2002 PHOTOCHEMICAL ASSESSMENT MONITORING STATIONS (PAMS)

New Jersey Department of Environmental Protection

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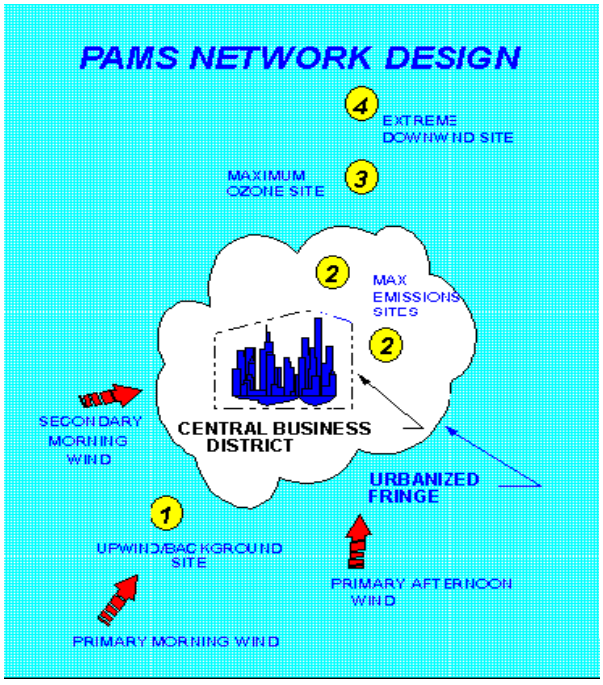
Most ground-level ozone is the result of oxides of nitrogen (NOx) and volatile organic compounds (VOCs) reacting in the presence of sunlight. As a result, it is necessary to measure these ozone forming pollutants, also known as precursor pollutants, to effectively evaluate strategies for reducing ozone levels. The Photochemical Assessment Monitoring Stations (PAMS) network was established for this purpose. Data from the PAMS network is used to better characterize the nature and extent of the O_3 problem, track VOC and NOx emission inventory reductions, assess air quality trends, and make attainment/nonattainment decisions. PAMS monitor both criteria and non-criteria pollutants including ozone (O_3), oxides of nitrogen (NOx), nitric oxide (NO), nitrogen dioxide (NO2), and specific VOCs, including several carbonyls, that are important in ozone formation. In addition, the measurement of specific weather parameters (e.g. Wind speed/direction, temperature) is required at all PAMS, and upper air weather measurements are required in certain areas. The VOC and carbonyl measurements are only taken during the peak part of the ozone season, from June 1st to August 31st each year.

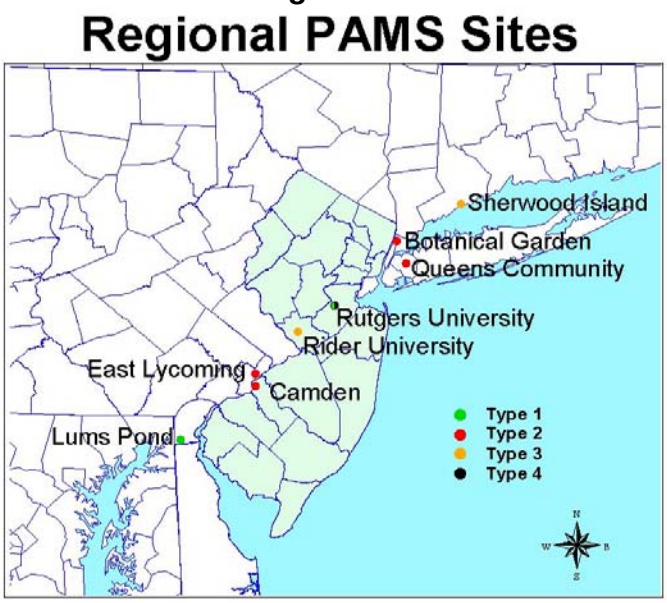
The PAMS network is designed around metropolitan areas where ozone is a significant problem, and each site in the network has a specific purpose as shown in the Figure 1 below. New Jersey is part of the Philadelphia and New York Metropolitan areas and has a total of three PAMS sites. A Type 3 maximum ozone site for the Philadelphia area is located at Rider University in Mercer County, a Type 2 maximum emissions site is located downwind of the Philadelphia Metropolitan urban area in Camden, and a site at Rutgers Universtiy in New Brunswick has been designated both a PAMS Type 1 upwind site for the New York urban area, as well as a Type 4 downwind site for the Philadelphia Metropolitan urban area. An upper air weather monitoring station is also located at the Rutgers University site. All of the PAMS sites for the Philadelphia and New York City areas are shown in Figure 2.

