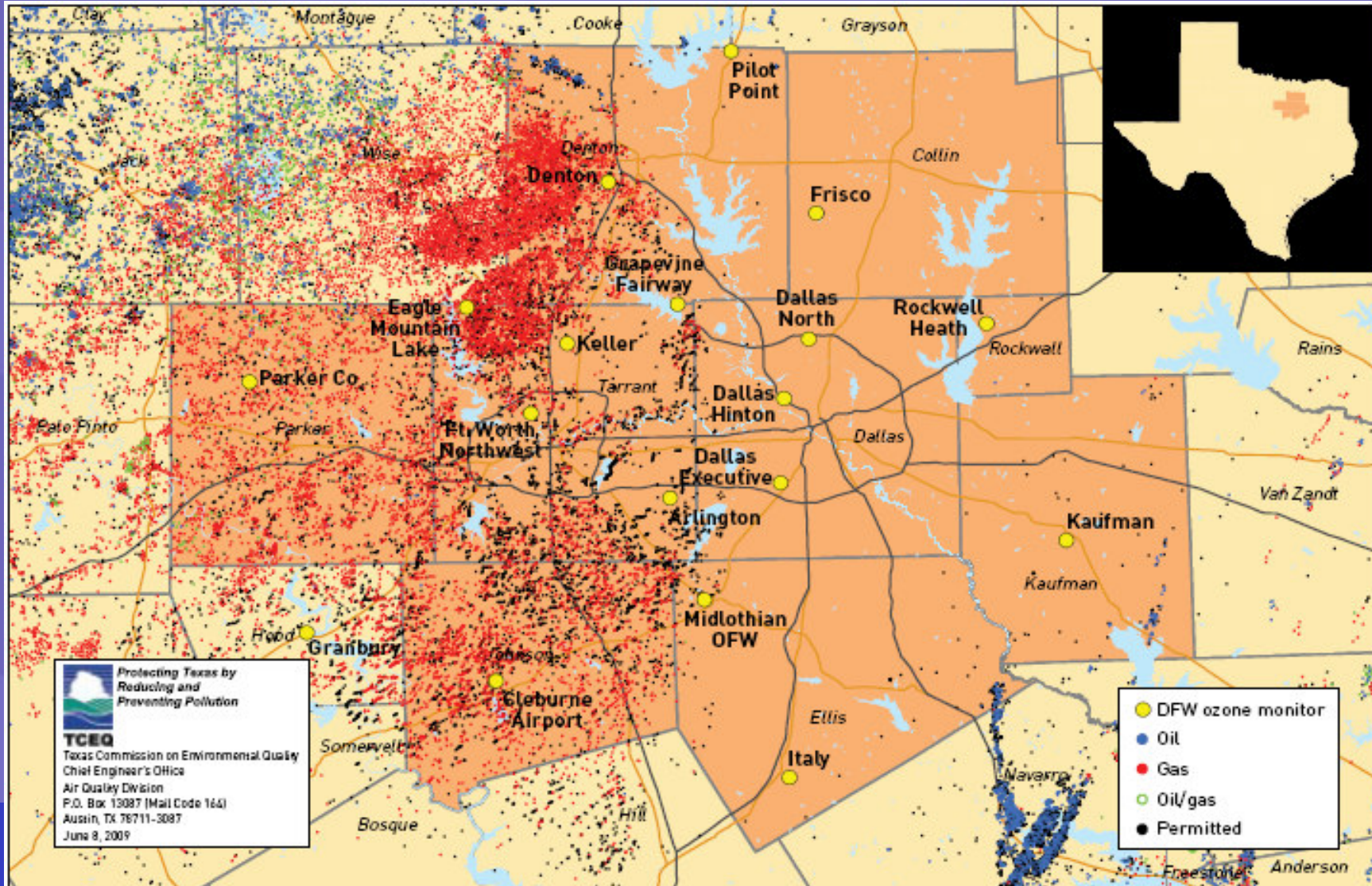


Barnett Shale Area Wells

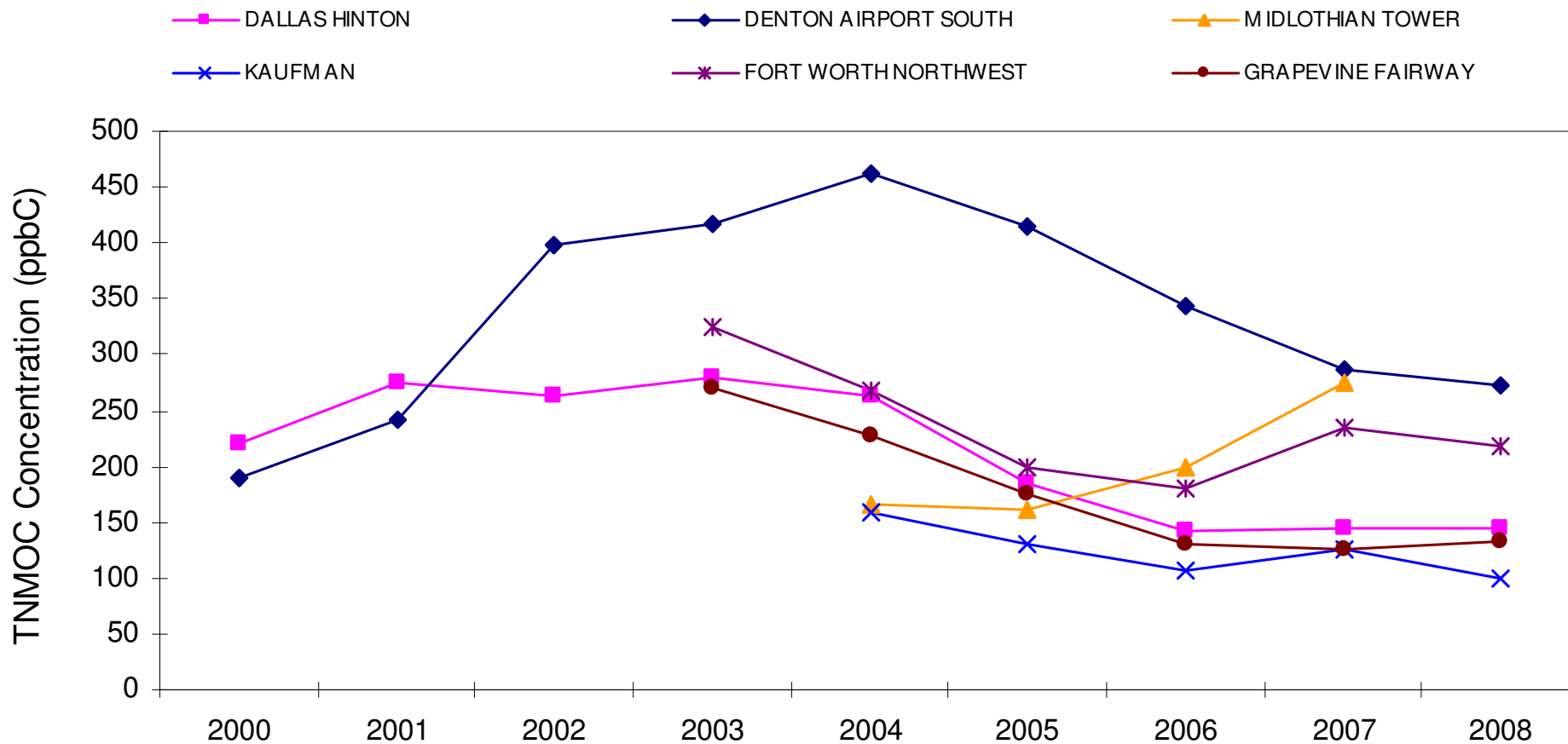


- Insert a clip or still of leaking storage tank(s)

Summary

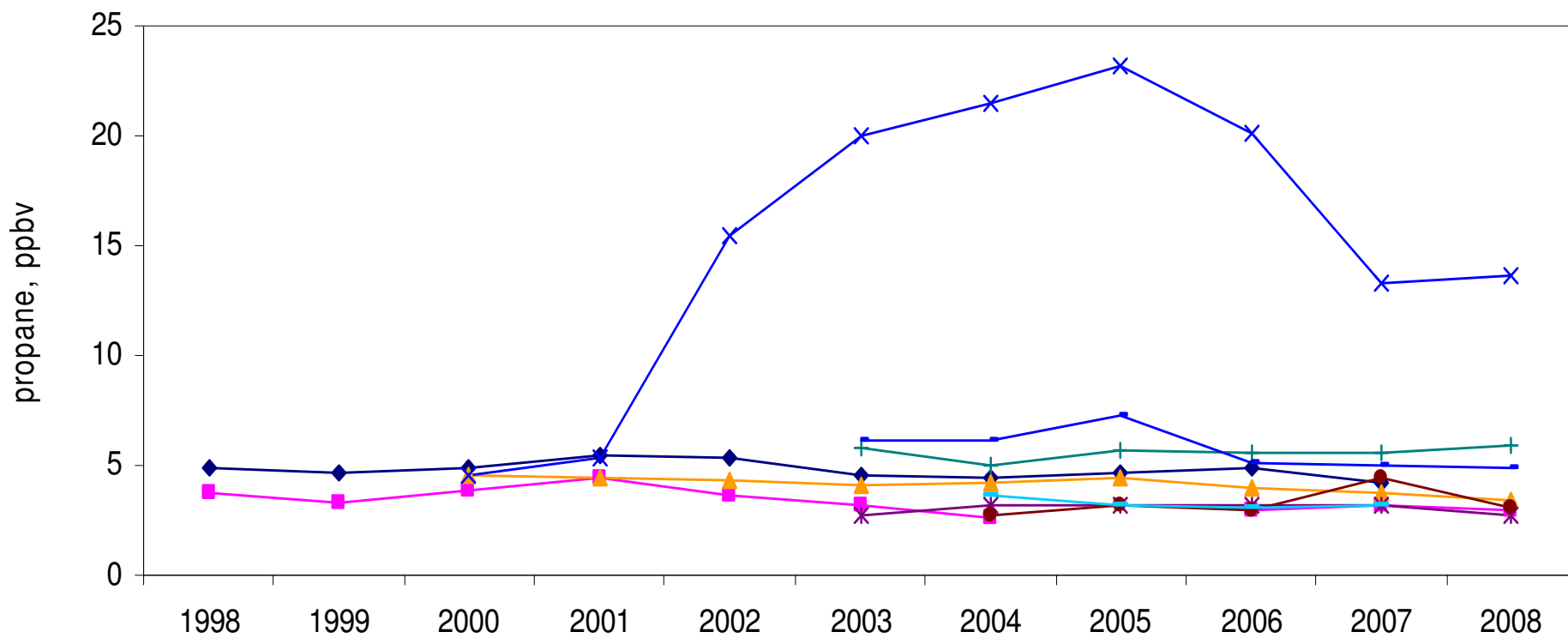
- Test hypothesis: Oil/Gas production in Barnett Shale affects the area's air quality
 - Analysis of TCEQ's VOC Monitoring Data
 - Comparison to Trends in County-Level Drilling and Production Activity
 - No one has looked at ozone effects yet
- Encourage use of cost-effective emission controls

