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Final Report

Air Quality Survey

Seattle-Tacoma International Airport

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Port of Seattle
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Prepared by

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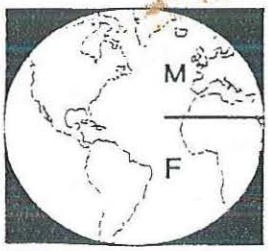

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Executive Summary

An air quality survey of airborne toxic organic compounds and carbon monoxide was conducted in the vicinity of Seattle-Tacoma International (Sea-Tac) Airport. Samples were collected during four late fall to early winter days in 1993 at locations within the Airport Operations Area, upwind of the airport, downwind of the airport, near International Blvd, and at a residential location in Normandy Park. The sampling periods were selected to contrast different meteorological conditions and corresponding modes of airport operation.

EPA reference methods were used to collect volatile organic compounds (VOCs), including benzene, with evacuated canisters, and carbonyl compounds, including formaldehyde, with reagent coated cartridges. Approximately 50 % of the VOCs tested for in the study were detected in the evacuated canisters. Benzene, a specific target, was found in every sample collected. In general the canister sampling data did not indicate variations with meteorology or mode of airport operation. Generally higher concentrations were collected at Gate B3 and next to International Blvd, while relatively lower concentrations were observed at the residential location in Normandy Park. However these trends were not consistent for every compound or sampling period, and the monitoring network did not discern significant differences in upwind versus downwind concentrations.

While not directly comparable, concentrations of several of the VOCs collected at Sea-Tac Airport were higher than the screening criteria used by the Washington Department of Ecology for assessment of toxic pollutant emissions from a new stationary industrial source. These VOC levels at Sea-Tac Airport are not atypical, with measured concentrations within the range observed in other urban areas. The signature or ratios of several key VOCs were indicative of automobile exhaust and did not resemble the VOC profiles associated with aircraft emissions.

The canister samples collected in the study were also analyzed for carbon monoxide. The carbon monoxide levels observed in the study did not follow any distinctive temporal or spatial pattern. The monitoring network did not indicate that Sea-Tac Airport airfield operations were a significant source and all carbon monoxide concentrations in the survey were less than the 8-hour average national ambient air quality standard.

The survey included measurements of formaldehyde and other carbonyl compounds at three locations, representing a potential source area site, an upwind site, and a downwind site. Formaldehyde and acetaldehyde were present in all the samples and acrolein was always detected at Gate B3. The average concentrations of these compounds were higher for the sampling periods when the airport was in a south flow mode of operation. The relatively higher values also occurred for the sampling periods which included the late afternoon and it is unclear whether the higher values were caused by different modes of operation or different periods of the diurnal cycle. Samples of formaldehyde, acetaldehyde, and acrolein were higher at Gate B3 than at the upwind or downwind locations. The upwind/downwind carbonyl sampling data collected in this study were indicative of active sources at Sea-Tac Airport.

Formaldehyde, acetaldehyde, and acrolein samples collected in the study were higher than the new stationary industrial source screening criteria applied by the Washington Department of Ecology for these compounds. Formaldehyde, acetaldehyde, and acrolein concentrations observed at Sea-Tac Airport were within the range reported for other urban areas.

1.0 Introduction

An air quality survey was conducted of airborne toxic organic compounds and carbon monoxide in the vicinity of Seattle-Tacoma International (Sea-Tac) Airport. The study was performed by the *Atmospheric Sciences Group* of McCulley, Frick and Gilman, Inc. on behalf of the Port of Seattle. Samples were collected during the period from October to December 1993, within the Airport Operations Area (AOA), upwind of the airport, downwind of the airport, near a major roadway, and at a residential location in Normandy Park. The methodologies that were employed for sample collection and the results of the study are described in the remainder of this report.

1.1 Background

The Washington Department of Ecology (WDOE) conducted a screening level assessment of emissions and concentrations from airport sources based on the application of the FAA's Emissions and Dispersion Modeling System (EDMS).[1] While the 1991 study was only intended as a screening assessment and did not include an air sampling program, WDOE's report evoked a very concerned response from the nearby community. The report suggested that the airport might be a significant source of toxic air pollutants, and that the neighboring community might be at risk. The WDOE report has been cited by citizens opposed to proposals to expand Sea-Tac Airport's operational capacity and to develop the South Aviation Support Area.

WDOE's study suggested the primary toxic pollutants of concern were benzene and other volatile organic compounds (VOCs). Benzene, toluene, isomers of xylene and other VOCs are present in jet fuel and are contained in jet turbine exhaust due to incomplete combustion. Evaporation of fuel during storage, refueling, and fuel handling operations also results in emissions of these VOCs. These same compounds are also contained in gasoline and automobile exhaust, and elevated levels observed in many urban areas have been attributed to automobiles.[2]

In addition to VOCs emitted by aircraft operation, members of the study steering committee expressed concern over formaldehyde and carbon monoxide (CO) levels near Sea-Tac Airport. The steering committee is comprised of representatives from concerned citizens groups and regulatory agencies. Formaldehyde has received regulatory attention as a possible carcinogen and CO is a criteria pollutant regulated under the Clean Air Act. Formaldehyde and CO are directly emitted as the result of incomplete combustion. Formaldehyde, acetaldehyde, and other aldehydes can also be formed in the environment as the products of oxidation of virtually all hydrocarbons and play an important role in photochemical processes. Formaldehyde and acetaldehyde are emitted by vehicles that use oxygenated fuels like methanol and have also been reported in the literature as one of the principal hydrocarbon components of jet turbine exhaust.[3,4]

1.2 Objectives & Study Overview

The field sampling program was designed to provide a preliminary survey of VOC, carbonyl, and CO levels in the vicinity of Sea-Tac Airport with the intent of addressing many of the concerns raised by the WDOE report and the steering committee. The objectives of the sampling program were as follows:

- to assess the concentrations of VOCs, carbonyl compounds, and CO near Sea-Tac Airport
- to compare concurrent upwind, downwind, and residential concentrations of the target compounds
- assess sampling techniques that could possibly be employed in more extensive air quality surveys

The study was intended as a survey and not designed to evaluate all regulated air pollutants or provide comprehensive identification of all potential emission sources.

VOC samples were collected with evacuated canisters and analyzed with Gas Chromatography according to EPA Method TO-14.[5,6] In order to address the concerns of the steering committee, the evacuated canisters were also analyzed for CO using method ASTM D-3416.[7] Canister samples were collected at 9 locations, on 4 different days. The sampling periods corresponded to different meteorological and/or operational scenarios. The sampling network was spatially diverse to compare VOC levels downwind of potential airport sources with respect to upwind monitoring locations and other receptors of interest, for example next to International Blvd and at a residence in Normandy Park, a residential city west of the airport.

EPA recommends a different approach for the collection of formaldehyde and other carbonyl compounds (aldehydes and ketones) which are not stable or degrade in the canisters. These compounds were collected and analyzed according to EPA Method TO-11.[8] This method involves drawing ambient air at a constant rate through a coated adsorbent cartridge followed by High Pressure Liquid Chromatography (HPLC). Cartridge sampling was conducted at 3 locations during the same 4 periods to coincide with the canister sampling.

As an alternative to the conventional canister based method, a related study also employed a remote sensing Fourier Transform Infrared (FTIR) spectrometer for quantification of gaseous compounds near possible airport sources. FTIR spectroscopy is an emerging technology in air pollution monitoring and the program tested the utility of this device at Sea-Tac Airport. Staff from the University of Washington were responsible for the operation and deployment of the remote sensing FTIR. The FTIR spectrometer investigation at Sea-Tac Airport showed promise for future use, but as discussed further in Section 2.6, the instrument employed in the study was not able to provide sufficient quantitative data in field conditions.

The sampling methodologies employed in the current study are presented in Section 2, including descriptions of the evacuated canister sampling program, formaldehyde sampling program, the FTIR spectrometer investigation, and QA/QC procedures. The results of the data analysis are presented in Section 3. The data were compared by location and sampling period. The data were assessed in the context of upwind/downwind differences, and compared with similar data from other urban areas and with ambient air quality criteria. The report concludes with a summary, references, and supporting appendices.

2.0 Sampling Methodology

The field program surveyed the magnitude and spatial distribution of VOCs, CO, and carbonyls in the immediate vicinity of the major sources at Sea-Tac Airport and in the surrounding community. The techniques used in the study were outlined previously in a Sampling Plan developed for review by interested parties.[9] The principal study focus was on benzene and other VOCs sampled by evacuated canisters according to EPA Method TO-14. The evacuated canisters also provided the means of sampling for CO. Formaldehyde and other carbonyl compounds were sampled with EPA Method TO-11 using reagent coated cartridges. The FTIR spectrometer was also employed to test the utility of this instrument for future applications. The remainder of this section more fully describes the sampling methods that were employed in the field program.

2.1 Evacuated Canister Sampling

2.1.1 Volatile Organic Compounds

EPA Method TO-14 involves the collection of whole air samples with evacuated canister sampling systems and subsequent analysis by Gas Chromatography coupled with a Mass Spectrometer (GC/MS). There are many methods of sampling for gaseous hydrocarbons in the ambient air including sorbent tubes, evacuated canisters, portable gas chromatographs, and open-path optical remote sensing techniques. The selection of the EPA Method TO-14 was based on considerations of the hydrocarbon species of interest; regulatory preferences; the number, duration and frequency of sampling; and budget.

Collection of air samples with an evacuated canister sampling system and analysis with GC/MS is a recent development in hydrocarbon sampling. The method is widely employed in sampling programs concerned with VOCs, especially compounds like benzene, chloroform, isomers of xylene, vinyl chloride, and others. The sampling system employed 6 liter SUMMA passivated stainless steel canisters with flows regulated by critical flow orifices. The pressure differential between the canister and atmospheric pressure allowed a time-integrated sample to be collected for 6 to 8 hours. Flow into the sampler is continuous and steady as long as the pressure differential remains above a critical value. The entire sampling system was obtained from the laboratory,* where the canisters were batch-certified clean according to the protocols outlined in EPA Method TO-14.

The evacuated canister systems were mounted on 1.5 m sampling platforms or attached to chain-link fences at some sites. The systems consisted of an evacuated canister fitted with a critical-flow orifice, pressure gauge, and particle filter. The field operators manually initiated the sample collection, then routinely checked the flow throughout the sampling period with a calibrated rotameter. Flow rates typically were set at about 8.5 cm^3/min, resulting in the collection of a 4 liter sample in 8 hours. Rotameter and pressure gauge readings were recorded in an operator log with visual observations concerning potential nearby sources, mode of airport operation, and the weather. Sampling was manually terminated at a specified time or when

* All samples from the field sampling program were analyzed by Air Toxics Ltd. in Folsom, CA. Air Toxics is a Tier 1 approved Subcontract Laboratory for the Special Analytical Services Branch of the EPA.

the pressure readings approached a minimum critical vacuum. At the end of the sampling period, the partially filled canisters remain under a slight vacuum. The filled canisters where then collected and sent via 2-day air freight to the analytical laboratory.

The TO-14 list of VOCs is presented in Table 1. The minimum detection limit (MDL) for these compounds using GC/MS within an Ion Trap detector is approximately 0.1 part-per-billion (ppb). Actual detection limits were approximately 0.2 ppb due to the necessary purging used in the laboratory to obtain samples from the canisters. The GC/MS analyses target the TO-14 compound peaks on the chromatograph and certified gas phase standards were used to ensure accurate quantification. In addition to the assessment of the standard TO-14 list of VOCs, the laboratory reported the top 10 other tentatively identified compounds (TICs) in the canisters based on examination of the peaks in the chromatograph. Depending on the compound, quantification of the TIC is less accurate and less precise than for the compounds contained in the standard TO-14 VOC list.

The laboratory also examined the chromatograph records for each sample and assessed the total petroleum hydrocarbons (TPH) present in the canisters. The method is based on the integral of the area under the chromatograph and a qualitative match to a hydrocarbon reference. Due to the nature of the sampling in the study, the reference chosen for the analysis was Jet Fuel (molecular weight 156). Note that the TPH values listed in this report do not identify the mixtures in the canisters as Jet Fuel.

2.1.2 Carbon Monoxide

The EPA reference method for CO involves continuous measurement by Nondispersive Infrared Spectrometry. This method was not practical for the current study, because the method is not portable and the costs of a multi-station network were prohibitive. As an alternative, the ambient samples collected with evacuated canisters were analyzed for CO using Gas Chromatography according to ASTM D-3416. The MDL for this method is approximately 1 part-per-million (ppm). After laboratory dilution of the partially filled canisters, the actual MDL was about 2 ppm.

2.2 Formaldehyde Sampling

Aldehyde and ketone organic compounds including formaldehyde were collected according to EPA Method TO-11 which involves solid adsorbent exposure followed by HPLC. A known volume of sample air was drawn though a prepacked Sep-Pak chromatographic grade cartridge coated with a reagent (DNPH or 2,4-dinitrophenylhydrazine) which fixes the carbonyl compounds. The volume of air passing through the cartridge was controlled by a pump and monitored by routine inspection of a calibrated rotameter. At the laboratory, formaldehyde and other carbonyl compounds of interest were desorbed, then identified and quantified by comparison of their retention times and peak heights with those of standard solutions. The primary disadvantage of this method involves collecting enough formaldehyde for detection and ensuring that the formaldehyde reacts with the DNPH, while avoiding the total carbonyl adsorption capacity of the cartridge.

Table 1. EPA Method TO-14 Compound List

Compound [a]	Chemical Abstracts System (CAS) Number
Freon 12	75-71-8
Freon 114	76-14-2
50.49 ✓Methyl chloride Chlorodibromethane	74-87-3
Vinyl chloride	75-01-4
Methyl bromide	74-83-9
Ethyl chloride	75-00-3
Freon 11	75-69-4
Vinylidene chloride	75-35-4
Freon 113	76-13-1
✓Dichloromethane 3794	75-09-2
1,1-Dichloroethane	74-34-3
X cis-1,2-Dichloroethylene ~~37.74~~	156-59-2 107-06-02
✓Chloroform 119.39	67-66-3
1,1,1-Trichloroethane	71-55-6
✓Carbon tetrachloride 153.84	56-23-5
✓Benzene 78	71-43-2
✓1,2-Dichloroethane 98.96	107-06-2
✓Trichloroethylene 131.40	79-01-6
✓1,2-Dichloropropane 112.99	78-87-5
cis-1,3-Dichloropropene	10061-01-5
Toluene	108-88-3
trans-1,3-Dichloropropene	10061-02-6
1,1,2-Trichloroethane	79-00-5
165.85 ✓Tetrachloroethene Perchloroethylene	127-18-4
187.88 ✓1,2-Dibromoethane Ethylene Dibromide	106-93-4
Chlorobenzene	108-90-7
Ethylbenzene	100-41-4
m,p-Xylene	1330-20-7
o-Xylene	95-47-6
Styrene	100-42-5
1,1,2,2-Tetrachloroethane	79-34-5
1,3,5-Trimethylbenzene	108-67-8
1,2,4-Trimethylbenzene	95-63-6
m-Dichlorobenzene	541-73-1
p-Dichlorobenzene	106-46-7
Benzyl chloride	100-44-7
o-Dichlorobenzene	95-50-1
1,2,4-Trichlorobenzene	120-82-1
Hexachlorobutadiene	87-68-3
1,3-BUTADIENE = 106-99-0	

(a) Minimum detection limit of 0.1 ppb by volume

Formaldehyde 30.01

The formaldehyde sampling system consisted of a battery-operated pump connected to the DNPH coated cartridge with about 1 m of sampling line. The sampling systems were portable and placed next to the VOC canister systems with a sampling inlet about 1 m above the ground. Flow through the cartridge was measured with a calibrated rotameter and routinely recorded by the field operators. The DNPH cartridges were received from the laboratory and refrigerated until use in the field. After the sampling was complete the exposed samples were sealed in glass vials, then placed in a small cooler for overnight shipment to the laboratory.

