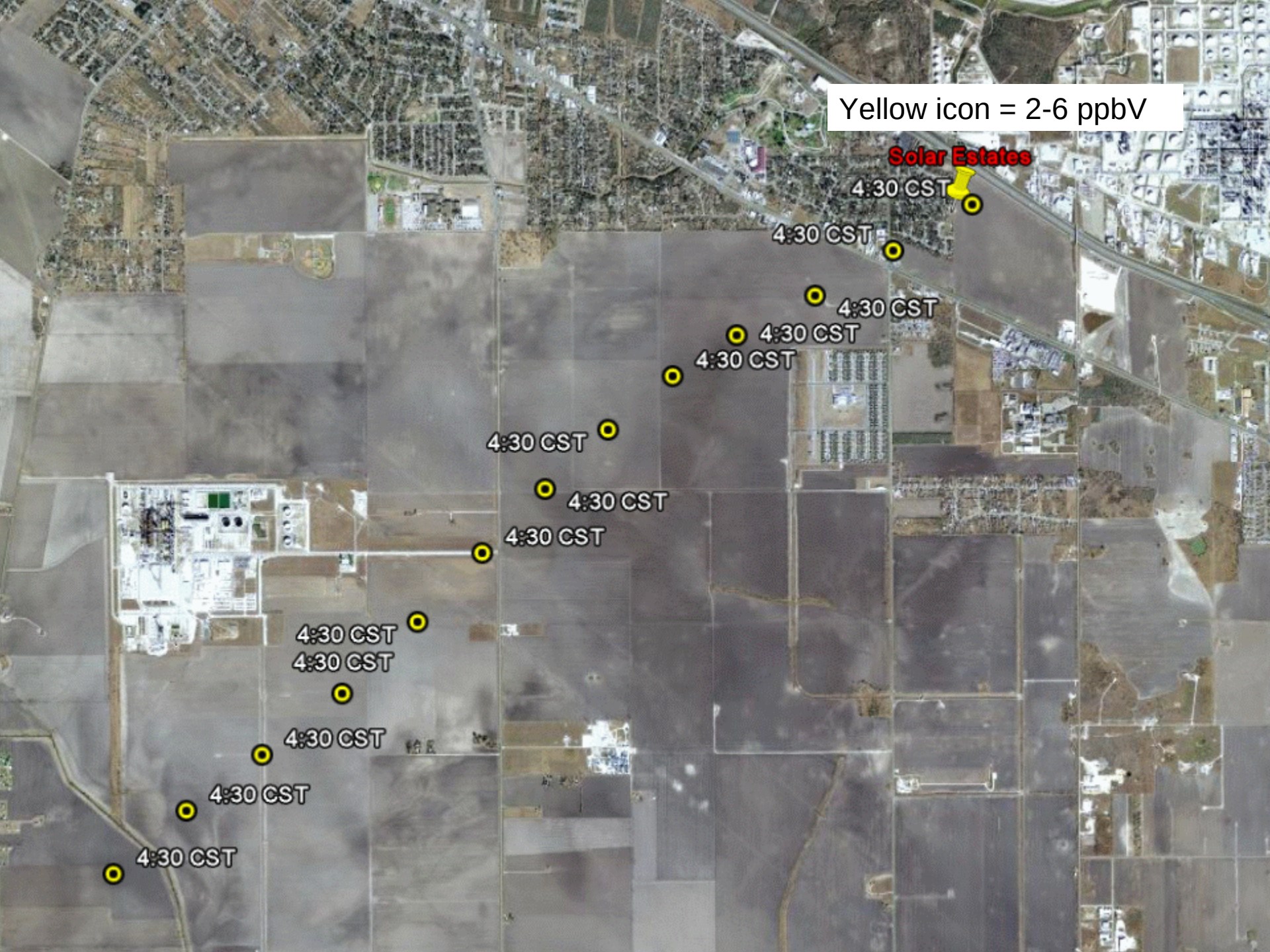
Yellow icon = 2-6 ppbV
Solar Estates
4:30 CST
4:30 CST
4:30 CST
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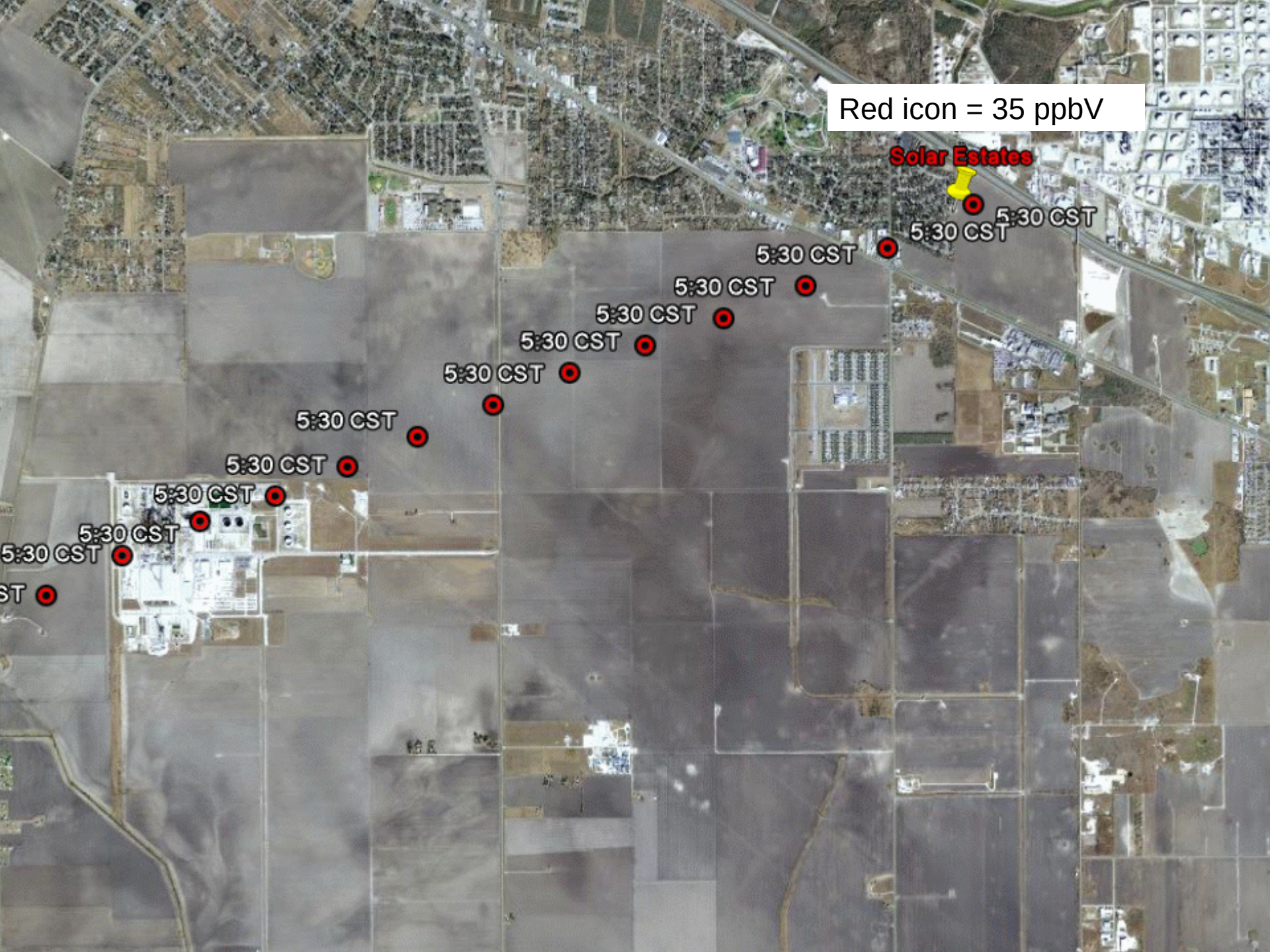
Red icon = 35 ppbV
Solar Estates
5:30 CST
5:30 CST
5:30 CST
5:30 CST
5:30 CST
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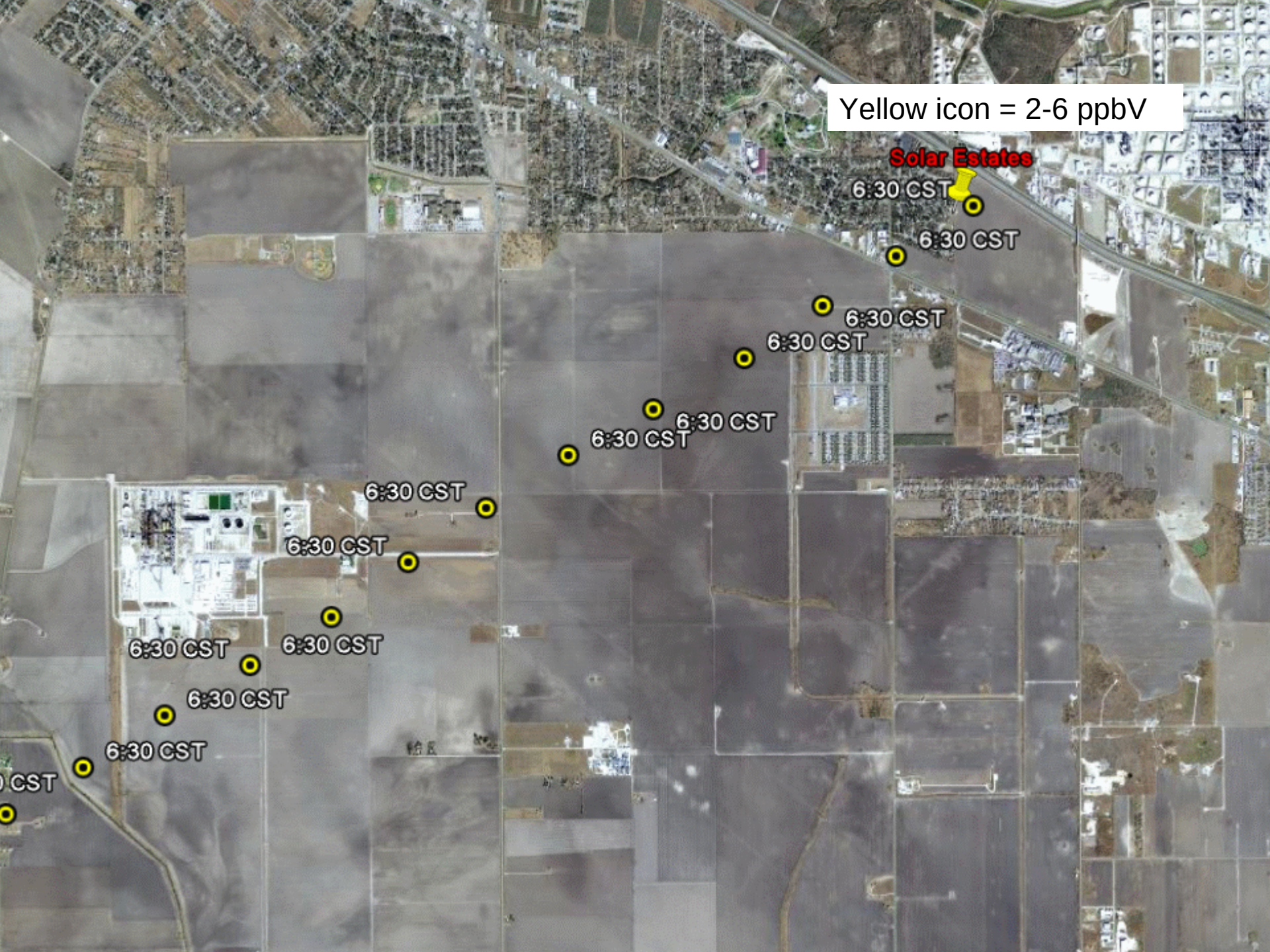
ST