Figure 1



[5] USEPA , PAMS General Information

Figure 2

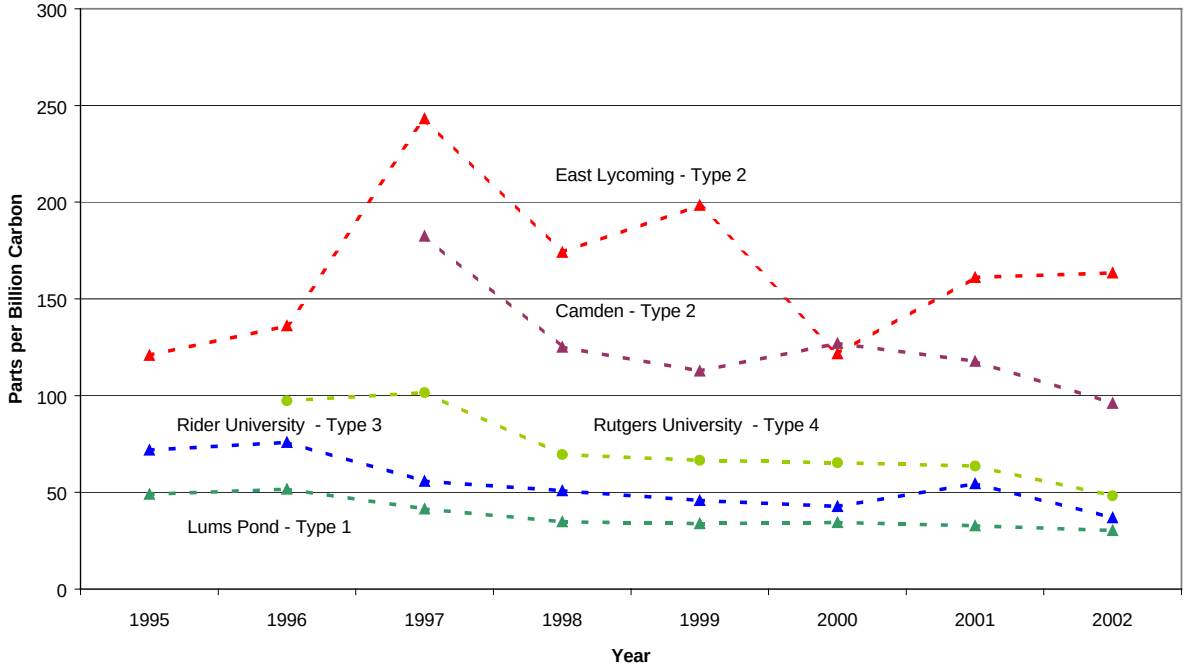


Note: Rutgers University PAMS site is both Type 4 for Philadelphia and Type 1 for New York City.

PAMS (CONT.)