Rural Denton County Exhibits Highest Levels of Hydrocarbons

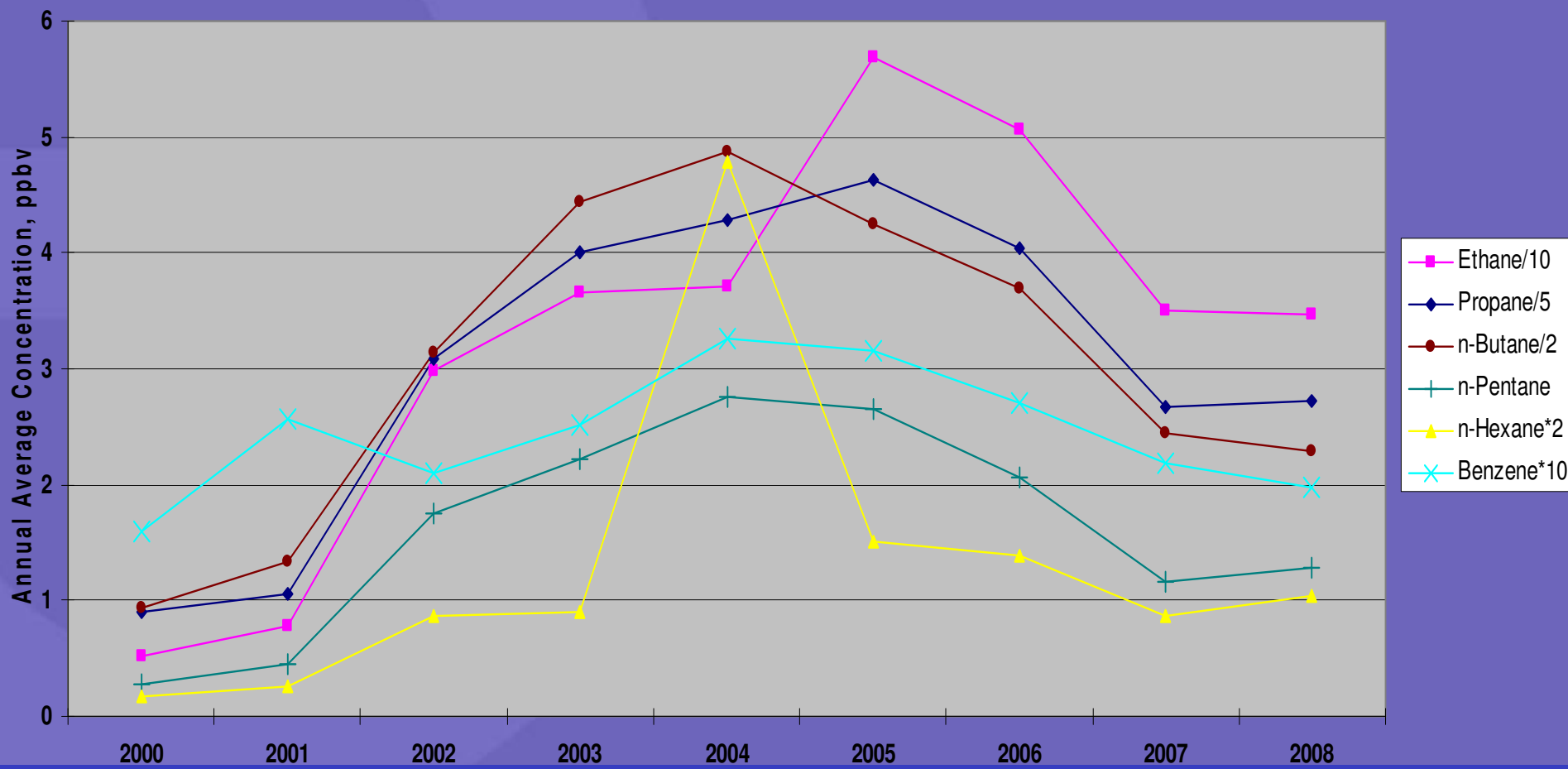


Hydrocarbon Trends in Denton County Are Distinct from Rest of Region

- BOY'S CLUB
- MIDLOTHIAN OFW
- DALLAS HINTON
- GREENVILLE
- KAUFMAN
- FORT WORTH NORTHWEST
- GRAPEVINE FAIRWAY
- DENTON AIRPORT SOUTH
- MIDLOTHIAN TOWER