Yellow icon = 2-6 ppbV
Solar Estates
6:30 CST
6:30 CST
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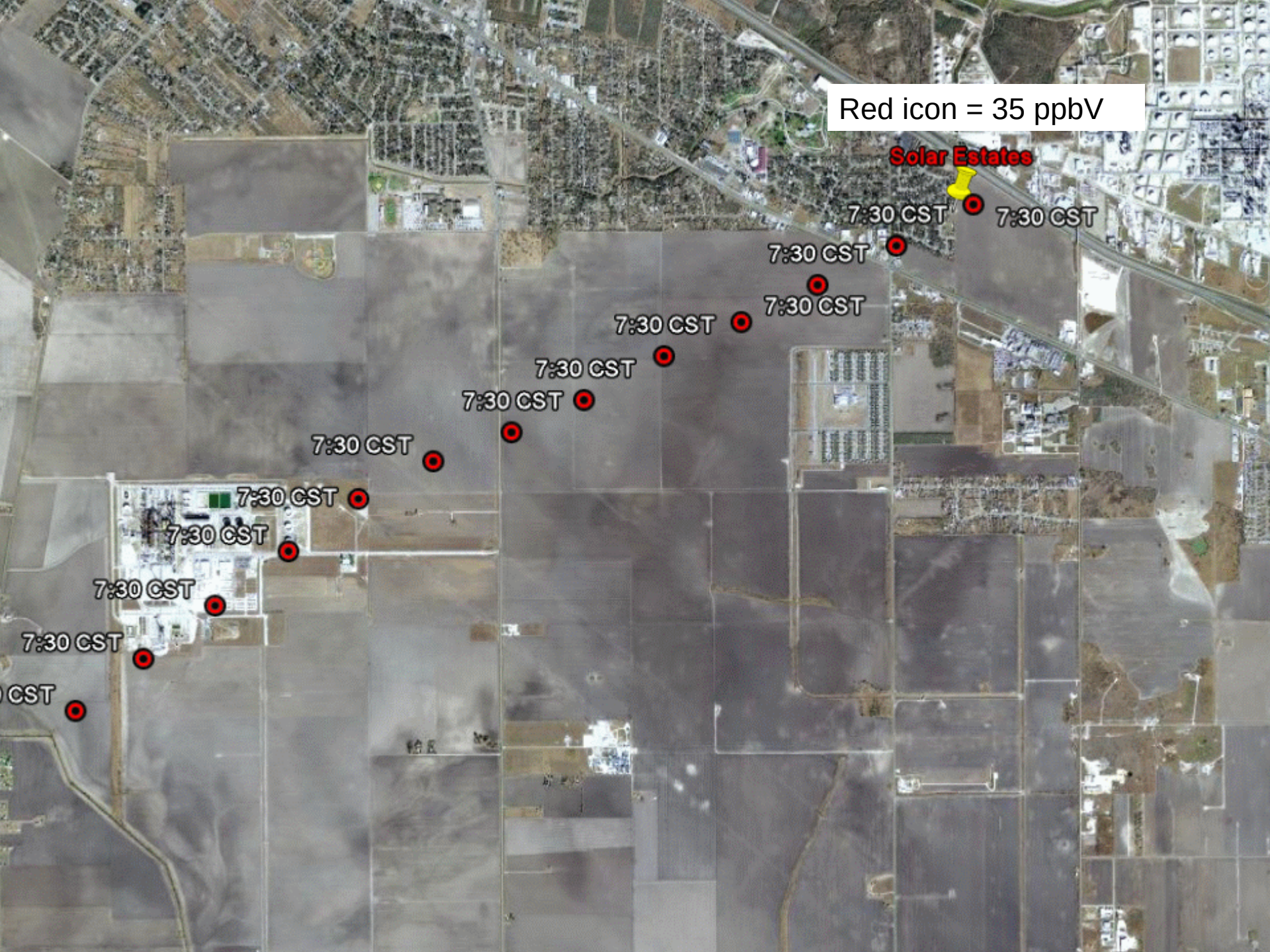
CST