EPA Method TO-11 recommends that the sample inlet be heated for application in environments where temperatures are much colder than 60 °F. For the first two sampling periods, the samples were collected at ambient temperatures averaging about 55 °F. Due to the potential for colder weather and concerns regarding the reactivity of the formaldehyde with the reagent, the sampling systems were enclosed and heated with a small lamp during the last two sampling periods. A thermometer placed inside the enclosures indicated that temperatures of 100 °F were attained during the last two sampling periods. Although the sampling configuration did not allow direct temperature measurements of air entering the cartridges, the relatively high enclosure temperatures were expected to result in sampled inlet temperatures above the recommended 60 °F.

A list of the EPA Method TO-11 compounds is presented in Table 2. The method was written specifically for formaldehyde, but the laboratory was also asked to quantify the other carbonyl compounds on the cartridge using an extension to the standard method. The MDL for formaldehyde and these compounds using HPLC with an ultraviolet-visible detector was 0.1 microgram (μg) on the cartridge. Flow rates were typically adjusted to about 700 cm^3/min by the field operators, which for an 8-hour sample results in a MDL of 0.30 $\mu g/m^3$ or 0.24 ppb for formaldehyde.

2.3 Sampling Locations

Sampling locations were based on consideration of possible sources at the airport, the potential impact areas identified by WDOE's EDMS modeling, accessibility, security, meteorology, and consultations with the Port of Seattle regarding aircraft operations. Specifically, each sampling period had evacuated canister samples collected at:

- 2 upwind sites — dependent on wind direction, these sites were placed in locations to assess the quality of air upwind of airport operations. Two sites were used to assess the expected spatial variability in upwind ambient VOC and CO concentrations
- 4 downwind sites — placed downwind of possible sources at Sea-Tac Airport to contrast with the upwind data and provide preliminary data concerning the crosswind extent of the VOC and CO plumes and relative importance of different airport source groups or activities
- source area site — located within a potential Sea-Tac Airport VOC and CO emissions source area. This site was fixed and used as a reference for the upwind/downwind monitoring locations

Table 2. EPA Method TO-11 Compound List

Compound [a]	CAS Number
Formaldehyde	50-00-0
Acetaldehyde	75-07-0
Acrolein	107-02-8
Acetone	67-64-1
Propionaldehyde	123-38-6
Crotonaldehyde	4170-30-3
Isobutyraldehyde	78-84-2
Methyl Ethyl Ketone	78-93-3
Benzaldehyde	100-52-7
Valeraldehdye	110-62-3
o-Tolualdehyde	529-20-4
m-Tolualdehyde	620-23-5
p-Tolualdehyde	104-87-0
Hexanaldehyde	66-25-1

(a) Minimum Detection Limit 0.1 μg or for a 8-hour sampling rate of 1 l/min, MDL $\approx$ .2 $\mu g/m^3$.

- residential site — located in Normandy Park (2 miles west of the airport) to provide background information in an offwind direction, removed from major roadways and the airport

- roadway site — located adjacent to International Blvd (SR-99) to provide an indication of VOC and CO concentrations associated with automobiles

- QA/QC site — Quality Assurance/Quality Control (QA/QC) samples were located next to one of the sites to assess the overall precision of EPA Method TO-14

Figure 1 and Figure 2 show the locations of the canister sampling network for northerly and southerly flow, respectively. Northerly flow refers to winds from the north, with aircraft taking off to the north and landing from the south. Southerly flow refers to winds and aircraft operations in the opposite direction. The locations and site exposures are further described in Table 3. Site 1 was located at Gate B3 near the main terminal and corresponds to the source area or reference location. Site 2 was near International Blvd and corresponds to the roadway site. A residential site (Site 7) was located in Normandy Park and Site 10 & Site 13 were used for QA/QC purposes. The remainder of the sites were placed to provide indications of the potential upwind/downwind differences in VOC and CO concentrations from aircraft activity. Downwind sites correspond to areas identified in the WDOE study, areas downwind of the terminal, or downwind of aircraft queued on the taxiways. Sites 1,2,4,5,7,8,9 and a QA/QC site were used for all sampling periods. Site 3 and Site 6 were downwind during northerly winds and Site 11 and Site 12 were downwind during southerly flow.

The formaldehyde sampling program was conducted on a more limited spatial scale than that of the canister sampling program. For each sampling period, upwind, downwind, and source area samples were collected at the same locations as three of the canister sampling sites. The sampling locations corresponded to Sites 1,4, & 9 as shown in Figure 1 and Figure 2. While this network was not as extensive as for VOC's and CO, it provided a preliminary survey of formaldehyde levels near Sea-Tac Airport and resulted in data which was also used to contrast upwind/downwind levels.

2.4 Sampling Periods

The sampling program provided preliminary information concerning the temporal variability in VOC, formaldehyde, and CO concentrations due to differing meteorology and source activity at Sea-Tac Airport. Individual sampling periods were based on projected aircraft activity, wind conditions, and logistical considerations concerning sampling within the AOA. Based on consultations with the Port of Seattle and the study steering committee, the study goals called for sampling during four periods as follows:

- (1 or 2) north flow aircraft operation mode, persistent winds from the north
- (1 or 2) south flow aircraft operation mode, persistent winds from the south
- (1) stagnation condition, light and variable winds

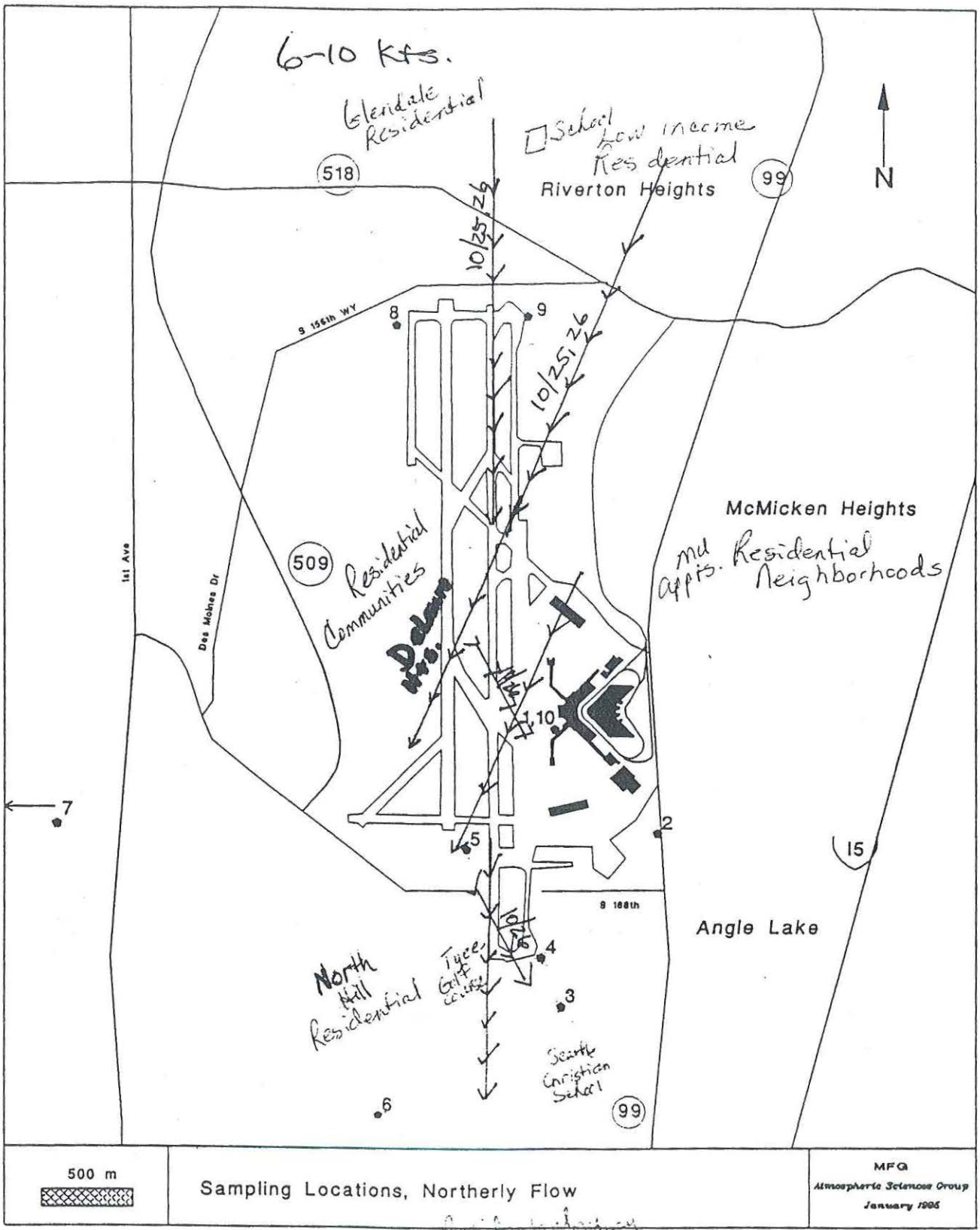

Figure 1. Sampling Locations, Northerly Flow

11/26 & 12/14
FRIDAY TUESDAY

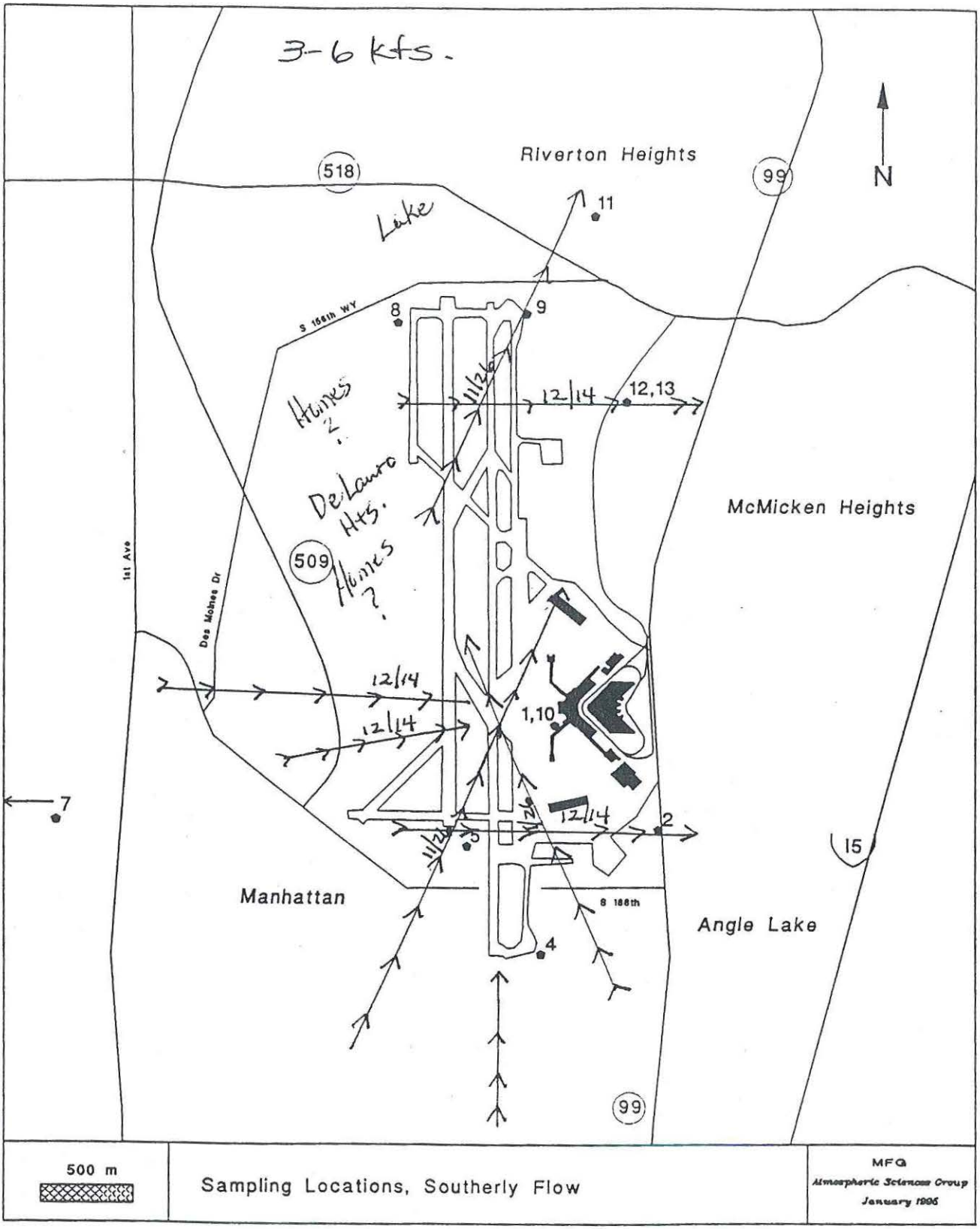

Figure 2. Sampling Locations, Southerly Flow

Table 3. Canister Sampling Locations

Site Number	Location	Purpose	Exposure/Comments [a]
1	Gate B3	source area site	fair exposure
2	Budget rental car lot South of Gateway Hotel International Blvd	roadway site	20 m from roadway good exposure
3	24th ave S & S 194th next to Tyee Golf course	north flow downwind	good exposure
4	SE Corner of AOA	north flow downwind south flow upwind	excellent exposure
5	SW Corner of AOA	north flow downwind south flow upwind	excellent exposure
6	Former Maywood School S 200th St	north flow downwind	on roof excellent exposure
7	Residence 1117 Shoremont Ave SW Normandy Park	offwind residential background site	in front yard fair exposure
8	NW Corner AOA	north flow upwind south flow downwind	excellent exposure
9	NE Corner AOA	north flow upwind south flow downwind	excellent exposure
10	located next to site 1	QA site	fair exposure
11	Former Residence 26th Ave S	south flow downwind	in backyard good exposure
12	Maintenance Yard Off Host Rd	south flow downwind	good exposure
13	located next to site 12	QA site	good exposure

AOA refers to the Airport Operations Area

[a] The exposure of each sampling location to wind was subjectively assessed using the following classes:

excellent - sample location was free from surrounding objects and received unobstructed exposure to winds from all directions

good - sample location was within 2 heights of a surrounding object for winds from a 90° sector, unobstructed exposure for other wind directions

fair - sample location was within 2 heights of a surrounding object for winds from a 180° sector, unobstructed exposure for other wind directions