The theory behind the locations chosen for these sites is that with regard to ozone precursors, the Type 2 sites should be located so as to be directly impacted by emissions from the urban area. The other sites will show ozone precursor levels that are the result of transport into or out of the urban area. These levels are diminished by chemical reactions and enhanced by inputs from sources along the transport pathway, as well as being affected by local sources near the sites. Figure 3 shows VOC trends for the PAMS sites in the Philadelphia area. Relative levels of precursors are pretty much what might be expected based on the site Type, with levels being lower upwind of the urban area, highest in the urban area, and declining with distance downwind of the urban center. The trends over time show that at Lums Pond (upwind - Type 1), Rider University (maximum ozone concentration - Type 3) and Rutgers University (downwind - Type 4), VOCs have declined over the measurement period. The declines in ozone precursor levels were initially more steep, with more level, though still declining concentrations, over the last several years. The maximum emissions impact , ie., Type 2 sites (Camden and East Lycoming) for this area show a somewhat more complicated trend. For the Camden site, which is located at the site of maximum precursor level based on the second most predominant wind direction, the levels are lower than for the East Lycoming site. The concentrations seem to show a more steady declining trend similar to the other sites already discussed. This might be expected since these are seasonal average values, and over the course of a season this site is not downwind of the urban center as often as is the East Lycoming site. This site would also be expected to show variability more like the non-urban center sites, since the factors that influence the precursor levels at Camden are usually more similar to those sites. The East Lycoming site on the other hand, is located in the predominant downwind direction, and hence when considering average values, will be most impacted by the urban area. Urban areas have many ozone precursor point source emitters, while the other sites, particularly in the summer months, are largely impacted by transportation related sources as well as transport from the urban area. As might be expected then, the East Lycoming data shows the most year to year variation due to the variety of sources that impact it.

Figure 3
Philadelphia Region
Total Non-methane Organic Carbon (TNMOC)
Seasonal Average 1995-2002



PAMS (cont.)

Figure 4 shows VOC trends for the PAMS sites in the New York City metropolitan area. The Queens Community College site ceased operations after the 2001 season. In general, observations here are similar to those for the Philadelphia area. Relative levels of precursors are what might be expected, with the sites most impacted by the urban area having the highest levels. The Bronx Botanical Garden site, located in the most predominant downwind direction, has the highest levels and the greatest variability. The Queens Community College site, located in the second most predominant morning downwind directions, shows lower and less variable precursor levels, much like the Philadelphia region's Camden site. The Rutgers University and Sherwood Island State Park sites show relative levels and trends similar to the Type 1 and Type 3 sites in the Philadelphia region.

In conclusion, VOC values measured at nearly all PAMS sites in the Philadelphia and New York City areas declined during the time period these measurements were made. Changes in gasoline formulation over the period as well as the effect of newer, cleaner vehicles replacing older vehicles in the automotive fleet likely account for at least some of the reductions. Type 2 sites, though impacted by vehicle emissions, are also affected by urban stationary sources whose year to year variability and emission trends over the measurement period are less clear. All sites are also impacted by naturally occurring isoprene, which is emitted by trees. All VOCs are not equal in their contribution to ozone formation and while isoprene levels are generally lower than many other VOCs, its ozone forming potential is one of the highest, and isoprene might account for a significant amount of the ozone forming potential, especially at the non-urban sites. Isoprene levels are thought to be influenced by factors that affect tree health and growth, such as rainfall and severe temperatures.

Summaries of results for all the VOCs and carbonyls measured at the New Jersey PAMS sites are provided in Table 1 and Table 2.