Red icon = 35 ppbV
Solar Estates
7:30 CST
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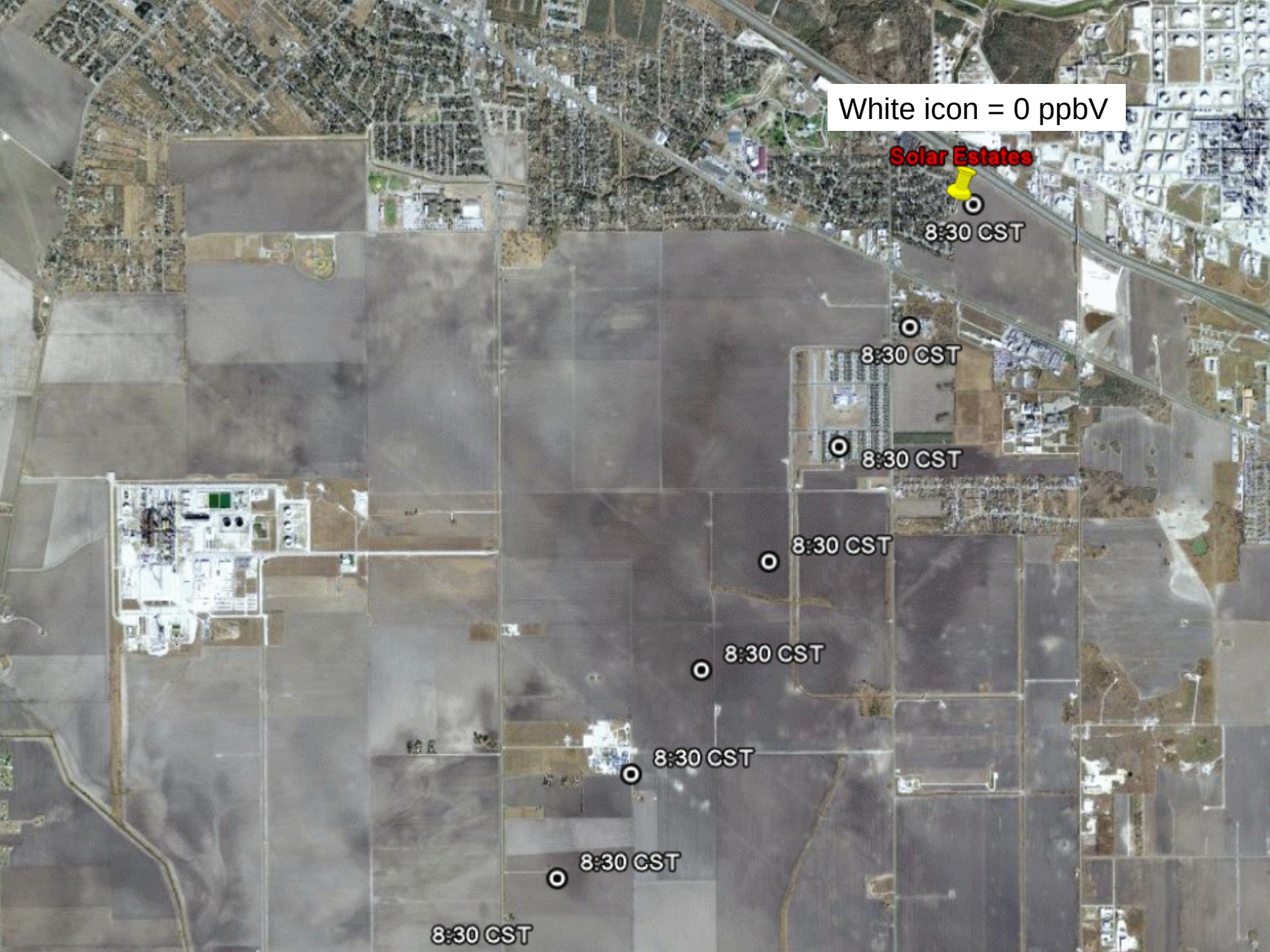
White icon = 0 ppbV
Solar Estates
8:30 CST
8:30 CST
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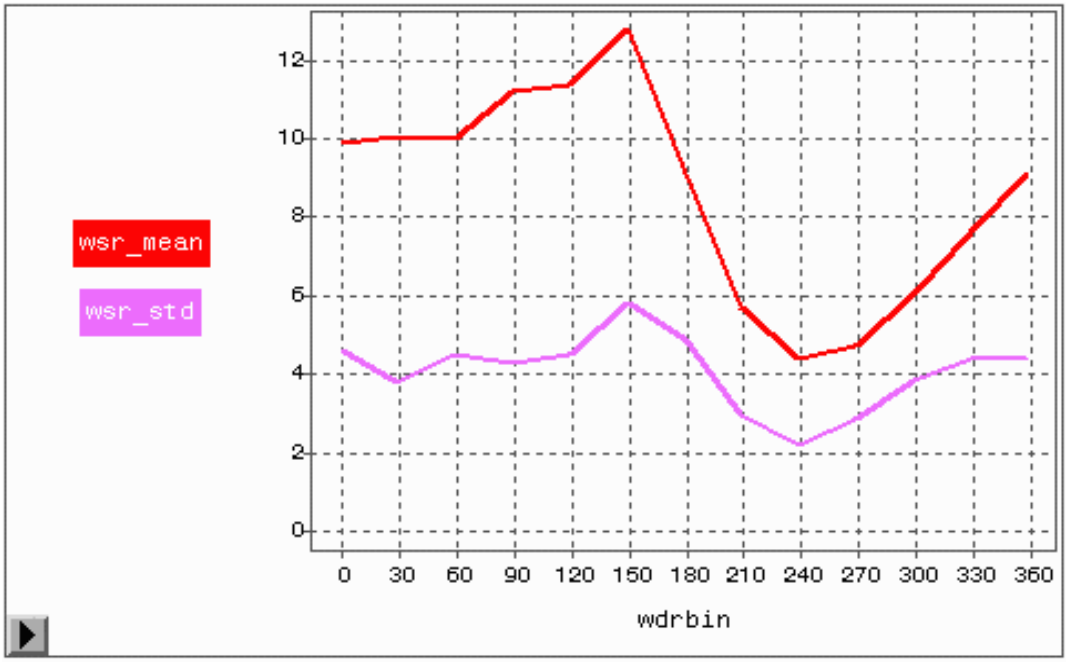
8:30 CST