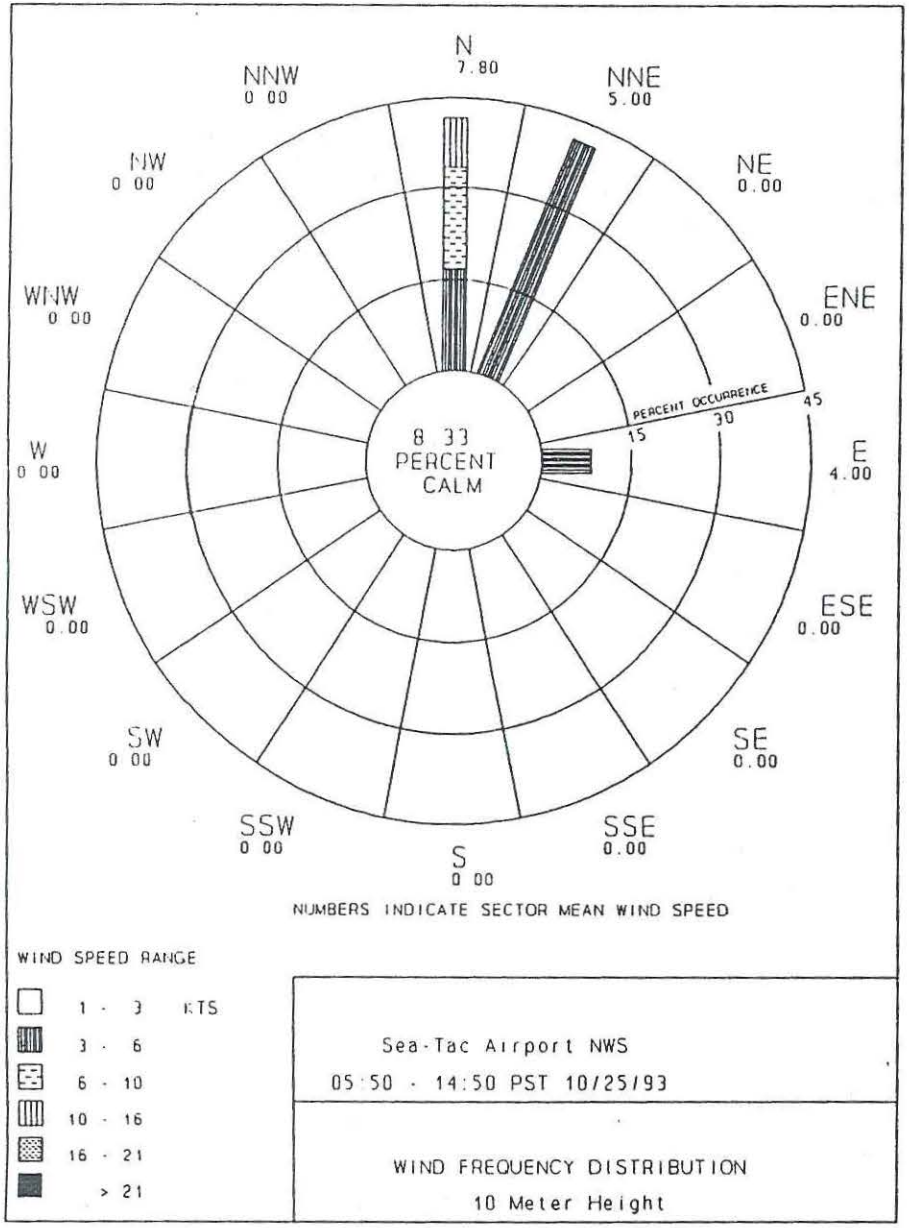

Figure 3. Winds on October 25, 1993

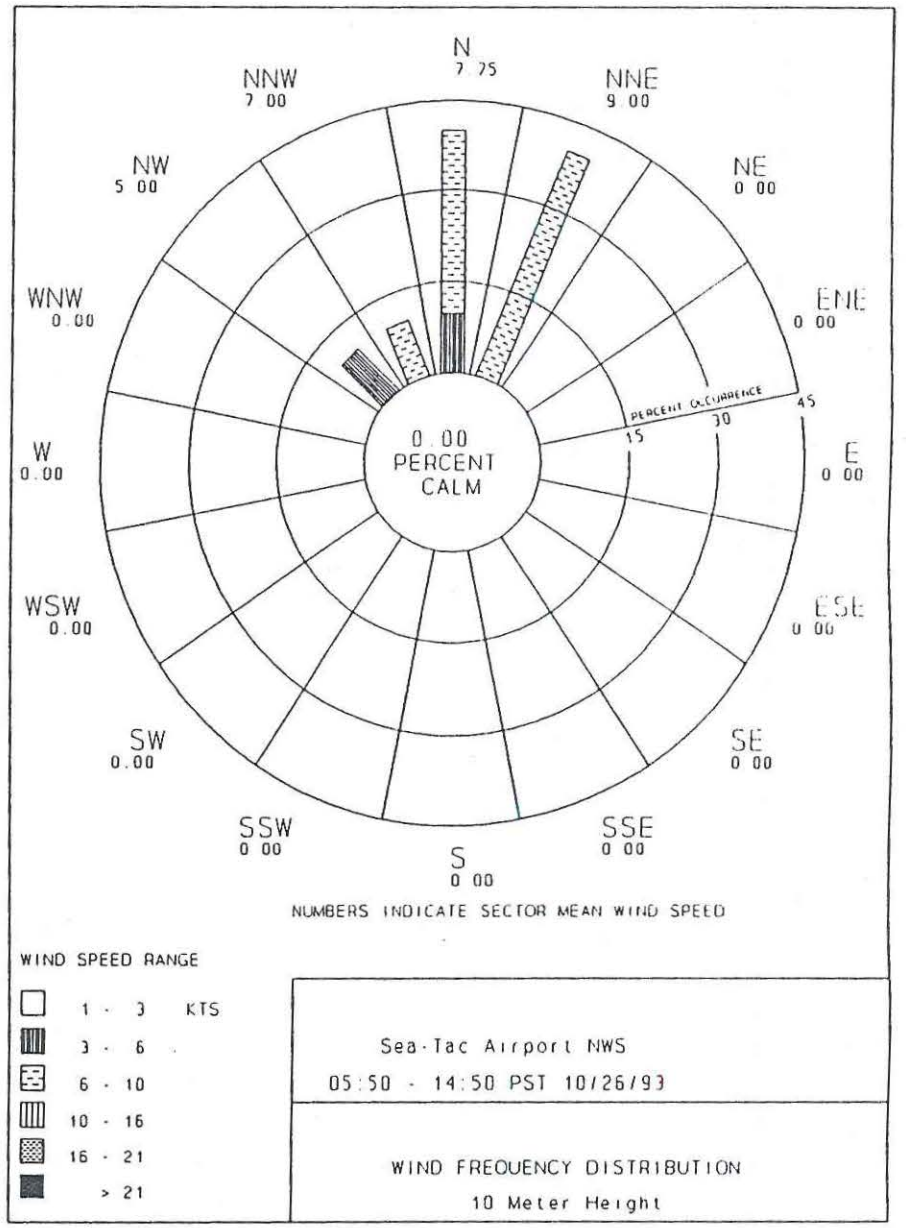

Figure 4. Winds on October 26, 1993

Using these guidelines and the wind forecasts obtained from the National Weather Service (NWS) Aviation Forecasting located at Sand Point, sampling was conducted on October 25, 1993; October 26, 1993; November 26, 1993; and December 14, 1993.

The meteorological conditions at Sea-Tac Airport during the sampling events are shown in Table 4. October 25 and 26 corresponded to periods of northerly flow and with the exception of a 1-hour period during the morning on October 25, the airport was under a northerly mode of operation. Sampling on these days commenced between 0600 to 0800 PST and ended between 1400 to 1500 PST. The sampling encompassed periods of increased aircraft activity, with peak departures in the morning and peak arrivals around midday. Wind roses constructed for October 25 and October 26 are displayed in Figure 3 and Figure 4, respectively. October 25 was characterized by light and variable winds in the early morning with associated ground fog, becoming sunny and relatively warm in the afternoon with moderate northerly winds. Northerly flow continued on October 26 with persistent winds averaging 8 knots (kts). Temperatures for both sampling periods were near 45 °F in the morning and rose to 61 °F in the early afternoon.

During the sampling on November 26 and December 14, Sea-Tac Airport was under a southerly mode of operation with aircraft taking off to the south. Sampling on these days commenced around the midday peak in airport activity and ended after a secondary peak in activity that occurs near 1800 PST. November 26 was the Friday after Thanksgiving, typically a day with relatively high passenger volumes. Wind roses for November 26 and December 14 are displayed in Figure 5 and Figure 6, respectively. The November 26 sampling period was overcast and cold at 42 °F, with southerly winds averaging 6 kts. The December 14 sampling occurred during a period of light rain with an average temperature of 47 °F. Winds on December 14 were light (averaging 3 kts), with flow from the south shifting to winds from the west with the approach of frontal system.

Although wind velocities were less than average for the majority of the sampling periods, the study did not capture a classical stagnation episode. Calm conditions were recorded on both October 25 and December 14, but these conditions did not persist on October 25 and the later period was not accompanied by a subsidence inversion. On October 25, a brown haze north of Sea-Tac Airport was clearly evident under a low level temperature inversion, but this layer dissipated with the arrival of stronger northerly winds in the early afternoon.

2.5 Quality Control & Quality Assurance

2.5.1 Canister Sampling

The sampling program followed the QA/QC recommendations outlined by EPA Method TO-14 for both the analytical and field aspects of the sampling. Batch-certified clean evacuated canister sampling systems were obtained from the laboratory. The risk of outside contamination was reduced because the sampling systems do not involve external pumps, mass flow controllers, or tubing. Potential degradation of compounds in the canisters was reduced by returning the samples to the laboratory well within the two-week recommended time period.

Table 4. Meteorological Conditions at Sea-Tac Airport During the Study

Date	Time (PST)	Temp (F)	Rel Humi (%)	Wind Dir (deg)	Wind Spd (knots)	Press ("Hg)	Comments
10/25/93	550	44	93	90	4	30.44	
10/25/93	650	45	93	20	4	30.46	Patchy Ground Fog
10/25/93	734			350	4	30.46	Patchy Ground Fog
10/25/93	750	46	89	20	5	30.47	Patchy Ground Fog
10/25/93	850	47	89	calm	calm	30.47	Fog Bank South to NE
10/25/93	945			10	5	30.48	
10/25/93	950	49	86	20	5	30.48	
10/25/93	1050	55	69	20	5	30.48	
10/25/93	1150	58	62	30	6	30.47	
10/25/93	1250	59	57	350	12	30.47	
10/25/93	1350	60	58	10	8	30.47	
10/25/93	1450	61	51	360	10	30.47	
10/26/93	550	45	93	20	10	30.50	
10/26/93	650	45	89	20	9	30.48	
10/26/93	750	45	96	20	8	30.48	Fog Bank West to NE
10/26/93	850	49	86	360	8	30.49	Patchy Ground Fog
10/26/93	950	52	74	30	9	30.48	
10/26/93	1050	56	59	10	8	30.47	
10/26/93	1150	59	57	350	6	30.46	
10/26/93	1250	61	60	320	5	30.43	
10/26/93	1350	60	60	10	9	30.42	
10/26/93	1450	59	62	330	7	30.40	
11/26/93	1051	40	50	180	6	30.23	
11/26/93	1151	43	45	160	4	30.21	
11/26/93	1251	45	47	250	5	30.20	
11/26/93	1353	42	55	200	6	30.19	
11/26/93	1450	44	51	200	7	30.20	
11/26/93	1550	41	65	210	6	30.19	
11/26/93	1650	38	70	160	5	30.18	
11/26/93	1750	41	44	150	8	30.17	
12/14/93	1150	46	79	180	4	29.82	light rain showers
12/14/93	1244			220	4	29.83	light rain showers
12/14/93	1250	47	86	calm	calm	29.83	light rain showers
12/14/93	1350	47	86	300	5	29.84	
12/14/93	1436			260	4	29.85	
12/14/93	1450	47	86	calm	calm	29.85	light rain showers
12/14/93	1551	47	86	280	3	29.87	
12/14/93	1652	46	86	260	3	29.89	
12/14/93	1752	47	86	160	4	29.91	
12/14/93	1851	45	93	290	4	29.93	