Figure 4
New York City Region
Total Non-methane Organic Carbon (TNMOC)
Seasonal Average 1995-2002

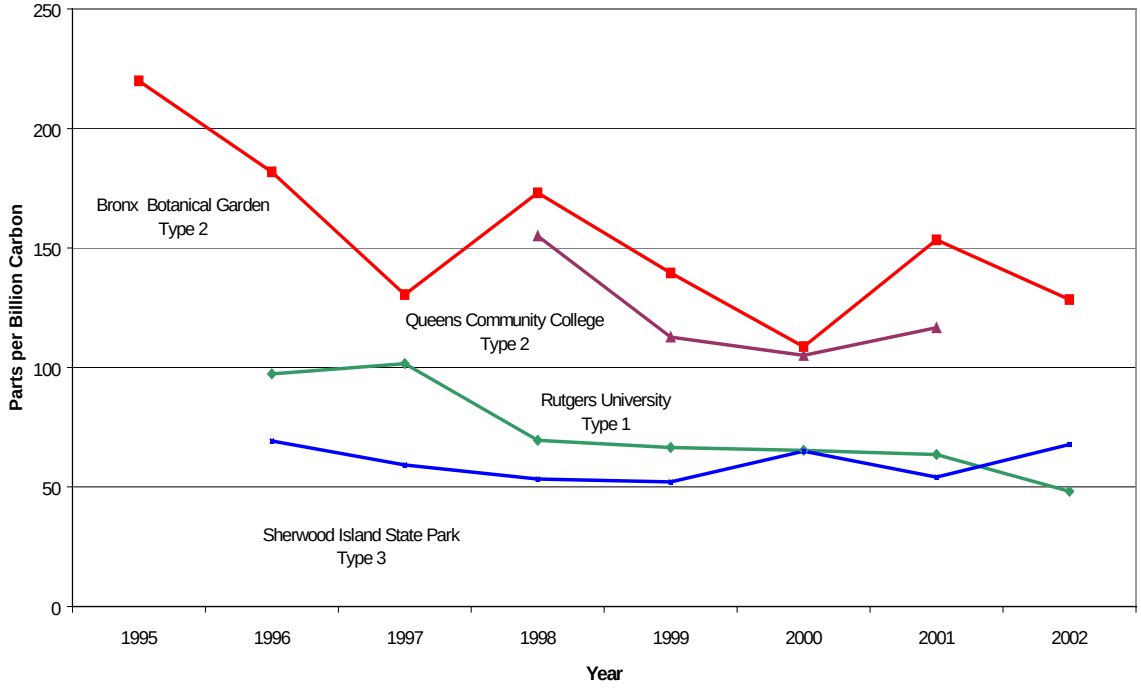


Table 1

Summary of Photochemical Assessment Monitoring (PAMS) Data

June, July, and August, 2002

Parts Per Billion (Volume) – ppbv

Parts Per Billion (Carbon) – ppbC

Max – Maximum Avg - Average

	Camden Lab				Rider University				Rutgers University			
	ppbv		ppbC		ppbv		ppbC		ppbv		ppbC	
	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg
Acetylene	3.26	0.35	6.51	0.71	0.54	0.10	1.07	0.21	7.53	0.45	15.05	0.90
Benzene	2.66	0.27	15.96	1.64	0.73	0.15	4.35	0.88	0.87	0.14	5.22	0.84
n-Butane	63.37	1.51	253.46	6.04	3.66	0.41	14.63	1.62	4.46	0.53	17.84	2.11
1-Butene	1.87	0.12	7.49	0.47	0.13	0.03	0.53	0.13	0.29	0.04	1.16	0.18
cis-2-Butene	1.02	0.10	4.09	0.39	0.10	0.02	0.38	0.08	0.42	0.03	1.69	0.11
trans-2-Butene	1.27	0.10	5.07	0.38	0.11	0.03	0.43	0.10	0.39	0.03	1.56	0.12
Cyclohexane	3.26	0.14	19.57	0.85	0.25	0.04	1.51	0.22	0.20	0.03	1.18	0.20
Cyclopentane	1.76	0.09	8.78	0.46	0.17	0.05	0.84	0.24	0.24	0.04	1.22	0.21
n-Decane	0.55	0.07	5.49	0.66	0.14	0.02	1.44	0.23	0.25	0.03	2.46	0.28
m-Diethylbenzene	0.20	0.03	1.99	0.26	0.10	0.01	0.99	0.13	0.13	0.01	1.30	0.11
p-Diethylbenzene	0.35	0.04	3.45	0.38	0.06	0.01	0.56	0.12	0.10	0.01	0.96	0.14
2,2-Dimethylbutane	2.25	0.14	11.25	0.68	0.15	0.03	0.73	0.17	0.43	0.04	2.15	0.21
2,3-Dimethylbutane	2.10	0.15	10.48	0.77	0.26	0.06	1.32	0.29	0.54	0.07	2.68	0.34
2,3-Dimethylpentane	1.05	0.08	7.34	0.58	0.20	0.04	1.38	0.29	0.22	0.04	1.53	0.26