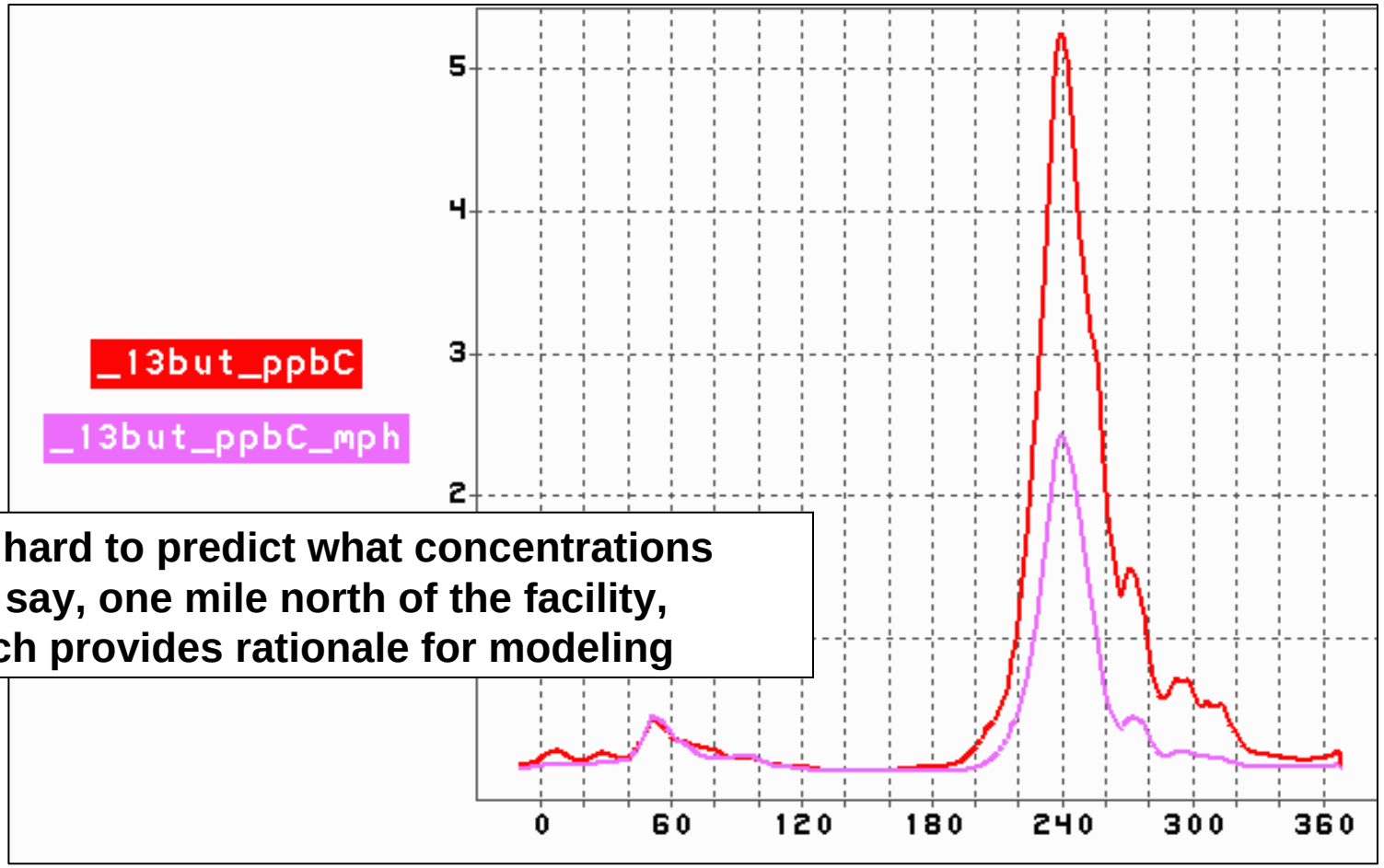
Distributions of Wind Direction & Speed at Solar Estates