Several Hydrocarbons Follow Similar Trends at Denton Monitor

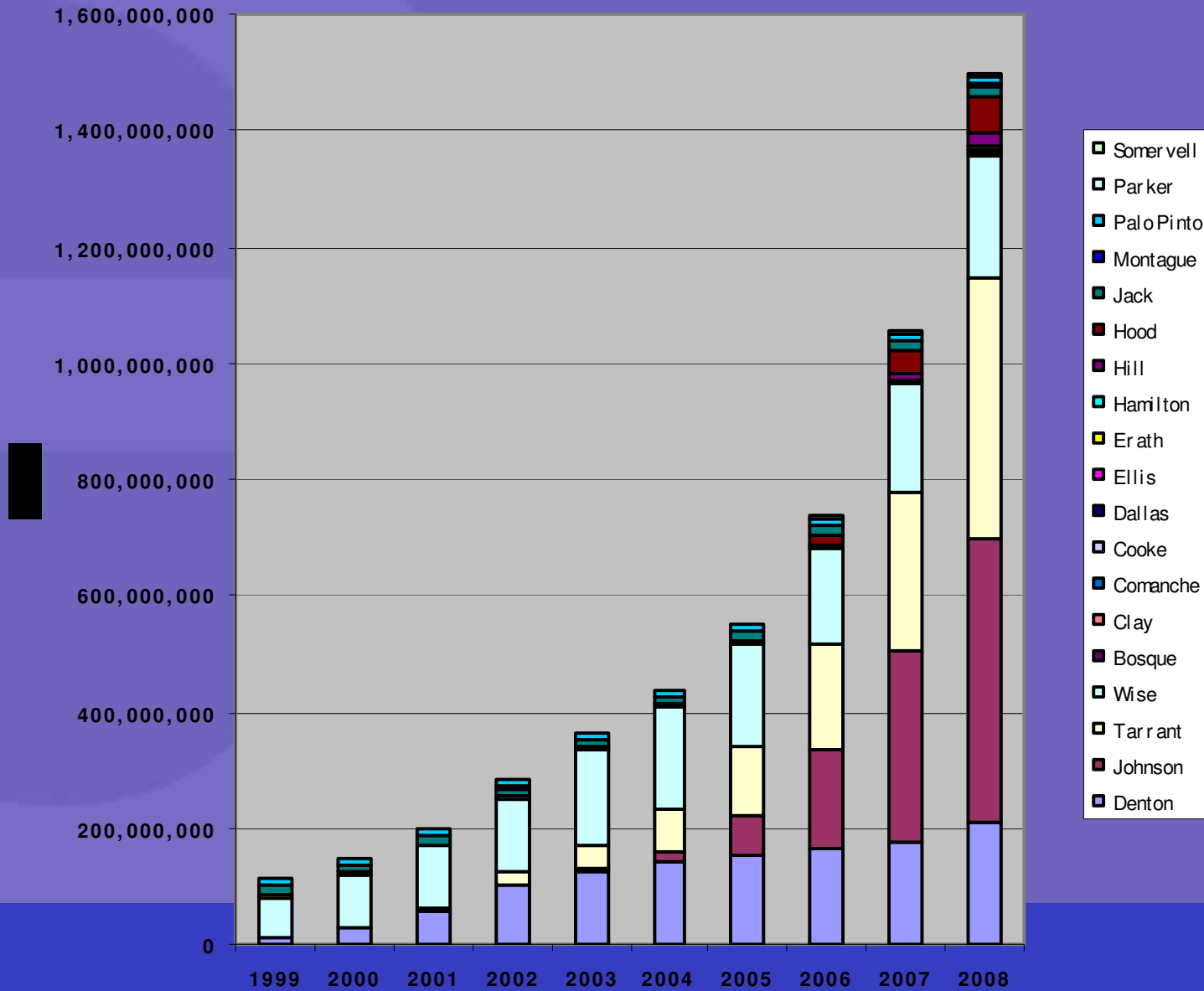


Note: Scaling Factors Applied as Indicated in Legend

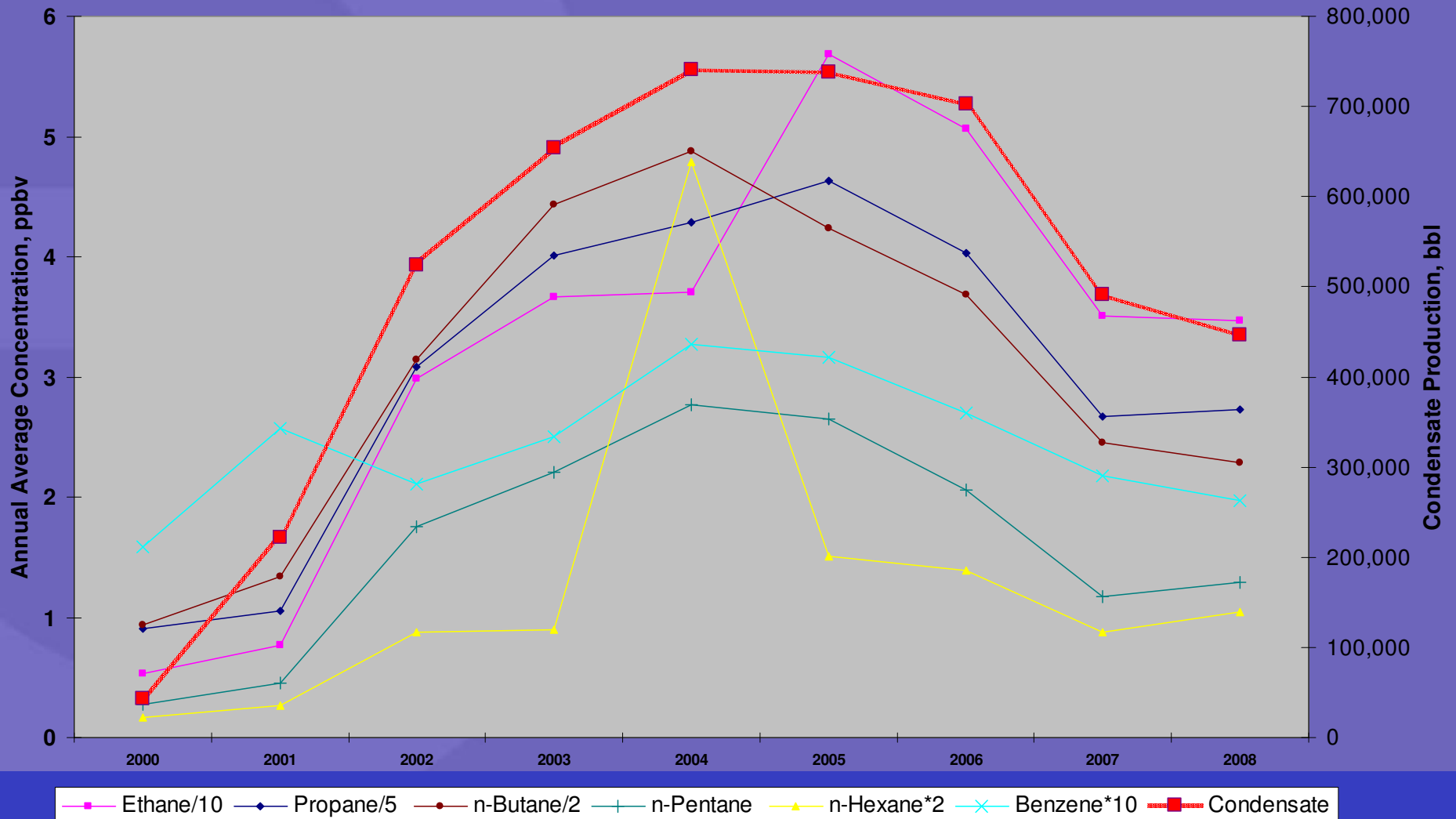
Q: Can the VOC trends observed at the Denton County monitor be explained by oil and gas activity?

A: To answer this, we looked at county-level well activity and production data from Railroad Commission