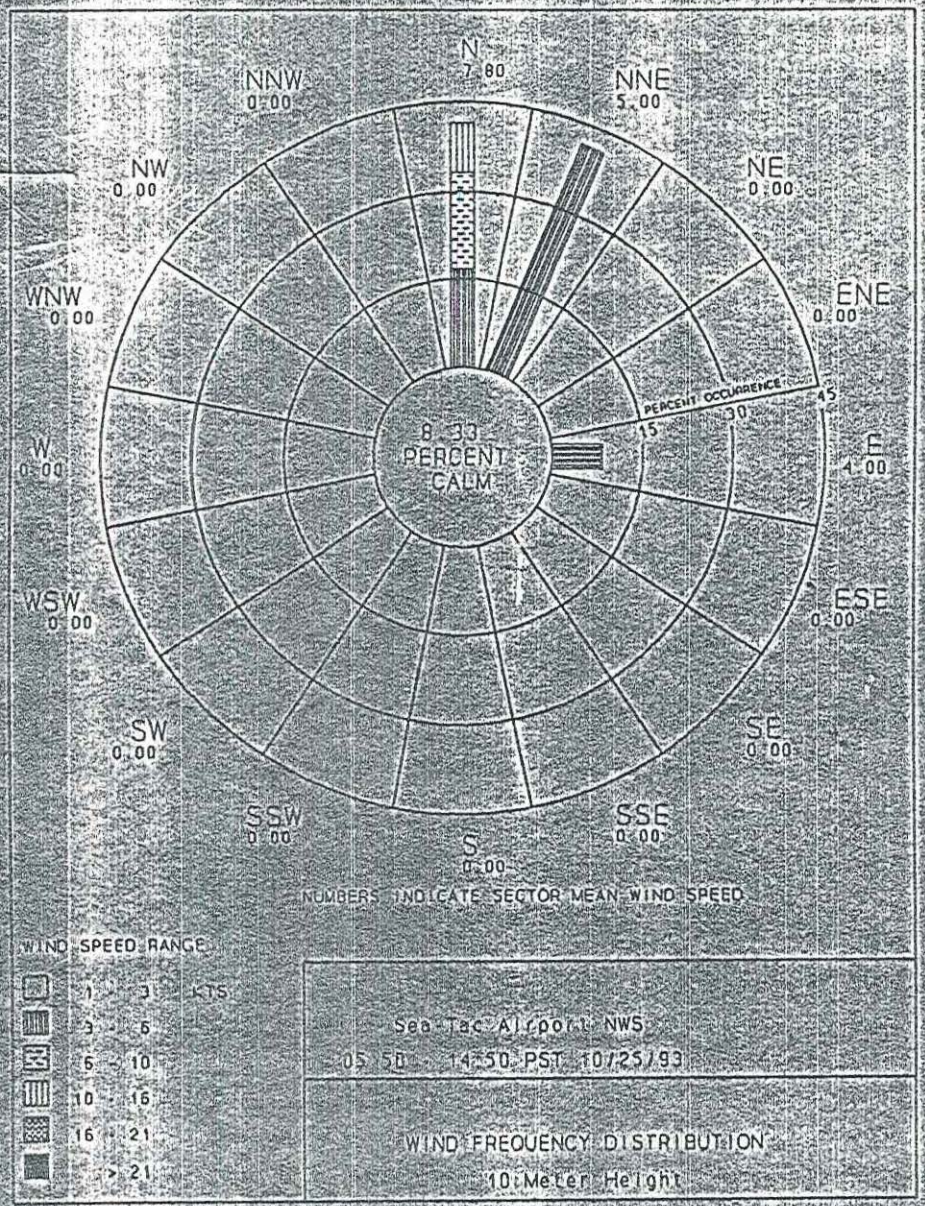

Figure 3. Winds on October 25, 1993

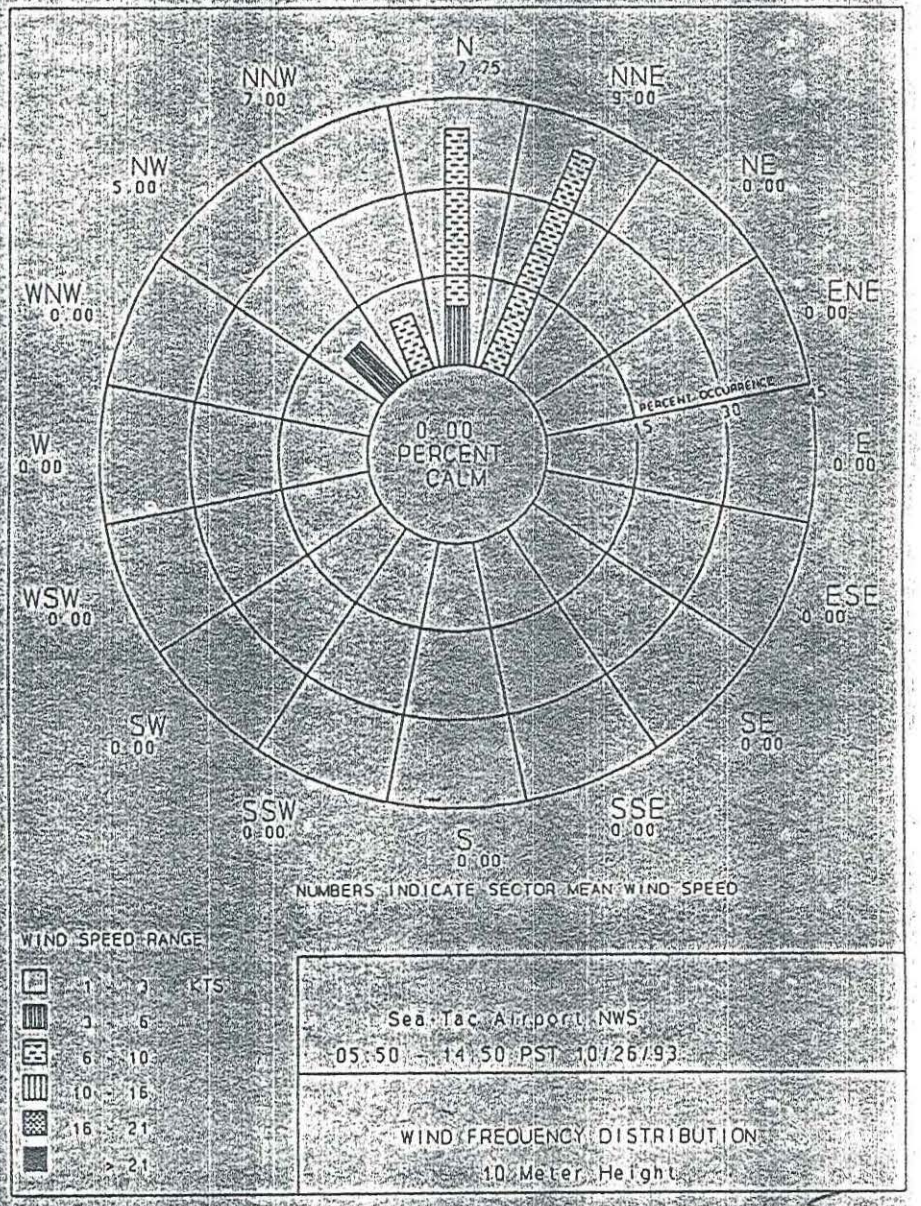

Figure 4. Winds on October 26, 1993

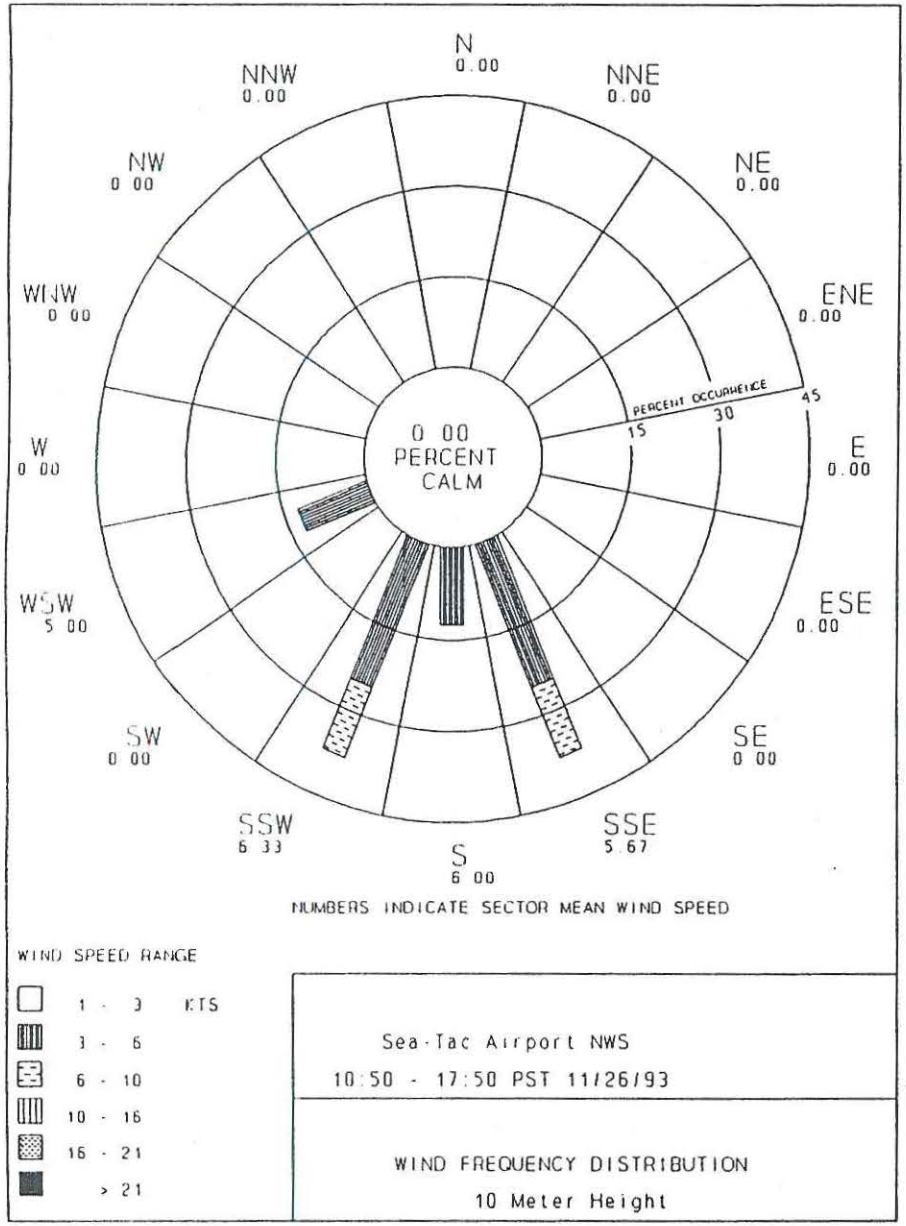

Figure 5. Winds on November 26, 1993

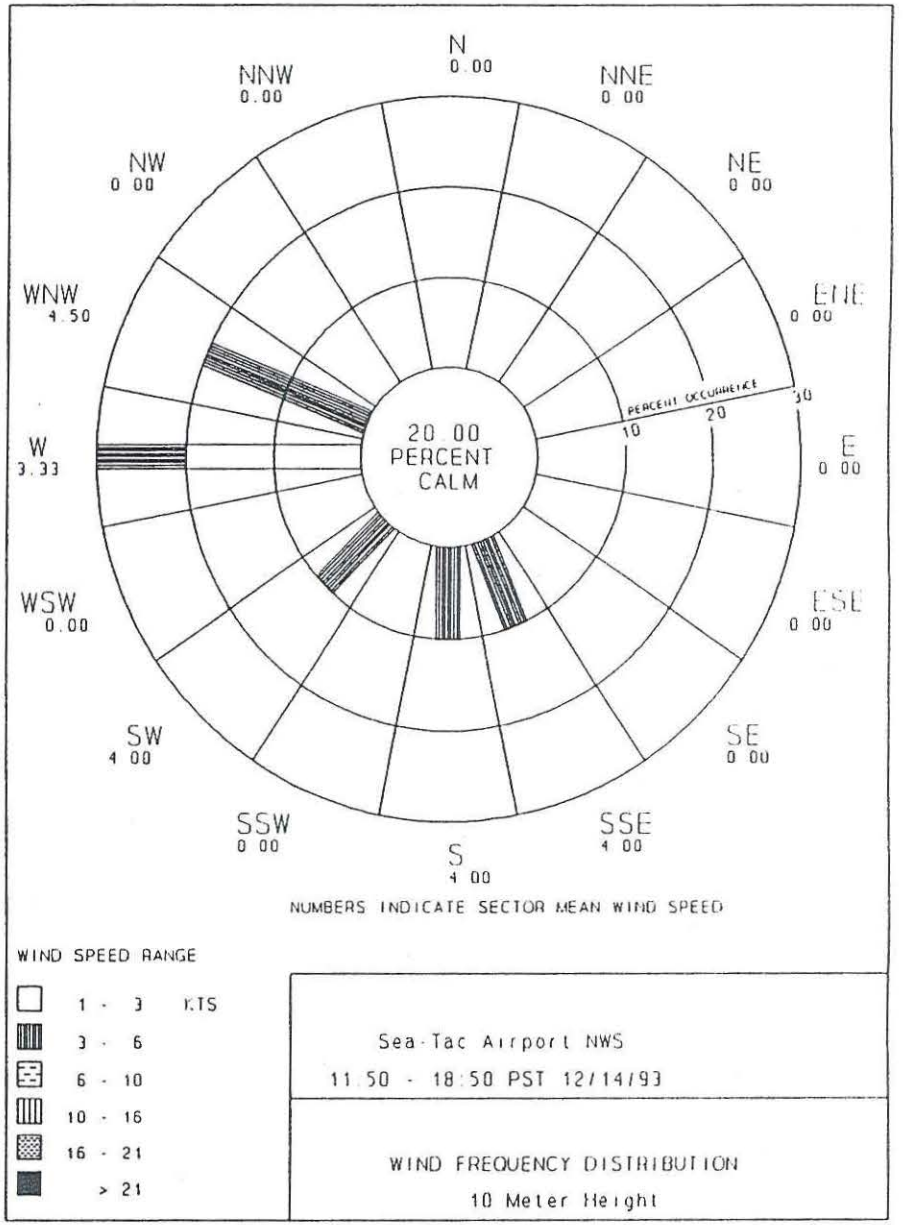

Figure 6. Winds on December 14, 1993

An analytical blank, duplicate, and Method Spike were performed by the laboratory for every 10 samples analyzed. Quantities of TO-14 compounds, CO, and TICs were not detected in any of the analytical blanks analyzed. With the exception of one freon 12 sample, Method Spike recoveries were within the quality control recovery limits of 70 to 130 % for all TO-14 compounds detected in the study. The analytical precision of the canister sampling for the TO-14 compounds, CO, and TPH is shown in Table 5. The relative standard deviations (RSD) of the differences between the replicates were less than 14 % for all compounds detected except freon 12.

The overall precision of the canister sampling program was assessed by comparing the results of 5 side-by-side samples. These samples were collected at Site 1/10 (Gate B3) and at Site 12/13. The results of the side-by-side sampling for the TO-14 compounds are presented in Table 6 and for the TICs in Table 7. With few exceptions the overall precision of the method for the TO-14 compounds was acceptable and less than that exhibited by the TICs. Note, that only the top 10 TICs were reported by the laboratory for each sample. The RSDs for benzene, toluene, CO, and TPH were 16 %, 19 %, 15 %, and 40 %, respectively.

Based on experience with the TO-14 Method, duplicate field sample results often have a relative percent difference (RPD) of up to 50 %, especially for the TICs.[10] Using this as a criteria, relatively low overall precision was found for freon 12, 1,1,1-trichloroethane, isopropyl alcohol, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), and benzaldehyde. The reasons for the imprecision are unclear but could be related to any one of the following:

- contamination of the sample in the field. This is unlikely due to the simplicity of the sampling system. All components upstream of the canister were obtained from the laboratory, batch certified clean.

- contamination of the sample in the laboratory. This is unlikely since the compounds were not detected in the analytical blanks.

- the TICs reported were not corrected identified. With the exception of benzaldehyde which was identified based on a match to a library of chromatograph signatures, the compounds in question were identified based on experience with calibration gases containing these compounds.

- analytical imprecision. The low performance for freon 12 can be attributed to analytical imprecision as demonstrated by the analytical duplicates.

- degradation of the compound in the canister. Some degradation of the polar hydrocarbon compounds like MEK have been reported in the literature for samples with low humidity.

- the canister system was not efficiently cleaned. Although the canisters were certified clean, not every canister was checked by the laboratory. The canisters were cleaned in batches, then samples at random were checked. In one instance a high MEK result in the duplicate could be traced to a very high value (8000 ppb) in the same canister from a prior analysis. However, in general no pattern of historically high values in previous samples could be established.

Table 5. EPA Method TO-14, Precision of Analytical Duplicates

Compound		10/25/93 Site 7	10/25/93 QA Dup	10/25/93 RPD (%)	10/26/93 Site 7	10/26/93 QA Dup	10/26/93 RPD (%)	11/26/93 Site 4	11/26/93 QA Dup	11/26/93 RPD (%)	12/14/93 Site 7	12/14/93 QA Dup	12/14/93 RPD (%)	Mean No.	Mean RPD (%)	Mean RSD (%)
Freon 12	(ppb)	0.30	0.65	73.7	0.77	0.33	-80.0	0.32	0.64	66.7	0.22	0.27	20.4	4	20.2	70.9
Freon 114	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Methyl chloride	(ppb)	0.25	0.27	7.7	0.88	0.86	-2.3	0.18	0.23	24.4	ND	ND		3	9.9	13.5
Vinyl chloride	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Methyl bromide	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Ethyl chloride	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Freon 11	(ppb)	0.29	0.27	-7.1	0.33	0.36	8.7	0.34	0.34	0.0	0.34	0.29	-15.9	4	-3.6	10.4
Vinylidene chloride	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Freon 113	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Dichloromethane	(ppb)	0.33	0.19	-53.8	ND	ND		ND	ND		ND	ND		1	-53.8	
1,1-Dichloroethane	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
cis-1,2-Dichloroethylene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Chloroform	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
1,1,1-Trichloroethane	(ppb)	0.20	0.20	0.0	ND	ND		0.42	0.41	-2.4	0.26	0.23	-12.2	3	-4.9	6.5
Carbon tetrachloride	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Benzene	(ppb)	1.40	1.30	-7.4	0.26	0.29	10.9	2.10	2.00	-4.9	2.20	2.00	-9.5	4	-2.7	9.3
1,2-Dichloroethane	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Trichloroethylene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
1,2-Dichloropropane	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
cis-1,3-Dichloropropene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Toluene	(ppb)	3.90	3.90	0.0	ND	ND		3.60	3.60	0.0	4.20	4.00	-4.9	3	-1.6	2.8
trans-1,3-Dichloropropen	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
1,1,2-Trichloroethane	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Tetrachloroethene	(ppb)	ND	ND		ND	ND		ND	ND		0.20	0.20	0.0	1	0.0	
1,2-Dibromoethane	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Chlorobenzene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Ethyl Benzene	(ppb)	0.63	0.62	-1.6	ND	ND		0.70	0.76	8.2	0.80	0.73	-9.2	3	-0.8	8.7
m,p-Xylene	(ppb)	2.30	2.30	0.0	ND	ND		2.40	2.40	0.0	2.70	2.60	-3.8	3	-1.3	2.2
o-Xylene	(ppb)	0.86	0.83	-3.6	ND	ND		0.90	0.86	-4.5	1.00	0.99	-1.0	3	-3.0	1.8
Styrene	(ppb)	0.30	0.27	-10.5	ND	ND		ND	ND		0.54	0.51	-5.7	2	-8.1	3.4
1,1,2,2-Tetrachloroethane	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
1,3,5-Trimethylbenzene	(ppb)	ND	ND		ND	ND		0.30	0.30	0.0	0.20	0.19	-5.1	2	-2.6	3.6
1,2,4-Trimethylbenzene	(ppb)	0.47	0.47	0.0	ND	ND		0.94	0.94	0.0	0.64	0.63	-1.6	3	-0.5	0.9
m-Dichlorobenzene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
p-Dichlorobenzene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Benzyl chloride	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
o-Dichlorobenzene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
1,2,4-Trichlorobenzene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
Hexachlorobutadiene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		0		
TPH	(ppb)	41	35	-15.8	61	65	6.3	240	220	-8.7	390	400	2.5	4	-3.9	10.2
Carbon monoxide (CO)	(ppm)	5.0	4.7	-6.2	ND	ND		3.6	4.1	13.0	2.8	3.4	19.4	3	8.7	13.3

ND: Compound below minimum detection limit (MDL)
TPH: Total Petroleum Hydrocarbons referenced to Jet Fuel
CO: Based on ASTM D-3416
RPD: Relative percent difference based on 200(dup-obs)/(dup+obs)
RSD: Standard deviation of RPD