Wdr bin deg	Num obs	Wsr mean mph	Wsr std mph
0	3,514	9.57	4.55
30	3,443	10.15	3.86
60	1,233	10.08	4.58
90	2,316	11.27	4.33
120	6,595	11.48	4.54
150	**12,976**	**12.92**	**5.87**
180	4,731	9.18	4.94
210	1,209	5.76	3.03
240	638	***4.46***	***2.25***
270	***486***	4.80	2.90
300	875	6.10	3.89
330	2,444	7.69	4.43

- Prevailing winds (Num obs) at Solar Estates (and in Corpus Christi overall) are south southeast.
- Westerly winds are least frequent.
- Coincidentally, SSE winds have highest mean & std dev (variability) for wind speed, and westerly winds have lowest speed and variability.

Kernal-smoothed mean 1,3-butadiene (ppbC) by wind direction w & w/o speed-adjustment



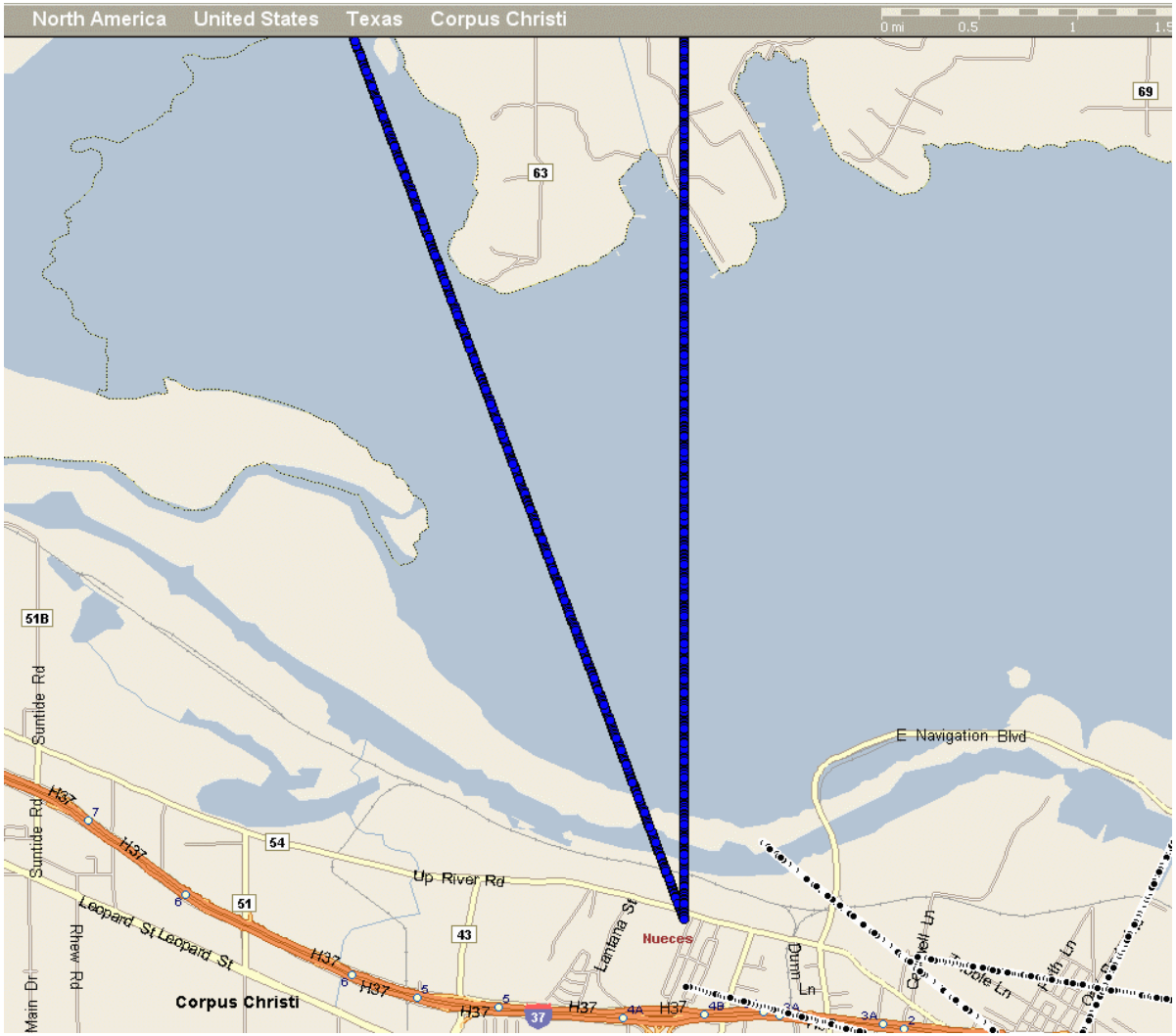
It is hard to predict what concentrations are, say, one mile north of the facility, which provides rationale for modeling