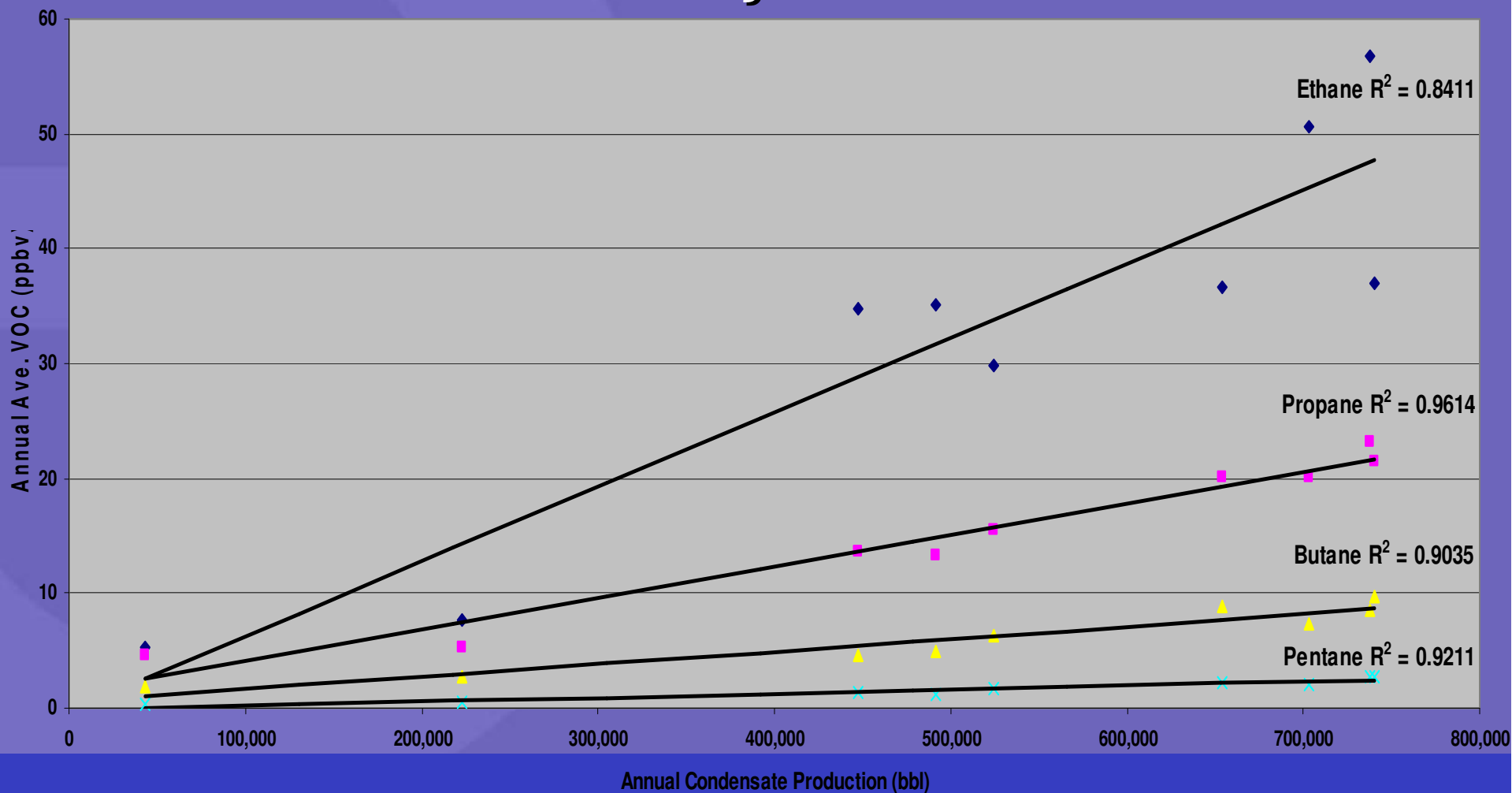
Natural Gas Production



Denton Co. VOC vs. Condensate Production



Linear Regression Gives Good Fit for C2-C5 Hydrocarbons



Conclusions (I)

- Canister samples taken in Denton County show elevated levels of hydrocarbons compared to other monitors in the DFW area
- The observed trends in ambient concentrations of light alkanes (ethane through pentane) are well predicted by the annual production of condensate in Denton County

Conclusions (II)

- Emissions associated with condensate production, such as leaks from storage tanks, appear to measurably affect ambient air quality in surrounding areas
- The effect of the observed VOC levels in Denton County on human health or regional ozone production have not been investigated
- There is no hydrocarbon monitoring data from other DFW counties with high condensate production (Wise, Parker and Hood)

Cost-effective methane reduction opportunities

Technology/practice	Volume of natural gas reductions (Mcf/yr)	Value of annual gas savings (dollars/yr)	Implementation costs	Payback time (months)
Change from high to low-bleed pneumatic device	50 to 260, depending on age of device at time of replacement	\$350-1,820, depending on age of device at time of replacement	\$210-1,850 depending on age of device at time of replacement	1-13, depending on age of device at time of replacement
Retrofitting high-bleed devices	230	\$1,610	\$675	6
Replace gas with air in pneumatic device (per facility)	20,000	\$140,000	\$60,000	6
Green completions	25.2 billion cubic feet annually	\$176 million	\$1,000-10,000	1-3
Plunger lift systems	4,700-18,250 per well	\$32,900-127,750	\$2,591-10,363 per well	2-14
Well automation devices	500 per well	\$35,000 per well	\$11,000 per well	3
Reducing glycol circulation rates on glycol dehydrators	N/A. In general, EPA found circulation rates to be two or more times higher than necessary.	\$2,758-275,940	Negligible	Immediate
Replacing glycol dehydrator with desiccant dehydrator	1,063	\$7,441	\$15,787	21
Using pipeline pump-down techniques to lower gas line pressure before maintenance	200,000	\$1,400,000	\$98,757 or zero if using in-line compressors	1 or immediate if using in-line compressors
Directed inspection and maintenance at compressor stations	29,412 per compressor station	\$88,239 per compressor station	\$26,248 per compressor station	N/A. Potential average first year savings equal \$61,991
Vapor recovery units on crude oil storage tanks	4,900-96,000	\$30,300-606,800	\$35,738-103-959	3-19
Replace compressor rod packing systems	865	\$6,055	\$540	2
Install BASO valves	Varies. One partner reported savings of 222 Mcf per year for a single installation	\$1554 per valve	< \$1000 per valve	less than one year
Replacement of wet seals with dry seals on wet seal centrifugal compressors	45,120 per seal	\$315,000 per seal	\$324,000 per seal	10 per seal