Table 6. EPA Method TO-14, Precision of Side-by-Side Sampling

CAS No.	Compound		10/25/93 Site 1	10/25/93 QA Site 10	10/25/93 RPD (%)	11/26/93 Site 1	11/26/93 QA Site 10	11/26/93 RPD (%)	11/26/93 Site 12	11/26/93 QA Site 13	11/26/93 RPD (%)	12/14/93 Site 1	12/14/93 QA Site 10	12/14/93 RPD (%)	12/14/93 Site 12	12/14/93 QA Site 13	12/14/93 RPD (%)	Mean No.	Mean RPD (%)	Mean RSD(%)	Mean CV(%)
75-71-8	Freon 12	(ppb)	0.83	0.30	-71.0	0.38	0.49	25.3	0.26	ND		0.55	ND		0.46	ND		2	-22.8	68.1	69.1
76-14-2	Freon 114	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
74-87-3	Methyl chloride	(ppb)	0.24	0.29	18.9	0.25	0.25	0.0	0.23	0.22	-4.4	0.22	0.25	12.8	ND	0.30		4	6.8	10.9	11.3
75-01-4	Vinyl chloride	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
74-83-9	Methyl bromide	(ppb)	ND	ND		ND	ND		NO	NO		ND	ND		ND	ND		0			
75-00-3	Ethyl chloride	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
75-69-4	Freon 11	(ppb)	0.35	0.39	10.8	0.33	0.33	0.0	0.29	0.43	38.9	0.29	0.39	29.4	0.30	0.29	-3.4	5	15.1	18.4	19.1
75-35-4	Vinylidene chloride	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
76-13-1	Freon 113	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
75-09-2	Dichloromethane	(ppb)	ND	0.29		ND	ND		ND	ND		ND	ND		ND	ND					
74-34-3	1,1-Dichloroethane	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
156-59-2	cis-1,2-Dichloroethylene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
67-66-3	Chloroform	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
71-55-6	1,1,1-Trichloroethane	(ppb)	0.25	0.28	11.3	1.10	1.70	42.9	0.23	3.10	172.4	ND	0.29		0.27	0.22	-20.4	4	51.5	84.6	153.2
56-23-5	Carbon tetrachloride	(ppb)	ND	ND		ND	ND		ND	ND		NO	NO		ND	ND		0			
71-43-2	Benzene	(ppb)	2.20	3.40	42.9	4.00	4.10	2.5	2.40	2.60	8.0	2.80	2.90	3.5	2.70	3.00	10.5	5	13.5	16.8	15.5
107-06-2	1,2-Dichloroethane	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
79-01-6	Trichloroethylene	(ppb)	ND	0.27		ND	ND		ND	ND		ND	ND		ND	ND		0			
78-87-5	1,2-Dichloropropane	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
10061-01-5	cis-1,3-Dichloropropene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
108-88-3	Toluene	(ppb)	6.50	7.60	15.6	8.40	9.30	10.2	4.60	6.40	32.7	5.40	8.20	41.2	7.20	6.40	-11.8	5	17.6	20.7	18.9
10061-02-6	trans-1,3-Dichloropropene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
79-00-5	1,1,2-Trichloroethane	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
127-18-4	Tetrachloroethene	(ppb)	ND	ND		0.18	ND		0.21	ND		0.28	ND		ND	ND		0			
106-93-4	1,2-Dibromoethane	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
108-90-7	Chlorobenzene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
100-41-4	Ethyl Benzene	(ppb)	1.10	1.30	16.7	1.50	1.50	0.0	0.67	1.10	48.6	1.00	1.60	46.2	1.50	1.10	-30.8	5	16.1	33.2	31.5
1330-20-7	m,p-Xylene	(ppb)	3.90	4.40	12.0	5.40	5.20	-3.8	2.20	3.90	55.7	3.80	6.20	48.0	5.70	4.20	-30.3	5	16.3	35.9	34.3
95-47-6	o-Xylene	(ppb)	1.40	1.60	13.3	1.90	1.80	-5.4	0.83	1.50	57.5	1.40	2.10	40.0	2.40	1.80	-40.0	5	13.1	38.3	37.5
100-42-5	Styrene	(ppb)	0.31	0.44	34.7	ND	0.16		ND	0.19		ND	0.42		0.39	0.29	-29.4	2	2.8	45.3	45.5
79-34-5	1,1,2,2-Tetrachloroethane	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
108-67-8	1,3,5-Trimethylbenzene	(ppb)	0.41	0.46	11.5	0.67	0.57	-16.1	0.20	0.20	0.0	0.41	0.58	34.3	0.42	0.31	-30.1	5	-0.1	24.9	27.3
95-63-6	1,2,4-Trimethylbenzene	(ppb)	1.30	1.40	7.4	2.00	1.70	-16.2	0.69	0.71	2.9	1.30	1.80	32.3	1.30	1.00	-26.1	5	0.0	22.6	25.1
541-73-1	m-Dichlorobenzene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
106-46-7	p-Dichlorobenzene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
100-44-7	Benzyl chloride	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
95-50-1	o-Dichlorobenzene	(ppb)	ND	ND		0.38	ND		ND	ND		ND	ND		ND	ND		0			
120-82-1	1,2,4-Trichlorobenzene	(ppb)	ND	0.26		ND	ND		ND	ND		ND	ND		ND	ND		0			
87-68-3	Hexachlorobutadiene	(ppb)	ND	ND		ND	ND		ND	ND		ND	ND		ND	ND		0			
	TPH	(ppb)	250	320	24.6	380	390	2.6	340	210	-47.3	420	480	13.3	340	630	59.8	5	10.6	38.8	40.2
	Carbon monoxide (CO)	(ppm)	4.3	4.5	4.5	4.4	4.9	10.8	3.9	3.2	-19.7	3.6	2.8	-25.0	3.8	3.4	-11.1	5	-8.1	15.4	14.8

ND: Compound below minimum detection limit (MDL)
TPH: Total Petroleum Hydrocarbons referenced to Jet Fuel
CO: Based on ASTM D-3416
RPD: Relative percent difference based on 200(dup-obs)/(dup+obs)
RSD: Standard deviation of RPD
CV: Coefficient of Variation of RPD

Table 7. TICs, Precision of Side-by-Side Sampling

Compound		10/25/93 Site 1	10/25/93 QA Site 10	10/25/93 RPD (%)	11/26/93 Site 1	11/26/93 QA Site 10	11/26/93 RPD (%)	11/26/93 Site 12	11/26/93 QA Site 13	11/26/93 RPD (%)	12/14/93 Site 1	12/14/93 QA Site 10	12/14/93 RPD (%)	12/14/93 Site 12	12/14/93 QA Site 13	12/14/93 RPD (%)	Mean No.	Mean RPD (%)	Mean RSD (%)
Ethyl Alcohol	(ppb)	20.0	22.0	9.5	37.0	34.0	-8.5	18.0	28.0	43.5	15.0	23.0	42.1	12.0	11.0	-8.7	5	15.6	25.9
Acetone	(ppb)	13.0	11.0	-16.7	12.0	8.6	-33.0	14.0	26.0	60.0	4.9	6.3	25.0	14.0	12.0	-15.4	5	4.0	37.9
Isopropyl Alcohol	(ppb)	3.8	8.0	71.2	5.0	4.7	-6.2		12.0					1.6			2	32.5	54.7
Methyl Ethyl Ketone	(ppb)		2.7						18.0			57.0		2.1	420.0	198.0	1	198.0	
Butane	(ppb)	12.0	11.0	-8.7	23.0	20.0	-14.0	9.0	11.0	20.0	14.0	17.0	19.4	10.0	9.0	-10.5	5	1.2	16.9
Isopentane	(ppb)	6.7	7.1	5.8	11.0	12.0	8.7	4.2	5.0	17.4	7.0	12.0	52.6	5.1	5.6	9.3	5	18.8	19.4
Pentane	(ppb)	3.9	4.1	5.0	6.3	6.2	-1.6		3.0		4.0	6.8	51.9	3.2	3.2	0.0	4	13.8	25.5
Hexane	(ppb)	1.6	1.8	11.8	8.9			4.2				3.8			10.0		1	11.8	
Methyl Isobutyl Ketone	(ppb)							11.0	5.8	-61.9				6.8	4.3	-45.0	2	-53.5	11.9
Benzaldehyde	(ppb)	1.5	10.0	147.8													1	147.8	
Butyl Alcohol	(ppb)	1.8							5.1										
n,n-Dimethyl Acetamide	(ppb)							11.0											
Sulfur Dioxide	(ppb)											17.0							
1,4-Dioxane	(ppb)										11.0								

NR: A blank value indicates that the compound was not one of the top ten TICs
RPD: Relative percent difference based on 200(dup-obs)/(dup+obs)
RSD: Standard deviation of RPD

- different air masses were sampled. In some instances, sample flow rates into the canisters were variable caused by small leaks in the sampling system. However, the operators logs for the duplicate sampling program indicated that the side-by-side sampling had very similar input flow histories.

The reasons for the relatively low method precision for several of the compounds could not clearly be established in this study. The summary tables in the following sections are flagged when data for freon 12, 1,1,1-trichloroethane, isopropyl alcohol, MEK, MIBK, and benzaldehyde are presented. In several instances, one of the samples had a concentration that was much higher than the canister next to it and out of line with any sample in the network. These "outliers" were used in the data summaries but statistics based on these values should be considered uncertain.

2.5.2 Formaldehyde Sampling

The analytical and field aspects of the sampling followed the QA/QC recommendations outlined by EPA Method TO-11. Batch-certified clean DNPH coated Sep-Pak sampling cartridges contained in glass tubes were obtained from the laboratory for the EPA Method TO-11 sampling program. On receipt from the laboratory the cartridges were stored in a refrigerator until use in the sampling program. After the sampling period, the exposed cartridges were capped, placed back in the glass transport tubes, and refrigerated until transport back to the laboratory. Transport times were kept under 48-hours using an overnight courier service.

The TO-11 sampling program included laboratory blanks and method spikes for every 3 samples analyzed. The sampling program also included one field blank, one field spike, and one side-by-side duplicate. Recoveries from the trip and analytical method spikes were all within recognized method limits. The analytical blanks indicated that small amounts of acetone and MEK were sometimes present in the blanks. When identified the blank values were subtracted from the total mass of that compound found on the cartridge. In these instances the summary tables were flagged to indicate that a blank has been subtracted. Recoveries from the trip and analytical method spikes were all within recognized method limits.

Table 8 presents the results of a side-by-side sample taken on December 14 at Gate B3 and provides an indication of the method's overall precision. The absolute relative percent difference for formaldehyde was 12.2 %, acetaldehyde was 20.4 %, and for acrolein was 7.7 %. The precision for some of the other compounds found on the cartridges were less satisfactory and these compounds are identified in the summary tables in the following sections.

2.6 FTIR Spectrometer Sampling Program

The University of Washington deployed its FTIR spectrometer for direct measurement of aircraft exhaust on November 26 to coincide with the VOC canister sampling program, and on a separate occasion on January 26, 1994. The sampling beam of the FTIR spectrometer was positioned across the taxiway as aircraft passed and in several instances across the runway as aircraft were taking off. A large variety of exhaust plumes from different aircraft were sampled. A relatively long path length (near 100 m) was required during the sampling periods due to restrictions concerning the placement of the instrument near the edge of the

taxiways. Owing to the long path length of the beam and the masking of the hydrocarbon signature by the presence of water vapor, the resulting signal was not strong enough to provide a quantitative measurement of organic compounds in the aircraft exhaust plumes.[11] However, the method did detect the exhaust plumes and qualitative matches for several organic compounds were obtained including benzene. The FTIR remote sensing technique showed promise for future application to measurement of aircraft emissions in the field, providing a more powerful FTIR spectrometer and improved sampling techniques could be employed.

Greater (200m) beam length being presently developed. May be ready in August.
M. Yost phone conv. 2/95.

Table 8. EPA Method TO-11, Precision of Side-by-Side Sampling

Cas No.	Compound		Sampling Date 12/14/93 Site 1 MDL	Site 1 Conc.	Site 10 (QA) MDL	Site 10 (QA) Conc.	RPD (%)
50-00-0	Formaldehyde	(ppb)	0.23	3.98	0.23	3.52	-12.2
75-07-0	Acetaldehyde	(ppb)	0.16	2.55	0.16	2.08	-20.4
107-02-8	Acrolein	(ppb)	0.13	16.29	0.13	15.08	-7.7
123-38-6	Propionaldehyde	(ppb)	0.12	ND	0.12	ND	
67-64-1	Acetone	(ppb)	0.12	2.93 b	0.12	2.33 b	-22.7
4170-30-3	Crotonaldehyde	(ppb)	0.10	ND	0.10	ND	
78-84-2	Isobutyraldehyde	(ppb)	0.10	ND	0.10	ND	
78-93-3	Methyl Ethyl Ketone	(ppb)	0.10	1.17	0.10	4.59	118.8
100-52-7	Benzaldehyde	(ppb)	0.07	1.26	0.07	1.19	-5.1
110-62-3	Valeraldehdye	(ppb)	0.08	2.28	0.08	0.31	-152.1
529-20-4	o-Tolualdehyde	(ppb)	NA	ND	NA	ND	
620-23-5	m-Tolualdehyde	(ppb)	NA	ND	NA	ND	
104-87-0	p-Tolualdehyde	(ppb)	NA	ND	NA	ND	
66-25-1	Hexanaldehyde	(ppb)	0.07	3.30	0.07	1.59	-70.2
	Start Time	(PST)		12:07		12:08	
	Stop Time	(PST)		18:58		18:58	
	Sampling Duration	(hrs)		06:51		06:50	

ND: Compound below minimum detection limit (MDL)
b: Corrected for amount in laboratory blank
RPD: Relative percent difference calculated from 200(dupl-obs)/(obs+dupl)

3.0 Sampling Results

The sampling methodologies described in the preceding section were applied to collect VOC, CO, and TPH using evacuated canisters and to collect formaldehyde and other carbonyls using DNPH coated cartridges. Six to 8-hour samples were collected on the mornings of October 25 and October 26, 1993 and on the afternoons of November 26 and December 14, 1993. This section presents the results of the sampling programs. The data are compared by location, by date, and in an upwind versus downwind context. Comparisons are provided to similar data from other urban areas and to ambient air quality criteria. The results of the canister sampling program are presented in Section 3.1 and the formaldehyde sampling results are in Section 3.2.

3.1 Canister Sampling Results

Canister samples collected at 9 locations on 4 days were analyzed for the TO-14 list of VOCs, CO, and TPH. In addition to the TO-14 list of compounds, the top 10 TICs were also reported. The location of the sampling sites (Figure 1 and Figure 2) and the sampling conditions were described in the previous section. Complete listings of the sampling results for each sampling period and location are presented in Appendix A. Plots of selected results are also contained in Appendix A, where the sample results for benzene, toluene, isomers of xylene, CO and TPH are posted on a base map of Sea-Tac Airport and vicinity.

Table 9 presents the TO-14 list of VOC, TPH, and CO data summarized by sampling period. Approximately 50 % of the TO-14 list of VOCs were detected by the canister sampling program and 13 of the 39 compounds were above the MDLs for at least one site on every date sampled. Benzene was detected in every sample collected, and freon 12, freon 11, toluene, ethylbenzene, isomers of xylene, and 1,2,4-trimethylbenzene were found in all but a few canisters.

With a few exceptions, the spatially averaged data in Table 9 could not be stratified by sampling period. Considering the precision of the method, the concentrations of TO-14 compounds were similar for north flow (October 25 and 26) versus south flow (November 26 and December 14) modes of aircraft operation. Exceptions were dichloroethane which was only found during north flow and carbon tetrachloride which was only found under southerly winds. TPH values tended to be higher for the last two sampling periods (south flow mode of operation), while CO was highest for the first sampling period. Meteorological influences such as wind speed and temperature were not discernible in the concentration data collected.

In addition to the TO-14 list of compounds, a summary of the TICs identified in the canisters is displayed in Table 10. Ethyl alcohol (ethanol), acetone, isopropyl alcohol, butane, isopentane, and pentane were found in almost very sample collected. MEK, MIBK, hexane, and benzaldehyde occurred less frequently, and several compounds were only reported in a few of the samples collected.

Table 11 provides information concerning the average spatial differences of the canister sampling results. The overall statistics of the entire sampling program including the mean, median, minimum, maximum, and standard deviation of the data are also presented. Site 1 (Gate B3) and Site 2 (next to International Blvd) usually had the highest average concentrations for the more frequently detected compounds, but this trend was not consistent for all compounds or sampling periods. With the exception of a few "outliers", differences

between the sampling locations often only ranged by a factor-of-two between the highest and lowest samples. Site 7 (Normandy Park) usually had the lowest average concentrations for most of the TO-14 compounds, especially on October 26 when most compound concentrations at this site were below the MDLs.