Peak direction around 240-250 degrees

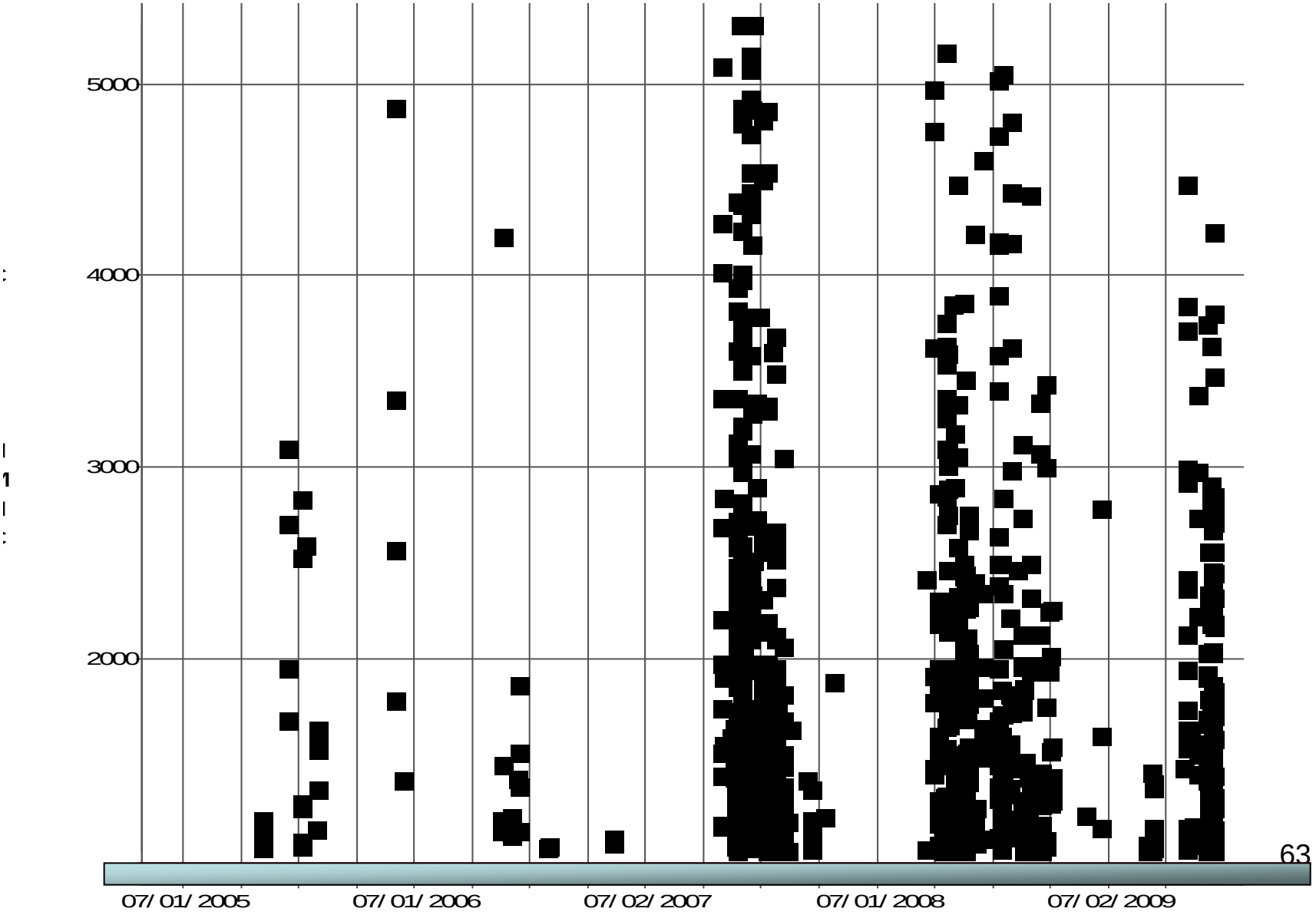
Case Study 3: White Point Emissions

- Late-2007 began to receive more alerts under northerly winds at sites on north side of ship channel.
- Key wind directions and back-trajectory analyses showed the White Point peninsula on north side of Nueces Bay may be source area.
- TCEQ and RRC confirmed much oil & natural gas extraction work in progress.