2,4-Dimethylpentane	1.02	0.07	7.11	0.52	0.12	0.03	0.87	0.23	0.19	0.03	1.33	0.19
Ethane	32.48	3.34	64.95	6.68	6.63	2.01	13.25	4.02	14.94	2.56	29.88	5.12
Ethylbenzene	1.42	0.09	11.38	0.70	1.41	0.04	11.25	0.33	0.43	0.05	3.41	0.36
Ethylene (Ethene)	10.50	1.12	21.00	2.24	1.91	0.35	3.82	0.71	11.29	1.06	22.57	2.12
m-Ethyltoluene	1.19	0.08	10.70	0.68	0.22	0.02	1.98	0.22	0.45	0.05	4.04	0.41
o-Ethyltoluene	0.41	0.04	3.66	0.33	0.05	0.01	0.49	0.12	0.12	0.02	1.04	0.14
p-Ethyltoluene	0.53	0.08	4.81	0.68	0.26	0.04	2.37	0.33	0.21	0.02	1.89	0.15
n-Heptane	1.80	0.13	12.58	0.91	0.34	0.05	2.37	0.36	0.48	0.05	3.36	0.37
Hexane	8.83	0.31	53.00	1.88	0.58	0.12	3.50	0.70	1.75	0.12	10.47	0.70
1-Hexene	0.32	0.04	1.93	0.27	0.40	0.03	2.42	0.15	0.11	0.01	0.63	0.07
Isobutane	33.03	1.05	132.12	4.20	2.24	0.27	8.96	1.09	4.25	0.32	17.01	1.29
Isopentane	39.83	1.55	199.15	7.77	2.92	0.53	14.58	2.66	7.19	0.66	35.97	3.30
Isoprene	2.33	0.20	11.64	0.99	3.50	0.25	17.49	1.27	6.80	0.60	34.00	2.98
Isopropylbenzene	1.11	0.11	9.96	1.01	0.25	0.02	2.25	0.18	0.13	0.01	1.21	0.13
Methylcyclohexane	2.94	0.13	20.60	0.90	0.35	0.04	2.45	0.30	0.40	0.04	2.78	0.28
Methylcyclopentane	3.74	0.18	22.44	1.09	0.34	0.07	2.05	0.41	0.49	0.07	2.95	0.42
2-Methylheptane	0.48	0.05	3.80	0.41	0.11	0.02	0.84	0.14	0.23	0.02	1.84	0.15
3-Methylheptane	0.59	0.05	4.71	0.36	0.12	0.02	0.92	0.16	0.14	0.02	1.10	0.17
2-Methylhexane	1.15	0.12	8.08	0.84	0.25	0.05	1.78	0.36	0.30	0.05	2.13	0.36

Table 1 (Continued)
Summary of Photochemical Assessment Monitoring (PAMS) Data
June, July, and August, 2002