Benzene was the primary toxic compound of concern identified in the earlier WDOE screening study. For the 36 canister samples collected for this project, the average benzene concentration was 2.0 ppb with a standard deviation of 0.8 ppb. The highest average benzene concentration of 3.0 ppb was collected at Site 2 (next to International Blvd), followed closely by 2.9 ppb at Site 1 (Gate B3). The highest single benzene sample of 4.2 ppb was collected at Site 2 during northerly flow on October 25, followed by 4.0 ppb at Site 1 during southerly flow on November 26. The lowest average concentrations of benzene (1.4 ppb) occurred during northerly flow at Site 6 (Maywood School). This site was downwind of the airport. Benzene concentrations in an offwind direction at Site 7 (Normandy Park) were also relatively low, averaging 1.5 ppb. Site 7 had the single lowest sample of benzene recorded on October 26 of 0.3 ppb. The observed levels were well below the modeled values of up to 160 ppb in the WDOE screening study.

In addition to the TO-14 list of VOCs, Table 11 also provides an indication of the spatial differences in CO and TPH concentrations found in the canisters. TPH concentrations followed the general pattern exhibited by benzene, toluene, and isomers of xylene, with Site 1 and Site 2 having the relatively higher average values. The highest average TPH values in the study occurred during southerly flow at the downwind Site 11 and Site 12. Carbon monoxide concentrations did not follow this trend except that the lowest average concentrations were at Site 7 (Normandy Park). The highest average CO concentration was 5.0, at Site 9 (NE corner of the AOA). This site also recorded the highest 6 to 8-hour concentration of 7.3 ppm. The highest CO concentration occurred during northerly flow when Site 9 was upwind of the airport. All CO samples were below the 8-hour national ambient air quality standard of 9 ppm and the hourly values indicated in the WDOE screening study.

In order to further examine the spatial results of the evacuated canister sampling program, Table 12 and Table 13 present the upwind versus downwind concentrations for north flow and south flow operating conditions, respectively. For both northerly and southerly flow, concentrations of VOCs at the downwind sampling locations were not significantly different than observed at the upwind monitoring sites. While concentrations of these compounds were often higher in potential source areas at Site 1 (Gate B3) and at Site 2 (next to International Blvd), the sampling network did not discern significant upwind/downwind differences.

Table 9. Summary of Canister Sampling by Date

CAS No.	Compound		Overall Mean 10/25/93	10/26/93	11/26/93	12/14/93
75-71-8	Freon 12	(ppb) *	0.63	0.48	0.38	0.45
76-14-2	Freon 114	(ppb)	ND	ND	ND	ND
74-87-3	Methyl chloride	(ppb)	0.18	0.44	0.23	0.22
75-01-4	Vinyl chloride	(ppb)	ND	ND	ND	ND
74-83-9	Methyl bromide	(ppb)	ND	ND	ND	ND
75-00-3	Ethyl chloride	(ppb)	ND	ND	ND	ND
75-69-4	Freon 11	(ppb)	0.34	0.29	0.30	0.30
75-35-4	Vinyiidene chloride	(ppb)	ND	ND	ND	ND
76-13-1	Freon 113	(ppb)	ND	ND	ND	ND
75-09-2	Dichloromethane	(ppb)	0.25	0.63	ND	ND
74-34-3	1,1-Dichloroethane	(ppb)	ND	ND	ND	ND
156-59-2	cis-1,2-Dichloroethylene	(ppb)	0.13	ND	ND	ND
67-66-3	Chloroform	(ppb)	ND	ND	ND	ND
71-55-6	1,1,1-Trichloroethane	(ppb) *	0.31	4.55	4.33	0.23
56-23-5	Carbon tetrachloride	(ppb)	ND	ND	0.10	0.12
71-43-2	Benzene	(ppb)	2.27	1.38	2.28	2.21
107-06-2	1,2-Dichloroethane	(ppb)	ND	ND	ND	ND
79-01-6	Trichloroethylene	(ppb)	0.25	ND	ND	ND
78-87-5	1,2-Dichloropropane	(ppb)	ND	ND	ND	ND
10061-01-5	cis-1,3-Dichloropropene	(ppb)	ND	ND	ND	ND
108-88-3	Toluene	(ppb)	5.67	8.85	4.49	6.29
10061-02-6	trans-1,3-Dichloropropene	(ppb)	ND	ND	ND	ND
79-00-5	1,1,2-Trichloroethane	(ppb)	ND	ND	ND	ND
127-18-4	Tetrachloroethene	(ppb)	0.12	0.17	0.14	0.18
106-93-4	1,2-Dibromoethane	(ppb)	ND	ND	ND	ND
108-90-7	Chlorobenzene	(ppb)	ND	ND	ND	ND
100-41-4	Ethyl Benzene	(ppb)	0.87	0.62	0.70	1.14
1330-20-7	m,p-Xylene	(ppb)	3.03	2.12	2.38	4.17
95-47-6	o-Xylene	(ppb)	1.09	0.76	0.87	1.59
100-42-5	Styrene	(ppb)	0.23	0.14	0.10	0.27
79-34-5	1,1,2,2-Tetrachloroethane	(ppb)	ND	ND	ND	ND
108-67-8	1,3,5-Trimethylbenzene	(ppb)	0.22	0.16	0.20	0.31
95-63-6	1,2,4-Trimethylbenzene	(ppb)	0.85	0.58	0.71	0.99
541-73-1	m-Dichlorobenzene	(ppb)	ND	ND	ND	ND
106-46-7	p-Dichlorobenzene	(ppb)	ND	ND	ND	ND
100-44-7	Benzyl chloride	(ppb)	ND	ND	ND	ND
95-50-1	o-Dichlorobenzene	(ppb)	ND	ND	0.12	ND
120-82-1	1,2,4-Trichlorobenzene	(ppb)	ND	ND	ND	ND
87-68-3	Hexachlorobutadiene	(ppb)	ND	ND	ND	ND
	TO-14 Detection Limit	(ppb)	0.21	0.18	0.18	0.22
	Number of Samples		9	9	9	9
	TPH	(ppb)	90	182	237	397
	Carbon monoxide (CO)	(ppm)	5.7	3.9	4.3	3.6
	Start Time	(PST)	07:10	06:41	11:12	12:24
	Stop Time	(PST)	14:14	14:50	17:37	18:51
	Sampling Duration	(hrs)	07:04	08:08	06:25	06:24

ND : Compound below minimum detection limit (MDL) for entire data group
TPH : Total Petroleum Hydrocarbons referenced to Jet Fuel
CO : Based on ASTM D-3416
* : Relatively low method precision for this compound

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Table 10. Summary of Top 10 Other Tentatively Identified Compounds

CAS No.	Compound			10/25/93 ns	10/25/93 mean	10/26/93 ns	10/26/93 mean	11/26/93 ns	11/26/93 mean	12/14/93 ns	12/14/93 mean
64-17-5	Ethyl Alcohol	(ppb)		8	17.6	8	17.0	9	19.6	9	9.5
67-64-1	Acetone	(ppb)		9	12.7	9	17.1	9	13.2	9	7.2
67-63-0	Isopropyl Alcohol	(ppb)	*	7	3.4	7	3.8	7	7.1	5	12.3
78-93-3	Methyl Ethyl Ketone	(ppb)	*	6	2.9	7	3.0	4	8.7	7	36.7
106-97-8	Butane	(ppb)		9	9.2	9	7.1	9	9.2	9	9.1
78-78-4	Isopentane	(ppb)		9	4.5	7	3.9	9	4.3	9	4.1
109-66-0	Pentane	(ppb)		9	2.8	7	2.2	6	2.8	8	2.6
110-54-3	Hexane	(ppb)		8	4.9	4	2.3	3	5.2	2	5.5
71-36-3	Butyl Alcohol	(ppb)		4	3.5			4	2.0	3	1.3
108-10-1	Methyl Isobutyl Ketone	(ppb)	*	4	17.8	3	12.5	4	14.8	4	12.6
100-52-7	Benzaldehyde	(ppb)	*	5	3.6	6	4.4	1	3.3	3	3.9
127-19-5	n,n-Dimethyl Acetamide	(ppb)				1	2.2	3	7.1		
624-92-0	Dimethyl Disulfide	(ppb)				1	2.7				
66-25-1	Hexanaldehyde	(ppb)				2	5.3				
108-39-4	m-Cresol	(ppb)				1	2.6				
622-96-8	4-Ethyl Toluene	(ppb)				1	0.9				
110-62-3	Valeraldehdye	(ppb)				2	5.6	2	3.5		
111-71-7	n-Heptaldehyde	(ppb)				1	8.9	1	2.7		
124-13-0	Octanal	(ppb)				1	5.4				
123-91-1	1,4-Dioxane	(ppb)				1	1.3			1	11.0
98-86-2	Methyl Phenyl Ketone	(ppb)						1	3.3	2	3.7
108-05-4	Vinyl Acetate	(ppb)						1	5.0		
142-82-5	Heptane	(ppb)						1	0.9		
108-95-2	Phenol	(ppb)								2	10.9
111-65-9	Octane	(ppb)								1	0.8

mean : includes only those samples reported. Does not include QA values.
ns : number of times reported out of 9 samples per sampling period
* : relatively low method precision for this compound

Table 11. Summary of Canister Sampling by Site

Compound		Average Concentration for Each Site											Overall				
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 11	Site 12	mean	median	min	max	std
Freon 12	(ppb) *	0.48	0.34	0.61	0.61	0.63	0.63	0.39	0.42	0.56	0.28	0.36	0.49	0.55	0.10	0.77	0.21
Freon 114	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl chloride	(ppb)	0.24	0.17	0.23	0.28	0.19	0.18	0.36	0.49	0.22	0.30	0.17	0.26	0.24	0.08	1.30	0.22
Vinyl chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl bromide	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 11	(ppb)	0.32	0.34	0.34	0.34	0.30	0.31	0.31	0.25	0.31	0.29	0.30	0.31	0.30	0.09	0.40	0.05
Vinylidene chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 113	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloromethane	(ppb)	1.12	0.24	ND	0.18	0.15	ND	0.15	0.15	0.16	ND	ND	0.27	0.11	0.08	4.20	0.68
1,1-Dichloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethylene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	0.15	ND	ND	0.10	0.10	0.08	0.30	0.04
Chloroform	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	(ppb) *	0.44	0.60	11.67	0.35	0.22	0.28	8.89	4.19	0.27	0.28	0.25	2.35	0.28	0.09	35.00	7.20
Carbon tetrachloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	0.13	0.13	ND	ND	0.10	0.10	0.08	0.22	0.03
Benzene	(ppb)	2.88	2.98	1.95	1.58	1.83	1.45	1.49	1.70	2.05	1.70	2.55	2.04	2.10	0.26	4.20	0.77
1,2-Dichloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	(ppb)	ND	ND	ND	ND	ND	0.21	ND	ND	0.38	ND	ND	0.13	0.10	0.08	1.20	0.19
1,2-Dichloropropane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	(ppb)	7.83	7.10	4.90	4.80	5.45	5.45	2.97	13.15	5.55	3.90	5.90	6.32	5.10	0.09	40.00	6.11
trans-1,3-Dichloropropene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	(ppb)	0.21	0.17	ND	0.19	0.17	0.15	0.12	0.10	0.16	ND	0.16	0.15	0.13	0.08	0.33	0.07
1,2-Dibromoethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Benzene	(ppb)	1.20	1.23	0.73	0.89	0.63	0.64	0.54	0.72	0.74	0.65	1.09	0.83	0.77	0.09	1.80	0.37
m,p-Xylene	(ppb)	4.38	4.40	2.50	3.18	2.13	2.15	1.80	2.43	2.60	2.25	3.95	2.92	2.70	0.09	6.60	1.42
o-Xylene	(ppb)	1.55	1.60	0.90	1.23	0.75	0.75	0.68	0.91	0.95	0.76	1.62	1.08	0.96	0.09	2.60	0.55
Styrene	(ppb)	0.22	0.23	0.21	0.14	ND	0.17	0.26	0.16	0.17	0.17	0.24	0.19	0.13	0.08	0.54	0.12
1,1,2,2-Tetrachloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	(ppb)	0.48	0.33	0.16	0.24	0.18	0.11	0.12	0.15	0.15	0.16	0.31	0.22	0.20	0.08	0.67	0.15
1,2,4-Trimethylbenzene	(ppb)	1.50	1.01	0.70	0.78	0.69	0.58	0.42	0.56	0.69	0.56	1.00	0.78	0.70	0.09	2.00	0.40
m-Dichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p Dichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzyl chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o Dichlorobenzene	(ppb)	0.17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.11	0.10	0.08	0.38	0.05
1,2,4-Trichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TO-14 Detection Limit	(ppb)	0.20	0.20	0.21	0.19	0.20	0.22	0.18	0.20	0.22	0.20	0.19	0.20	0.19	0.16	0.25	0.03
Number of Samples		4	4	2	4	4	2	4	4	4	2	2	36				
TPH	(ppb)	325	315	164	244	182	108	196	166	138	330	340	226	240	23	480	138
Carbon monoxide (CO)	(ppm)	4.3	4.5	4.4	5.0	4.4	4.7	3.4	4.5	5.2	3.9	3.9	4.38	4.4	0.85	7.30	1.16

ND : Compound below minimum detection limit (MDL) for entire data group
TPH : Total Petroleum Hydrocarbons referenced to Jet Fuel
CO : Based on ASTM D-3416
Stats : Mean, Min, Max & Std use MDL/2 when the sample was below the MDL. Does not include QA Values.
* : Relatively low method precision for this compound

Table 12. Upwind vs. Downwind Summary of Canister Sampling for Northerly Flow

CAS No.	Compound			Average Concentrations on 10/25 & 10/26/93 Upwind Site 8&9	Downwind Site 3-6	Gate B3 Site 1	Roadside Site 2	Nmdy Park Site 7
75-71-8	Freon 12	(ppb)	*	0.49	0.64	0.50	0.43	0.54
76-14-2	Freon 114	(ppb)		ND	ND	ND	ND	ND
74-87-3	Methyl chloride	(ppb)		0.45	0.22	0.24	0.18	0.57
75-01-4	Vinyl chloride	(ppb)		ND	ND	ND	ND	ND
74-83-9	Methyl bromide	(ppb)		ND	ND	ND	ND	ND
75-00-3	Ethyl chloride	(ppb)		ND	ND	ND	ND	ND
75-69-4	Freon 11	(ppb)		0.26	0.33	0.33	0.36	0.31
75-35-4	Vinylidene chloride	(ppb)		ND	ND	ND	ND	ND
76-13-1	Freon 113	(ppb)		ND	ND	ND	ND	ND
75-09-2	Dichloromethane	(ppb)		0.21	0.19	2.15	0.38	0.21
74-34-3	1,1-Dichloroethane	(ppb)		ND	ND	ND	ND	ND
156-59-2	cis-1,2-Dichloroethylene	(ppb)		0.15	ND	ND	ND	ND
67-66-3	Chloroform	(ppb)		ND	ND	ND	ND	ND
71-55-6	1,1,1-Trichloroethane	(ppb)	*	4.22	3.17	0.27	0.35	0.14
56-23-5	Carbon tetrachloride	(ppb)		ND	ND	ND	ND	ND
71-43-2	Benzene	(ppb)		1.75	1.66	2.35	3.10	0.83
107-06-2	1,2-Dichloroethane	(ppb)		ND	ND	ND	ND	ND
79-01-6	Trichloroethylene	(ppb)		0.38	0.12	ND	ND	ND
78-87-5	1,2-Dichloropropane	(ppb)		ND	ND	ND	ND	ND
10061-01-5	cis-1,3-Dichloropropene	(ppb)		ND	ND	ND	ND	ND
108-88-3	Toluene	(ppb)		13.93 ?	5.03	8.75	6.65	1.99
10061-02-6	trans-1,3-Dichloropropene	(ppb)		Reba ND	ND	ND	ND	ND
79-00-5	1,1,2-Trichloroethane	(ppb)		Lake ND	ND	ND	ND	ND
127-18-4	Tetrachloroethene	(ppb)		Volatizing? 0.13	0.15	0.18	0.15	ND
106-93-4	1,2-Dibromoethane	(ppb)		ND	ND	ND	ND	ND
108-90-7	Chlorobenzene	(ppb)		ND	ND	ND	ND	ND
100-41-4	Ethyl Benzene	(ppb)		0.70	0.67	1.15	1.14	0.36
1330-20-7	m,p-Xylene	(ppb)		2.40	2.26	4.15	4.00	1.19
95-47-6	o-Xylene	(ppb)		0.87	0.81	1.45	1.40	0.47
100-42-5	Styrene	(ppb)		0.16	0.16	0.34	0.17	0.19
79-34-5	1,1,2,2-Tetrachloroethane	(ppb)		ND	ND	ND	ND	ND
108-67-8	1,3,5-Trimethylbenzene	(ppb)		0.15	0.14	0.43	0.33	ND
95-63-6	1,2,4-Trimethylbenzene	(ppb)		0.66	0.62	1.35	1.01	0.28
541-73-1	m-Dichlorobenzene	(ppb)		ND	ND	ND	ND	ND
106-46-7	p-Dichlorobenzene	(ppb)		ND	ND	ND	ND	ND
100-44-7	Benzyl chloride	(ppb)		ND	ND	ND	ND	ND
95-50-1	o-Dichlorobenzene	(ppb)		ND	ND	ND	ND	ND
120-82-1	1,2,4-Trichlorobenzene	(ppb)		ND	ND	ND	ND	ND
87-68-3	Hexachlorobutadiene	(ppb)		ND	ND	ND	ND	ND
	TO-14 Detection Limit	(ppb)		0.21	0.20	0.20	0.19	0.18
	Number of Samples			4	8	2	2	2
	TPH	(ppb)		74	127	250	265	51
	Carbon monoxide (CO)	(ppm)		5.7	5.0	4.5	4.5	2.9