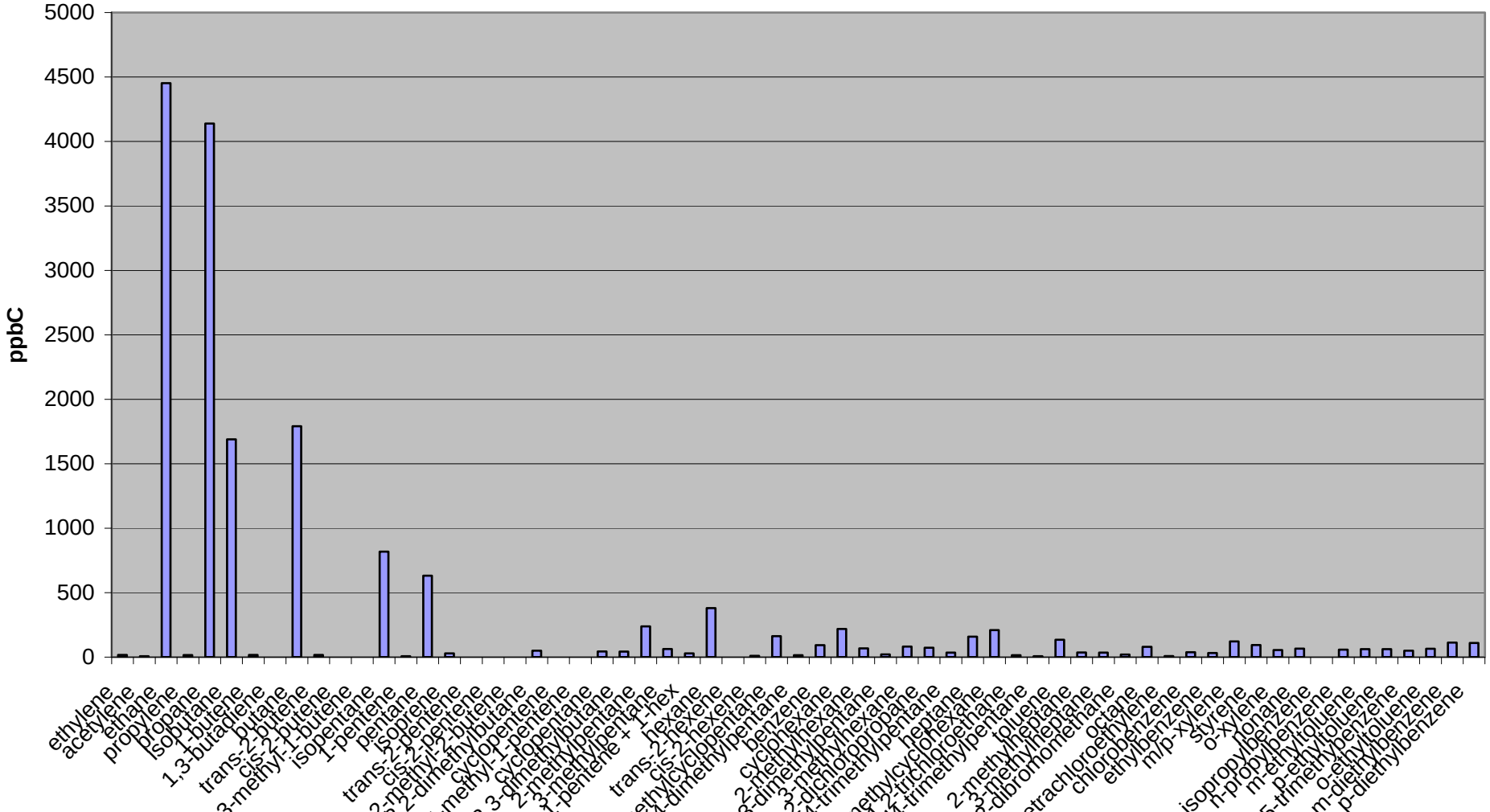
Dona Park elevated concentrations direction “cone”; top of figure is “White Point area”



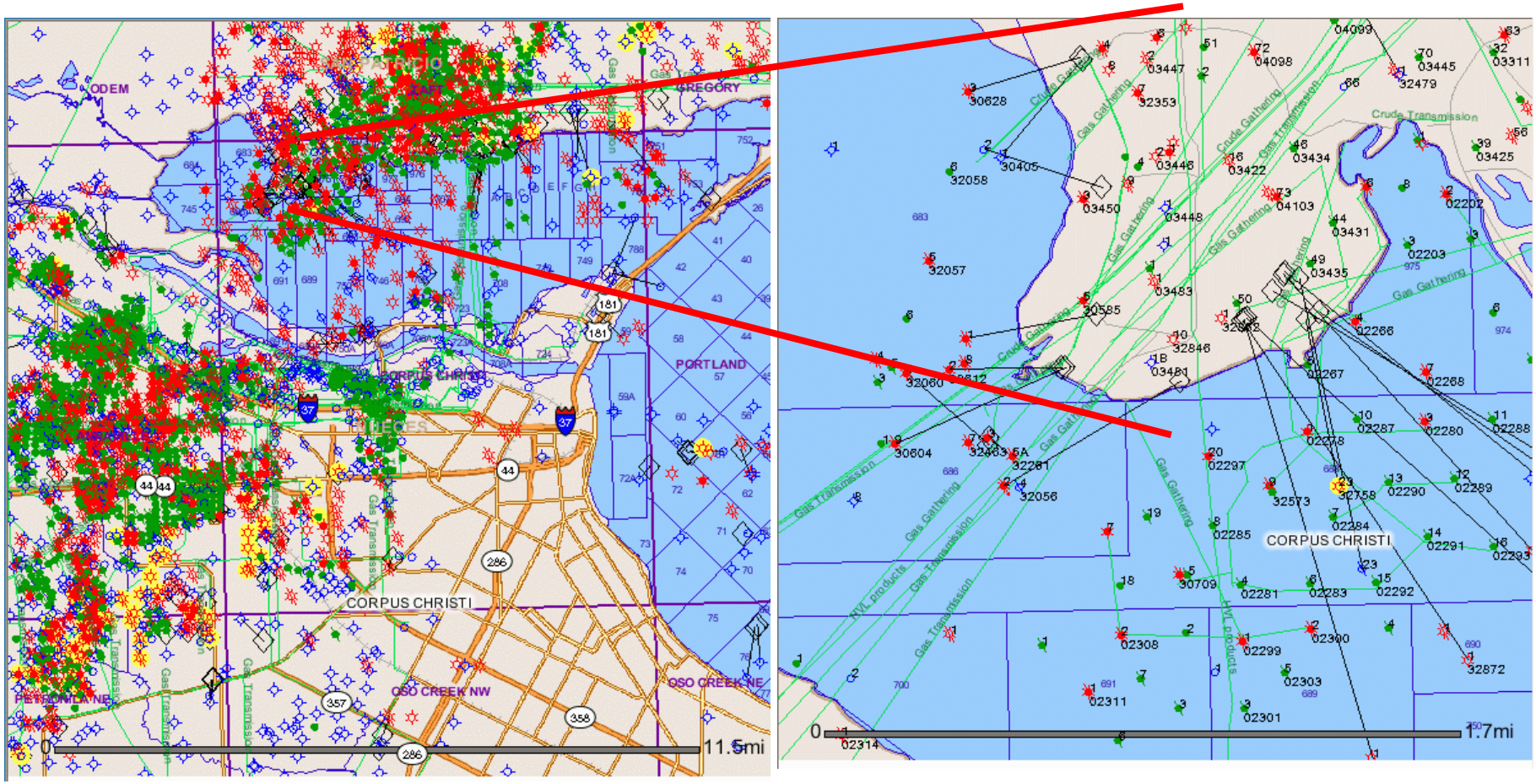
Dona Park filtered TNMHC values: conc. >= 1000 ppbC wind direction between 340, 360 degrees.