	Camden Lab				Rider University				Rutgers University			
	ppbv		ppbC		ppbv		ppbC		ppbv		ppbC	
	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg
3-Methylhexane	1.26	0.14	8.79	1.00	0.33	0.06	2.32	0.43	0.38	0.06	2.63	0.43
2-Methylpentane	8.33	0.42	49.97	2.49	0.68	0.14	4.09	0.86	1.47	0.17	8.83	1.03
3-Methylpentane	5.46	0.26	32.73	1.56	0.46	0.10	2.73	0.58	0.94	0.11	5.62	0.67
n-Nonane	0.35	0.06	3.17	0.52	0.14	0.02	1.27	0.21	0.28	0.02	2.52	0.22
n-Octane	0.79	0.07	6.33	0.59	0.29	0.03	2.30	0.22	0.28	0.03	2.26	0.24
n-Pentane	32.28	0.80	161.42	4.01	1.69	0.26	8.47	1.29	3.57	0.36	17.84	1.78
1-Pentene	0.40	0.07	2.01	0.34	0.09	0.02	0.45	0.10	0.31	0.03	1.53	0.14
cis-2-Pentene	0.39	0.07	1.94	0.33	0.08	0.02	0.41	0.08	0.32	0.02	1.61	0.11
trans-2-Pentene	0.78	0.09	3.92	0.45	0.13	0.02	0.66	0.11	0.64	0.03	3.20	0.17
Propane	180.02	3.64	540.05	10.93	10.32	1.32	30.97	3.96	10.10	1.57	30.30	4.71
n-Propylbenzene	0.33	0.03	2.98	0.31	0.05	0.01	0.49	0.13	0.10	0.02	0.94	0.14
Propylene (Propene)	16.47	0.83	49.41	2.50	2.27	0.24	6.81	0.72	2.71	0.36	8.12	1.09
Styrene	0.57	0.04	4.56	0.33	0.09	0.02	0.74	0.16	0.08	0.02	0.67	0.15
Toluene	13.81	0.56	96.67	3.94	4.92	0.34	34.41	2.38	13.66	0.73	95.62	5.09
1,2,3-Trimethylbenzene	0.50	0.08	4.49	0.73	0.36	0.04	3.26	0.37	0.39	0.04	3.51	0.35
1,2,4-Trimethylbenzene	1.74	0.08	15.66	0.73	0.21	0.03	1.93	0.31	0.57	0.05	5.10	0.47
1,3,5-Trimethylbenzene	0.76	0.05	6.83	0.46	0.11	0.02	1.02	0.20	0.21	0.03	1.89	0.23
2,2,4-Trimethylpentane	5.94	0.19	47.49	1.53	0.61	0.09	4.87	0.69	0.91	0.11	7.25	0.89
2,3,4-Trimethylpentane	2.53	0.07	20.24	0.55	0.31	0.03	2.50	0.25	0.31	0.04	2.44	0.29
n-Undecane	0.35	0.05	3.89	0.57	0.12	0.02	1.30	0.20	0.17	0.02	1.83	0.21
m/p-Xylene	5.51	0.24	44.04	1.90	4.06	0.11	32.44	0.91	1.45	0.14	11.58	1.13
o-Xylene	1.94	0.10	15.54	0.82	0.89	0.05	7.09	0.37	0.47	0.05	3.78	0.41

Table 2
Camden Lab
PAMS Carbonyls
June, July, and August, 2002
Parts Per Billion (Volume)
28 Sampling Dates (224 Observations)

	# of Detects*	Max	Avg		# of Detects	Max	Avg
Acetaldehyde	224	5.03	1.60	Formaldehyde	224	13.09	4.88
Acetone	224	49.5	7.51	Hexaldehyde	186	0.50	0.07
Benzaldehyde	217	0.31	0.08	Isovaleraldehyde	26	0.04	0.00
Butyr/Isobutyraldehyde	188	1.11	0.22	Propionaldehyde	158	0.47	0.08
Crotonaldehyde	203	1.59	0.07	Tolualdehyde	211	0.20	0.05
2,5-Dimethybenzaldehyde	4	0.02	0.00	Valeraldehyde	224	0.47	0.06

* The number of samples, out of a possible 224, in which the compound was detected.