ND : Compound below minimum detection limit (MDL) for entire data group
TPH : Total Petroleum Hydrocarbons referenced to Jet Fuel
CO : Based on ASTM D-3416
Mean : Mean uses MDL/2 when the sample was below the MDL and does not include QA Values
* : Relatively low overall method precision for this compound

Table 13. Upwind vs. Downwind Summary of Canister Sampling for Southerly Flow

CAS No.	Compound			Average Concentrations on 11/26 & 12/14/93 Upwind Site 4&5	Downwind Site 8-12	Gate B3 Site 1	Roadside Site 2	Nmdy Park Site 7
75-71-8	Freon 12	(ppb)	*	0.58	0.41	0.47	0.25	0.25
76-14-2	Freon 114	(ppb)		ND	ND	ND	ND	ND
74-87-3	Methyl chloride	(ppb)		0.23	0.25	0.24	0.16	0.16
75-01-4	Vinyl chloride	(ppb)		ND	ND	ND	ND	ND
74-83-9	Methyl bromide	(ppb)		ND	ND	ND	ND	ND
75-00-3	Ethyl chloride	(ppb)		ND	ND	ND	ND	ND
75-69-4	Freon 11	(ppb)		0.31	0.30	0.31	0.31	0.31
75-35-4	Vinylidene chloride	(ppb)		ND	ND	ND	ND	ND
76-13-1	Freon 113	(ppb)		ND	ND	ND	ND	ND
75-09-2	Dichloromethane	(ppb)		ND	ND	ND	ND	ND
74-34-3	1,1-Dichloroethane	(ppb)		ND	ND	ND	ND	ND
156-59-2	cis-1,2-Dichloroethylene	(ppb)		ND	ND	ND	ND	ND
67-66-3	Chloroform	(ppb)		ND	ND	ND	ND	ND
71-55-6	1,1,1-Trichloroethane	(ppb)	*	0.21	0.25	0.60	0.86	17.63
56-23-5	Carbon tetrachloride	(ppb)		ND	0.12	ND	ND	ND
71-43-2	Benzene	(ppb)		1.78	2.06	3.40	2.85	2.15
107-06-2	1,2-Dichloroethane	(ppb)		ND	ND	ND	ND	ND
79-01-6	Trichloroethylene	(ppb)		ND	ND	ND	ND	ND
78-87-5	1,2-Dichloropropane	(ppb)		ND	ND	ND	ND	ND
10061-01-5	cis-1,3-Dichloropropene	(ppb)		ND	ND	ND	ND	ND
108-88-3	Toluene	(ppb)		5.38	4.84	6.90	7.55	3.95
10061-02-6	trans-1,3-Dichloropropene	(ppb)		ND	ND	ND	ND	ND
79-00-5	1,1,2-Trichloroethane	(ppb)		ND	ND	ND	ND	ND
127-18-4	Tetrachloroethene	(ppb)		0.18	0.13	0.23	0.20	0.15
106-93-4	1,2-Dibromoethane	(ppb)		ND	ND	ND	ND	ND
108-90-7	Chlorobenzene	(ppb)		ND	ND	ND	ND	ND
100-41-4	Ethyl Benzene	(ppb)		0.86	0.81	1.25	1.33	0.72
1330-20-7	m,p-Xylene	(ppb)		3.10	2.86	4.60	4.80	2.40
95-47-6	o-Xylene	(ppb)		1.18	1.09	1.65	1.80	0.89
100-42-5	Styrene	(ppb)		ND	0.19	ND	0.29	0.32
79-34-5	1,1,2,2-Tetrachloroethane	(ppb)		ND	ND	ND	ND	ND
108-67-8	1,3,5-Trimethylbenzene	(ppb)		0.27	0.19	0.54	0.33	0.15
95-63-6	1,2,4-Trimethylbenzene	(ppb)		0.85	0.68	1.65	1.01	0.57
541-73-1	m-Dichlorobenzene	(ppb)		ND	ND	ND	ND	ND
106-46-7	p-Dichlorobenzene	(ppb)		ND	ND	ND	ND	ND
100-44-7	Benzyl chloride	(ppb)		ND	ND	ND	ND	ND
95-50-1	o-Dichlorobenzene	(ppb)		ND	ND	0.24	ND	ND
120-82-1	1,2,4-Trichlorobenzene	(ppb)		ND	ND	ND	ND	ND
87-68-3	Hexachlorobutadiene	(ppb)		ND	ND	ND	ND	ND
	TO-14 Detection Limit	(ppb)		0.21	0.20	0.19	0.22	0.18
	Number of Samples			4	8	2	2	2
	TPH	(ppb)		308	283	400	365	340
	Carbon monoxide (CO)	(ppm)		3.9	3.9	4.0	4.5	3.8

ND : Compound below minimum detection limit (MDL) for entire data group
TPH : Total Petroleum Hydrocarbons referenced to Jet Fuel
CO : Based on ASTM D-3416
Mean : Mean uses MDL/2 when the sample was below the MDL and does not include QA Values
* : Relatively low overall method precision for this compound

It was not within the scope of this study to assess the implications of the measurements to human health. However, the predicted concentrations attributable to a new industrial stationary source of toxic air pollutants are often compared to the WDOE's Acceptable Source Impacts Levels (ASILs).* Predicted concentrations from an industrial stationary source below the ASILs are considered insignificant, while estimates above these values may trigger more refined health risk analyses or control technology reviews. Suspected carcinogens have risk-based annual ASILs and other toxic air pollutants have threshold-based 24-hour average criteria.

The ASILs were not calculated or intended for assessment of health risks from concentrations in a multi-source urban environment. The comparisons of the measurements in this study with the ASILs are only intended to indicate which compounds or sources may be relatively more important than others. The ASILs are not absolute exposure limits or a numerical ambient air quality criterion and concentrations above the ASILs are allowable and typically observed in urban areas.

The overall results of the TO-14 sampling are compared to the WDOE ASILs in Table 14. The overall average values of dichloromethane, carbon tetrachloride, benzene, and trichloroethylene were above the annual ASILs. Referring to Table 11, the average values at Site 1, Site 2, and Site 4 were greater than the dichloromethane ASIL; Site 8 and Site 9 were above the carbon tetrachloride ASIL; Site 6 and Site 9 were above the trichloroethylene ASIL; Site 1, Site 2, Site 4, and Site 5 were above the tetrachloroethene ASIL, and all sites were above the benzene ASIL. No samples were collected which exceeded the 24-hour ASILs.

While several of the compounds were found above the WDOE's annual ASILs, these levels are not uncommon in urban areas. Table 15 compares the median concentrations of selected pollutants with data obtained from the EPA's Toxic Air Monitoring System (TAMs) and other data from the scientific literature.[2,12] The TAMS sites are usually selected because of high industrial source emissions in surrounding areas, while the national VOC (NVOC) database sites (in Table 15) are located in areas more likely influenced by automobiles.[12] Both the TAMS and NVOC data were collected over a 24-hour period while the present data were obtained from 6 to 8-hour samples during the day. Since suspected source activity is likely higher during the daytime hours, the present study's samples are biased towards high concentrations. Considering this bias, the concentrations observed near Sea-Tac Airport are within the range exhibited in other urban areas, especially the data from the NVOC database.

Ethylbenzene, toluene, benzene, and isomers of xylene (ETBX) ratios are sometimes used to identify volatile hydrocarbon mixtures. Table 16 presents a comparison of the overall ETBX ratios from the present study with the data contained in Table 15 for other urban areas; composite source profiles for automobile exhaust and gasoline vapors;[13] and source profiles for aircraft exhaust[3,14] and a composite profile for commercial aircraft landing and takeoffs. The ETBX ratios from the present study including the overall mean and those observed at Site 1 (Gate B3) are indicative of automobiles and do not resemble the available aircraft exhaust profiles found in the literature. The levels of VOCs in the other urban areas also have been primarily attributed to motor vehicle emissions.[12]

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* According to WAC 173-460-020 an ASIL "means a concentration of a toxic air pollutant in the outdoor atmosphere in any area which does not have restricted or controlled public access that is used to evaluate the air quality impacts of a single source. There are three types of ASILs: Risk-based, threshold based, and special. Concentrations for these three types of ASILs are determined as provided in WAC 173-460-100. ASILs are listed in WAC 173-460-150 and 173-460-160."

Table 14. Comparison of TO-14 Compounds with WDOE ASILs

CAS No.	Compound	Overall Results (ppb) mean	median	min	max	std dev	WDOE ASIL (ppb) annual	24-hr
75-71-8	Freon 12 *	0.49	0.55	0.10	0.77	0.21		3237.6
76-14-2	Freon 114	ND	ND	ND	ND	ND		3292.1
74-87-3	Methyl chloride	0.26	0.24	0.08	1.30	0.22		164.8
75-01-4	Vinyl chloride	ND	ND	ND	ND	ND	0.005	
74-83-9	Methyl bromide	ND	ND	ND	ND	ND		1.3
75-00-3	Ethyl chloride	ND	ND	ND	ND	ND		3792.0
75-69-4	Freon 11	0.31	0.30	0.09	0.40	0.05		3383.7
75-35-4	Vinylidene chloride	ND	ND	ND	ND	ND		16.9
76-13-1	Freon 113	ND	ND	ND	ND	ND		3525.4
75-09-2	Dichloromethane	0.27	0.11	0.08	4.20	0.68	0.161	
74-34-3	1,1-Dichloroethane	ND	ND	ND	ND	ND		667.5
156-59-2	cis-1,2-Dichloroethylene	0.10	0.10	0.08	0.30	0.04		NA
67-66-3	Chloroform	ND	ND	ND	ND	ND	0.009	
71-55-6	1,1,1-Trichloroethane *	2.35	0.28	0.09	35.00	7.20		1173.7
56-23-5	Carbon tetrachloride	0.10	0.10	0.08	0.22	0.03	0.011	
71-43-2	Benzene	2.04	2.10	0.26	4.20	0.77	0.038	
107-06-2	1,2-Dichloroethane	ND	ND	ND	ND	ND	0.009	
79-01-6	Trichloroethylene	0.13	0.10	0.08	1.20	0.19	0.110	
78-87-5	1,2-Dichloropropane	ND	ND	ND	ND	ND		NA
10061-01-5	cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	NA	
108-88-3	Toluene	6.32	5.10	0.09	40.00	6.11		106.2
10061-02-6	trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	NA	
79-00-5	1,1,2-Trichloroethane	ND	ND	ND	ND	ND		33.0
127-18-4	Tetrachloroethene	0.15	0.13	0.08	0.33	0.07	0.162	
106-93-4	1,2-Dibromoethane	ND	ND	ND	ND	ND	0.001	
108-90-7	Chlorobenzene	ND	ND	ND	ND	ND		32.6
100-41-4	Ethyl Benzene	0.83	0.77	0.09	1.80	0.37		230.4
1330-20-7	m,p-Xylene	2.92	2.70	0.09	6.60	1.42		345.7
95-47-6	o-Xylene	1.08	0.96	0.09	2.60	0.55		345.7
100-42-5	Styrene	0.19	0.13	0.08	0.54	0.12		234.9
79-34-5	1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND		3.4
108-67-8	1,3,5-Trimethylbenzene	0.22	0.20	0.08	0.67	0.15		NA
95-63-6	1,2,4-Trimethylbenzene	0.78	0.70	0.09	2.00	0.40		NA
541-73-1	m-Dichlorobenzene	ND	ND	ND	ND	ND		NA
106-46-7	p-Dichlorobenzene	ND	ND	ND	ND	ND	0.250	
100-44-7	Benzyl chloride	ND	ND	ND	ND	ND		3.3
95-50-1	o-Dichlorobenzene	0.11	0.10	0.08	0.38	0.05		166.4
120-82-1	1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND		16.2
87-68-3	Hexachlorobutadiene	ND	ND	ND	ND	ND		NA

ND : Compound below minimum detection limit (MDL) for entire data group
Stats : Mean, Min, Max & Std use MDL/2 when the sample was below the MDL. Does not include QA Values.
NA : Compound does not have a WDOE ASIL.
ASIL : Acceptable source impact levels, revised 2/2/94 (WAC 173-460), converted to ppb.
* : Relatively low method precision for this compound

Table 14. Comparison of TO-14 Compounds with WDOE ASILs

CAS No.	Compound	Overall Results (ppb) mean	median	min	max	std dev	WDOE ASIL (ppb) annual	24-hr
75-71-8	Freon 12 *	0.49	0.55	0.10	0.77	0.21		3237.6
76-14-2	Freon 114	ND	ND	ND	ND	ND		3292.1
74-87-3	Methyl chloride	0.26	0.24	0.08	1.30	0.22		164.8
75-01-4	Vinyl chloride	ND	ND	ND	ND	ND	0.005	
74-83-9	Methyl bromide	ND	ND	ND	ND	ND		1.3
75-00-3	Ethyl chloride	ND	ND	ND	ND	ND		3792.0
75-69-4	Freon 11	0.31	0.30	0.09	0.40	0.05		3383.7
75-35-4	Vinylidene chloride	ND	ND	ND	ND	ND		16.9
76-13-1	Freon 113	ND	ND	ND	ND	ND		3525.4
75-09-2	Dichloromethane	0.27	0.11	0.08	4.20	0.68	0.161	
74-34-3	1,1-Dichloroethane	ND	ND	ND	ND	ND		667.5
156-59-2	cis-1,2-Dichloroethylene	0.10	0.10	0.08	0.30	0.04		NA
67-66-3	Chloroform	ND	ND	ND	ND	ND	0.009	
71-55-6	1,1,1-Trichloroethane *	2.35	0.28	0.09	35.00	7.20		1173.7
56-23-5	Carbon tetrachloride	0.10	0.10	0.08	0.22	0.03	0.011	
71-43-2	Benzene	2.04	2.10	0.26	4.20	0.77	0.038	
107-06-2	1,2-Dichloroethane	ND	ND	ND	ND	ND	0.009	
79-01-6	Trichloroethylene	0.13	0.10	0.08	1.20	0.19	0.110	
78-87-5	1,2-Dichloropropane	ND	ND	ND	ND	ND		NA
10061-01-5	cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	NA	
108-88-3	Toluene	6.32	5.10	0.09	40.00	6.11		106.2
10061-02-6	trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	NA	
79-00-5	1,1,2-Trichloroethane	ND	ND	ND	ND	ND		33.0
127-18-4	Tetrachloroethene	0.15	0.13	0.08	0.33	0.07	0.162	
106-93-4	1,2-Dibromoethane	ND	ND	ND	ND	ND	0.001	
108-90-7	Chlorobenzene	ND	ND	ND	ND	ND		32.6
100-41-4	Ethyl Benzene	0.83	0.77	0.09	1.80	0.37		230.4
1330-20-7	m,p-Xylene	2.92	2.70	0.09	6.60	1.42		345.7
95-47-6	o-Xylene	1.08	0.96	0.09	2.60	0.55		345.7
100-42-5	Styrene	0.19	0.13	0.08	0.54	0.12		234.9
79-34-5	1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND		3.4
108-67-8	1,3,5-Trimethylbenzene	0.22	0.20	0.08	0.67	0.15		NA
95-63-6	1,2,4-Trimethylbenzene	0.78	0.70	0.09	2.00	0.40		NA
541-73-1	m-Dichlorobenzene	ND	ND	ND	ND	ND		NA
106-46-7	p-Dichlorobenzene	ND	ND	ND	ND	ND	0.250	
100-44-7	Benzyl chloride	ND	ND	ND	ND	ND		3.3
95-50-1	o-Dichlorobenzene	0.11	0.10	0.08	0.38	0.05		166.4
120-82-1	1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND		16.2
87-68-3	Hexachlorobutadiene	ND	ND	ND	ND	ND		NA