JIH can triggered 12/10/09 6:43 p.m., White Point suspected upwind source



Railroad Commission Web site confirms recent oil & gas work (see http://www.rrc.state.tx.us/data/online/gis/)



7. Update on Canister Sampling

Preliminary ensemble multivariate analysis

Benzene Values

Site name	Count of cans	Average benzene ppbV	Max benzene ppbV	TCEQ Reference value
CCG CAMS 629	11	5.02	15.3	180
DPK CAMS 635	11	1.94	3.24	180
FHR CAMS 632	1	3.45	3.45	180
JIH CAMS 630	12	7.33	18.5	180
WEH CAMS 631	7	2.12	4.82	180

Odorous Values

Site name	Date-Time CST	Species	Value ppbV	Odor ESL	Health ESL
WEH CAMS 631	2/24/2009 18:47	Isobutane	7,123	2,040	8,000
JIH CAMS 630	11/9/2008 3:34	2-Methylpentane	89.3	83	1,000
JIH CAMS 630	11/9/2008 3:34	Isoprene	5.84	5	20
JIH CAMS 630	12/10/2008 18:43	n-Propylbenzene	6.44	3.8	250

Preliminary ensemble multivariate analysis

- Individual canister samples have been collected and used in case studies.
- Now a large enough number collected to look at the entire collection of data.
- Analysis to date uses 28 species with best quality data, 134 twenty-minute canister samples, 5 sites, 2006 – 2009.
- *Results only preliminary / exploratory.*

Data suggest several factors:

- C4 – C5 alkene factor – butene & pentene isomers
- BTEX factor – benzene, toluene, ethylbenzene, xylenes, TMBs
- Alkane factor (natural gas?) – ethane, propane, butane-pentane-hexane isomers, heptane
- Heavy alkane factor – heptane, octone, nonane
- Ring factor – cyclopentane, benzene, cyclohexane
- C2 factor – acetylene, ethylene

Next steps

- Combine factor “scores” with original data to discern
  - which sites are affected by which factors?
  - from those sites, what are typical upwind directions and source areas corresponding to specific factors?
- Ultimately we may compare the factors and upwind sources to reported emissions inventory => Bottom-up vs Top-down

8. Summary of SO_2 & H_2S Monitoring

No exceedances 2007 – 2009

SO_2 Concentration Summary

Site name	Summary Statistics	2007	2008	2009*	NAAQS
CCG	Annual Mean	0.4	0.6	0.2	30
	Highest Daily Mean	11.6	16.1	12.1	140
JIH	Annual Mean	1.3	1.6	0.8	30
	Highest Daily Mean	32.9	62.6	30.3	140
WEH	Annual Mean	0.6	0.2	0.1	30
	Highest Daily Mean	28.5	6.1	11.6	140
Huisache	Annual Mean	0.6	1.2	0.5	30
	Highest Daily Mean	19.3	45.2	5	140
Dona Park	Annual Mean	0.6	0.4	0.3	30
	Highest Daily Mean	9.8	6.2	7.8	140
Solar	Annual Mean	0.5	0.3	0.2	30
	Highest Daily Mean	15.3	3.5	2.4	140
FHR	Annual Mean	0.5	0.4	0.3	30
	Highest Daily Mean	5.1	6.3	4.4	140

9. Conclusions

- Auto-GCs: no values > ESL or ReV; values lower in most recent 2 years over first 2 years
- Benzene concentrations have downward trend 2005 – 2009.
- 1,3-Butadiene at Solar Estates bears watching
- TNMHC at FHR has declined significantly; declines also at other 6 sites
- Will continue to use directional information and speciated hydrocarbon data to identify specific source facilities that may be disproportionally emitting pollution.

Interactions with the Community

- Two New Supplemental Environmental Projects
  - Sought Advisory Board input to prioritize funds
- Requested POCC Approval to Install Cameras
  - Port Industries Technical Committee (April 16, 2009)
- Made Presentations on Project and Data
  - Long Term Health Work Group (November 12, 2008)
  - Coastal Bend Foundation (May 11, 2009)
  - Air Quality Group (June 24, 2009)
- Provided Auto-GC Data and Trend Analysis
  - Hillcrest Community Meeting (December 11, 2008)
- Meetings of the Volunteer Advisory Board

Statement by Representative of the Volunteer Advisory Board

Ms. Gretchen Arnold

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Project Web Site: http://www.utexas.edu/research/ceer/ccaqp