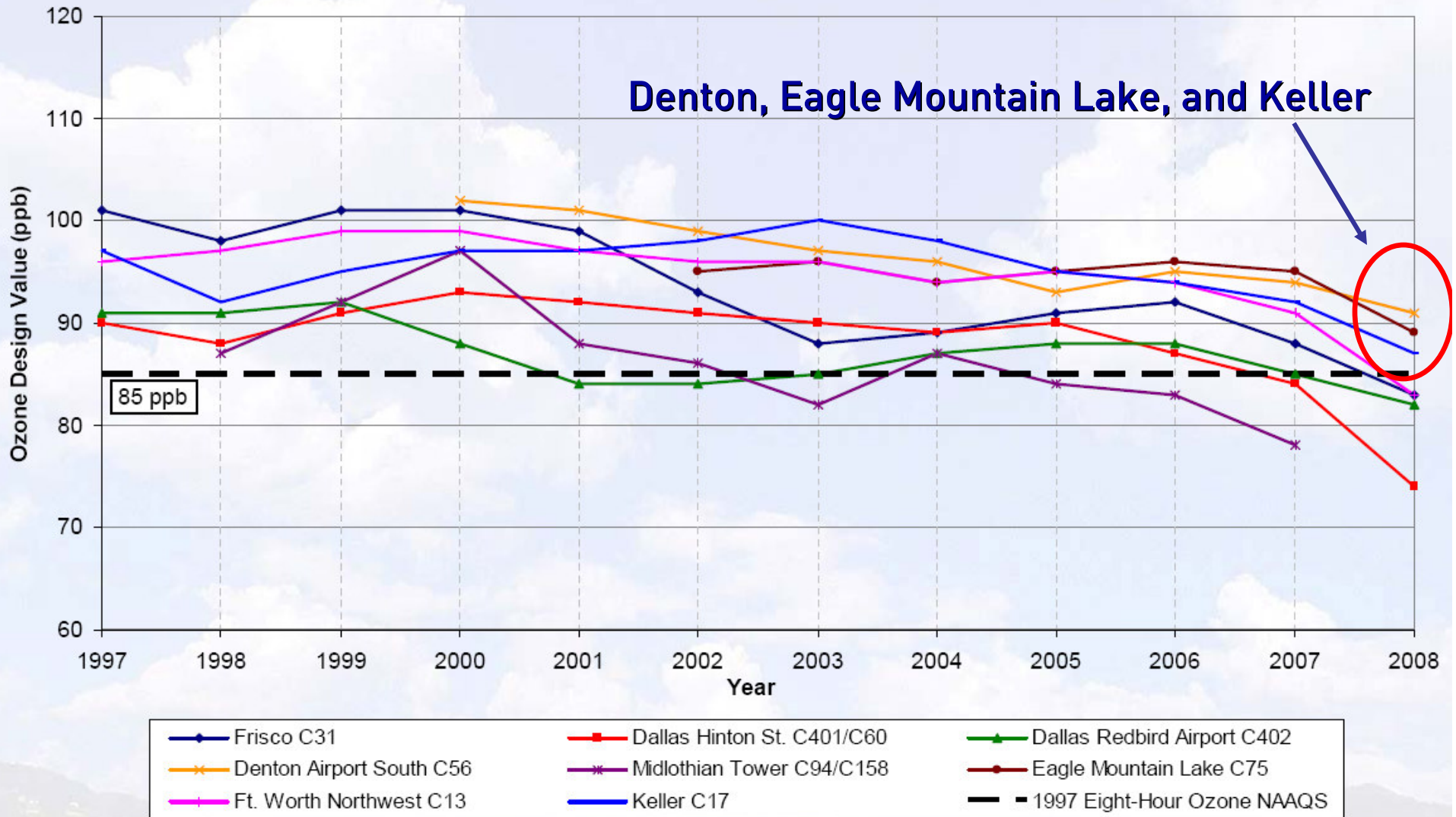
ENVIRONMENTAL DEFENSE FUND

Area	Monitoring Site	POC	Fourth Highest Average (ppb)			Current Three-Year Average (ppb)
			2007	2008	2009 as of 3:21 pm CDT 10/14/2009	
Dallas-Fort Worth						
	Ft. Worth Northwest C13/AH302	2	81	73	83	79
	Keller C17	2	84	85	90	86
	Frisco C31/C680	1	80	79	79	79
	Midlothian OFW C52/A137	1	76	72	72	73
	Denton Airport South C56/A163/X157	1	89	84	82	85
	Arlington Municipal Airport C61	1	75	78	80	77
	Dallas North No.2 C63/C679	1	79	76	88	81
	Rockwall Heath C69	1	74	73	78	75
	Grapevine Fairway C70/A301/X182	1	89	77	86	84
	Kaufman C71/A304/X071	1	74	69	68	70
	Granbury C73/C681	1	81	73	77	77
	Eagle Mountain Lake C75	1	84	85	91	86
	Parker County C76	1	88	77	80	81
	Cleburne Airport C77/C682	1	87	83	80	83
	Midlothian Tower C94/A305/X158 (Deactivated Aug 22, 2007)	1	72 *			
	Dallas Hinton St. C401/C60/AH161	3	76	64	62	67
	Dallas Executive Airport C402	1	80	77	79	78
	Greenville C1006/A198	1	69	63	67	66
	Pilot Point C1032	1	75	80	78	77
	Italy C1044/A323	1	66 *	72	70	69
	Corsicana Airport C1051	1			66 **	

- Highest ozone readings are near highest density of oil and gas activity
- No modeling of ozone air impacts from oil/gas done to date



Eight-Hour Ozone Design Values for Long-Term Monitors in the DFW Area (1997-2008*)



*2008 design values are current as of December 9, 2008 and are subject to change.

Recommendations

- Expand VOC monitoring, including in other Barnett counties with significant condensate production (Wise, Hood, Parker)
- Adopt cost-effective oil/gas emission controls
- Deploy an ozone monitor in Wise County and re-consider its inclusion in DFW nonattainment area

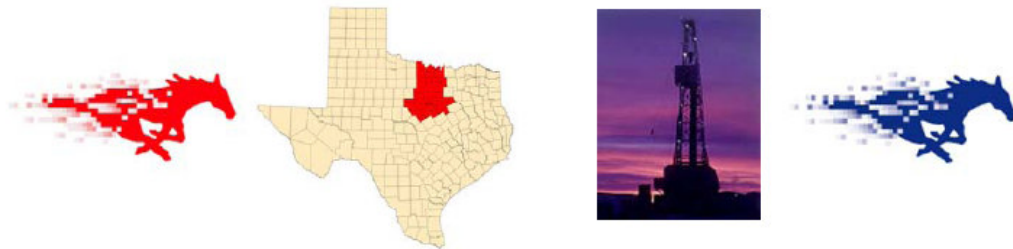
Background

Emissions from Natural Gas Production in the Barnett Shale Area and Opportunities for Cost-Effective Improvements

report by:
Al Armendariz, Ph.D.
Department of Environmental and Civil Engineering
Southern Methodist University
P.O. Box 750340
Dallas, Texas, 75275-0340

for:
Ramon Alvarez, Ph.D.
Environmental Defense Fund
44 East Avenue
Suite 304
Austin, Texas 78701

Version 1.1
January 26, 2009



- Dr. Armendariz's report concludes emissions from oil and gas activity in Barnett area are significant
- Despite industry criticism, estimated emissions found to be in line with TCEQ's own estimates

ENVIRONMENTAL DEFENSE FUND

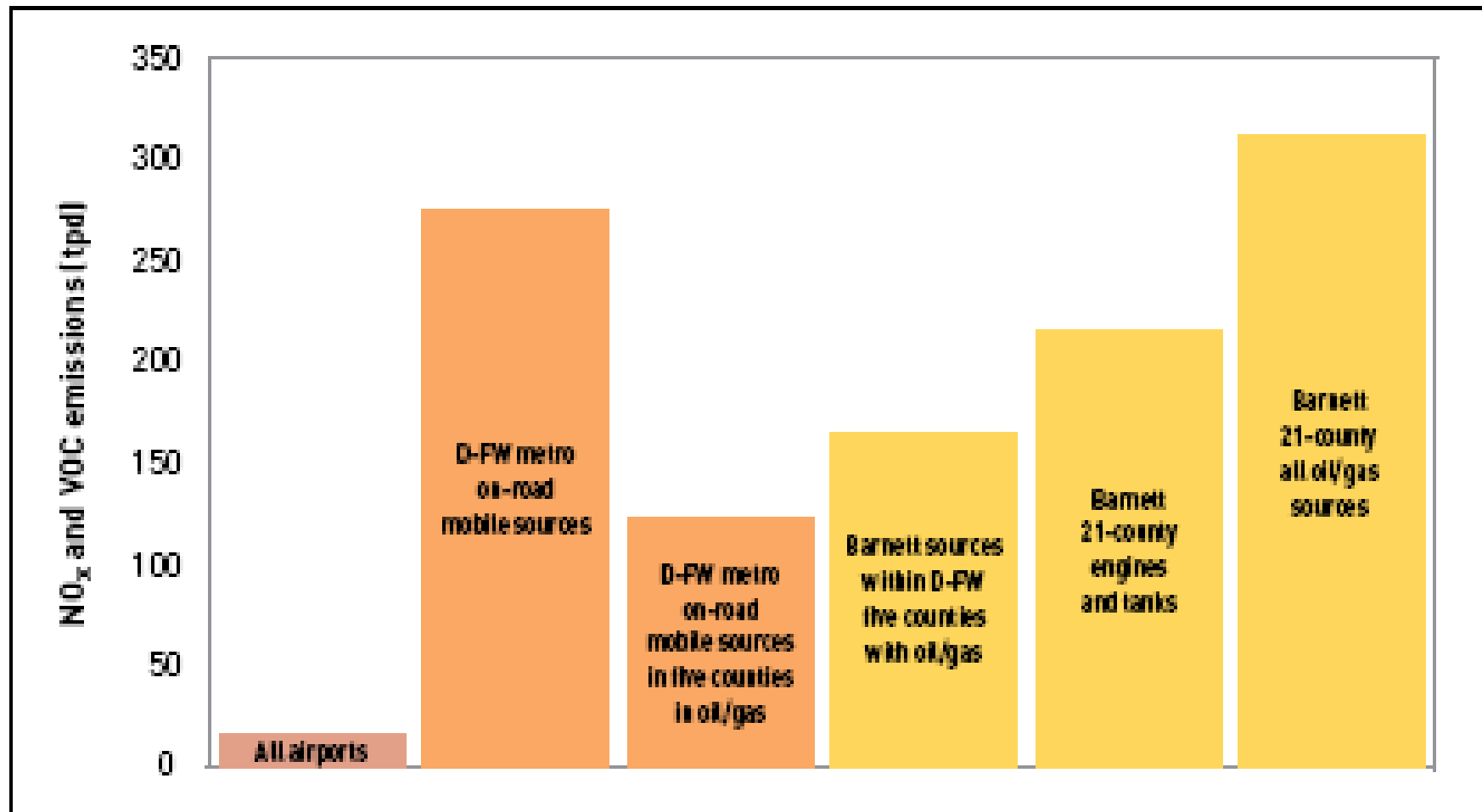
Peak summertime daily emissions (tons per day) from Barnett Shale area oil and gas production

	2009				
	Pollutant (tpd)				
	NO _x	VOC	HAPs	CH ₄	CO _{2e}
Compressor engine exhausts	46	19	3.6	61	13877
Condensate and oil tanks	0	146	11	23	483
Production fugitives	0	26	0.62	232	4884
Well drilling and completions	5.5	21	0.49	183	4061
Gas processing	0	15	0.37	50	1056
Transmission fugitives	0	28	0.67	411	8643
Total daily emissions (tpd)	51	255	17	961	33004

Source: Al Armendariz, Ph.D., Emissions from Natural Gas Production in the Barnett Shale Area and Opportunities for Cost-Effective Improvements, 6, (January 26, 2009).

ENVIRONMENTAL DEFENSE FUND

NO_x and VOC 2009 summer emissions



Emissions of NO_x and VOC in the summer of 2009 from all oil and gas sources in the Barnett Shale 20-county area will exceed emissions from on-road mobile sources in the D-FW metropolitan area by more than 30 tpd (307 vs. 273 tpd). Source: Al Armendariz, Ph.D., Emissions from Natural Gas Production in the Barnett Shale Area and Opportunities for Cost-Effective Improvements, 6, (January 26, 2009).