ND : Compound below minimum detection limit (MDL) for entire data group
Stats : Mean, Min, Max & Std use MDL/2 when the sample was below the MDL. Does not include QA Values.
NA : Compound does not have a WDOE ASIL.
ASIL : Acceptable source impact levels, revised 2/2/94 (WAC 173-460), converted to ppb.
* : Relatively low method precision for this compound

Table 15. Comparison of Selected TO-14 Compounds with Other Urban Data

City	Reference		Median Sample Values (ppb) Benzene	Toluene	m+p-Xylene	o-Xylene	Ethyl-benzene	Methyl Chloride	Dichloro methane	Carbon Tetra-chloride	111-Trichloro ethane	124-Tri methyl-benzene	Freon 12	Freon 11	Freon 113
Boston Site 1	TAMS 88,89	Industrial	0.9	2.1	0.9	0.4	0.3	0.5	0.3	0.1	0.6	0.4			
Boston Site 2	TAMS 88,89	Industrial	1.2	3.0	1.4	0.5	0.4	0.6	0.4	0.1	0.7	0.6			
Boston Site 3	TAMS 88,89	Residential	0.7	1.9	0.7	0.3	0.2	0.6	0.4	0.1	0.7	0.4			
Chicago Site 1	TAMS 88,89	Industrial	1.0	3.4	1.4	0.4	0.5	0.6	0.4	0.1	0.6	0.4			
Chicago Site 2	TAMS 88,89	Industrial	1.2	2.6	1.1	0.4	0.4	0.6	0.4	0.1	0.7	0.4			
Chicago Site 3	TAMS 88,89	Airport	0.9	1.8	0.8	0.4	0.3	0.6	0.4	0.1	0.7	0.4			
Houston Site 1	TAMS 88,89	Industrial	1.8	3.0	1.5	0.5	0.5	0.8	0.3	0.2	0.5	0.6			
Houston Site 2	TAMS 88,89	Industrial	1.1	1.8	0.9	0.3	0.3	0.7	0.3	0.1	0.4	0.4			
Houston Site 3	TAMS 88,89	Residential	1.3	3.2	1.4	0.6	0.5	0.7	0.3	0.1	0.8	0.6			
Tacoma	TAMS 88,89	Industrial/Port	1.0	2.2	1.2	0.4	0.4	0.6	0.4	0.1	0.5	0.5			
Phoenix'79	NVOC dbase	City Wide	4.3	8.7	3.8	1.6	0.8		0.9	0.3	0.9	1.5		0.2	0.2
Phoenix'88	NVOC dbase	City Wide	5.9	16.6	8.6	3.1	2.3		2.0	0.1	3.3	3.3	1.4	0.7	0.6
Chicago	NVOC dbase	City Wide	1.3	2.7	0.9	0.5	0.4		0.8	0.1	0.5	0.6	0.7	0.4	0.1
Denver	NVOC dbase	City Wide	2.7	6.7	3.4	1.6	1.2		0.7	0.2	0.7	0.7	0.8	0.6	0.1
Houston	NVOC dbase	City Wide	2.7	4.8	2.5	1.1	0.7		0.4	0.3	0.4	1.3	0.6	0.5	0.1
L.A.	NVOC dbase	City Wide	2.7		2.9	1.1	1.0		4.0	0.1	1.2	1.4	0.9	0.6	0.2
Philadelphia	NVOC dbase	City Wide	1.5	3.3	2.0	1.5	0.6		0.5	0.2	0.5	1.1	0.6	0.4	
Pittsburgh	NVOC dbase	City Wide	2.6	2.1	0.7	0.3	0.3			0.3	0.4	0.2	0.5	0.3	0.1
San Jose	NVOC dbase	City Wide	2.4	4.4	3.2	1.6	1.5		1.6	0.1	0.3	1.6	0.7	0.6	0.9
St. Louis	NVOC dbase	City Wide	1.6	4.3	1.9	0.8	0.6		0.3	0.1	0.2	0.8	0.6	0.4	0.1
Present Study		Overall Median	2.1	5.1	2.7	1.0	0.8	0.2	0.1	0.1	0.3*	0.7	0.6*	0.3	ND

TAMS (Toxic Air Monitoring System) & NVOC (National VOC database) data are 24-hour averages

TAMS Ref: Evans, and et al., 1992. Measurements of VOCs from the TAMS Network. JAWMA, 42:1319-1323.

NVOC Ref: Edgerton, and et al., 1989. Inter-Urban Comparison of Ambient VOCs in US Cities., JAPCA, 39:729-732.

*: Relatively low overall method precision for this compound

Table 16. Comparison of ETBX Ratios, Present Study vs Other Urban Areas & Source Profiles

City	Reference		Ratio to Ethyl Benzene			
			Benzene	Toluene	Xylene	Ethyl Benzene
Boston Site 1	TAMS 88,89	Industrial	2.8	6.7	4.2	1
Boston Site 2	TAMS 88,89	Industrial	2.6	6.8	4.4	1
Boston Site 3	TAMS 88,89	Residential	3.0	8.0	4.5	1
Chicago Site 1	TAMS 88,89	Industrial	2.1	6.9	3.7	1
Chicago Site 2	TAMS 88,89	Industrial	3.3	7.4	4.0	1
Chicago Site 3	TAMS 88,89	Airport	3.3	7.0	4.7	1
Houston Site 1	TAMS 88,89	Industrial	3.6	6.0	4.1	1
Houston Site 2	TAMS 88,89	Industrial	3.8	6.1	4.2	1
Houston Site 3	TAMS 88,89	Residential	2.9	6.7	4.2	1
Tacoma	TAMS 88,89	Industrial/Port	2.6	6.0	4.3	1
Phoenix'79	NVOC dbase	City Wide	5.4	10.9	6.7	1
Phoenix'88	NVOC dbase	City Wide	2.6	7.2	5.1	1
Chicago	NVOC dbase	City Wide	3.3	6.8	3.5	1
Denver	NVOC dbase	City Wide	2.3	5.6	4.2	1
Houston	NVOC dbase	City Wide	3.9	6.9	5.1	1
						1
L.A.	NVOC dbase	City Wide	2.7	NA	4.0	1
Philadelphia	NVOC dbase	City Wide	2.5	5.5	5.8	1
Pittsburgh	NVOC dbase	City Wide	8.7	7.0	3.3	1
San Jose	NVOC dbase	City Wide	1.6	2.9	3.2	1
St. Louis	NVOC dbase	City Wide	2.7	7.2	4.5	1
Present Study	ratio of overall median values		2.7	6.6	4.8	1
	Site 1 (Gate B3)		2.4	6.5	4.9	1
Motor Vehicle Emissions Composite (Scheff, et el.)			4.5	8.1	5.2	1
Gas Vapor Composite (Scheff, et al.)			4.8	4.2	1.6	1
Aircraft Emissions	TF39 Idle on JP-5		10.9	3.4	2.5	1
Aircraft Emissions	CFM86 Idle on JP-5		14.3	4.7	2.7	1
Aircraft Landing/Takeoff - Commercial			15.5	3.5	2.8	1

Ratios were based on volume concentrations eg. (ppb/ppb)

TAMS (Toxic Air Monitoring System) & NVOC (National VOC database) data are 24-hour averages

TAMS Ref: Evans, and et al., 1992. Measurements of VOCs from the TAMS Network. JAWMA, 42:1319-1323.

NVOC Ref: Edgerton, and et al., 1989. Inter-Urban Comparison of Ambient VOCs in US Cities., JAPCA, 39:729-73

Auto & Gas Ref: Scheff, and et al., 1989. Source Fingerprints for Receptor Modeling of VOCs. JAPCA. 39:469-478.

Aircraft Ref: Spicer, et al., 1984. Composition and Photochemical Reactivity of Turbine Engine Exhaust. Air Force Engineering and Services Center, Report No. ESL-TR-84-28.

3.2 Formaldehyde Sampling Results

DNPH-coated cartridge samples were collected according to EPA Method TO-11 at 3 locations on 4 days. The sampling locations correspond to Sites 1, 4, and 9 as shown in Figure 1 and the sampling periods coincided with the canister sampling program. The exposed cartridges were analyzed for formaldehyde, other aldehydes, and ketones. Complete listings of the sampling results for each sampling period and location are presented in Appendix B. The formaldehyde results for each sample period are also plotted on a base map of Sea-Tac Airport and vicinity in Appendix B.

Table 17 summarizes the TO-11 data by sampling period. Formaldehyde and acetaldehyde were found in every sample taken. MEK and acetone were also commonly contained on the cartridges and acrolein levels above the TO-11 MDL were always present at Site 1 (Gate B3). In general the TO-11 samples were higher for the last two sampling periods which occurred during a southerly mode of airport operation.* These latter two sampling periods also occurred in the afternoon, while the former sampling during northerly flow primarily occurred in the morning. Afternoon peaks in formaldehyde and acetaldehyde have been predicted in modeling studies due to oxidation of other VOCs.[15] Formaldehyde and acetaldehyde concentrations were the highest on the afternoon of November 26, a cold day with temperatures around 42 °F. This sampling period had persistent southerly winds averaging 6 kts. Acrolein concentrations were much higher on the afternoon of December 14. This day had the lowest overall average wind speed at 3 kts and the winds had a westerly component for some of the sampling period.

Table 18 contrasts the TO-11 data by sampling location and presents overall sampling statistics by compound. Upwind versus downwind comparisons for both southerly and northerly flow are indicated in Table 19. Samples for the primary carbonyl compounds of concern including formaldehyde, acetaldehyde, and acrolein were higher at Site 1 (Gate B3) than at the north or south ends of the AOA. In contrast to the canister sampling program, the results of the TO-11 sampling indicated that the downwind monitoring site's samples were typically higher than the upwind location's concentrations. Formaldehyde and acetaldehyde samples were approximately 40 % higher at the downwind site when compared to the upwind location. During southerly flow, acrolein values were 8.5 times higher at the downwind site.

The TO-11 sampling results are compared to corresponding WDOE ASILs and to data from other urban locations in Table 20 and Table 21, respectively. In the context of this study, the ASILs are indicators of relative importance, not absolute health risk or for comparisons as a regulatory limit. All the formaldehyde and acetaldehyde samples collected were above the annual ASILs for these compounds. However, the formaldehyde and acetaldehyde concentrations observed at Sea-Tac Airport were within the range reported for other urban areas as indicated in Table 21.[16] Six to 8 hour average acrolein concentrations were also above the 24-hour WDOE ASIL for 50 % of the samples collected.

Sampling data for acrolein in other urban areas are more limited than for formaldehyde and acetaldehyde, but are reported to range from 0 to 14 ppb in a survey of published data from Los Angeles, New Jersey, South America, and the Netherlands.[17] Recent photochemical simulations of the Los Angeles air basin

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* The TO-11 sampling enclosures were heated for the last two days of the study. It is unknown whether heating the sample environment, differing modes of operations, or other influences were the cause of the relatively higher values on these days.

indicate values of acrolein in the range of 1 to 2 ppb.[15] These monitored and modeled values are also comparable to the acrolein sampling data collected in the present study.

Formaldehyde, acetaldehyde, and acrolein are emitted directly by mobile and stationary sources and are also secondary pollutants formed in the atmosphere by reaction with other compounds. The ratio of formaldehyde to acetaldehyde indicated in this study was also observed in several of the other urban areas, but no consistent pattern or identifiable source group was apparent. This may be attributed to the nature of these pollutants which are influenced by reactions and removal mechanisms in the environment which make it difficult to compare source profiles with ambient concentration data. These compounds and acrolein are directly emitted by aircraft[3] and are also associated with emissions from motor vehicles using the oxygenated fuels methanol and ethanol.[16] The formaldehyde and acetaldehyde samples at Sea-Tac Airport were highly related and had a linear correlation coefficient of 0.94.

The correlation between formaldehyde/acetaldehyde concentrations and acrolein were not significant, indicating that different sources or ambient mechanisms may be affecting concentrations of these compounds. Photochemical model simulations indicate that the diurnal cycle of acrolein may be different than that for formaldehyde or acetaldehyde.[15]

Table 17. Summary of TO-11 Sampling by Date

CAS No.	Compound			Mean for Each Sample Period 10/25/93	10/26/93	11/26/93	12/14/93
50-00-0	Formaldehyde	(ppb)		2.09	1.69	5.38	2.80
75-07-0	Acetaldehyde	(ppb)		1.48	1.24	3.06	1.91
107-02-8	Acrolein	(ppb)		0.11	0.09	1.23	10.61
123-38-6	Propionaldehyde	(ppb)		ND	ND	ND	ND
67-64-1	Acetone	(ppb)		1.61	1.94	1.72	3.57
4170-30-3	Crotonaldehyde	(ppb)		ND	ND	ND	ND
78-84-2	Isobutyraldehyde	(ppb)		ND	ND	1.29	ND
78-93-3	Methyl Ethyl Ketone	(ppb)	*	0.76	1.92	ND	5.76
100-52-7	Benzaldehyde	(ppb)		ND	ND	0.40	1.56
110-62-3	Valeraldehdye	(ppb)	*	ND	ND	ND	1.78
529-20-4	o-Tolualdehyde	(ppb)		ND	ND	ND	ND
620-23-5	m-Tolualdehyde	(ppb)		ND	ND	ND	ND
104-87-0	p-Tolualdehyde	(ppb)		ND	ND	ND	ND
66-25-1	Hexanaldehyde	(ppb)	*	ND	ND	ND	3.40

ND : Compound below minimum detection limit (MDL) for entire data group
Mean : Means use MDL/2 when samples were below the MDL and do not include QA values.
* : Relatively low overall method precision for this compound

Table 18. Summary of TO-11 Sampling by Site

CAS No.	Compound			Site Average Site 1	Site 4	Site 9	Overall mean	median	min	max	std dev
50-00-0	Formaldehyde	(ppb)		4.14	2.12	2.72	2.99	3.03	1.12	6.90	1.79
75-07-0	Acetaldehyde	(ppb)		2.34	1.68	1.75	1.92	1.67	0.89	3.89	0.89
107-02-8	Acrolein	(ppb)		5.05	0.44	3.53	3.01	0.15	0.06	16.29	5.77
123-38-6	Propionaldehyde	(ppb)		ND	ND	ND	ND	ND	ND	ND	ND
67-64-1	Acetone	(ppb)		2.29	2.19	2.16	2.21	2.30	0.05	5.20	1.22
4170-30-3	Crotonaldehyde	(ppb)		ND	ND	ND	ND	ND	ND	ND	ND
78-84-2	Isobutyraldehyde	(ppb)		0.46	ND	0.57	0.36	0.05	0.04	2.12	0.73
78-93-3	Methyl Ethyl Ketone	(ppb)	*	1.07	2.33	2.97	2.12	1.17	0.04	9.34	2.92
100-52-7	Benzaldehyde	(ppb)		0.62	0.35	0.56	0.51	0.04	0.03	2.14	0.74
110-62-3	Valeraldehdye	(ppb)	*	0.60	0.35	0.48	0.48	0.04	0.04	2.28	0.82
529-20-4	o-Tolualdehyde	(ppb)		ND	ND	ND	ND	ND	ND	ND	ND
620-23-5	m-Tolualdehyde	(ppb)		ND	ND	ND	ND	ND	ND	ND	ND
104-87-0	p-Tolualdehyde	(ppb)		ND	ND	ND	ND	ND	ND	ND	ND
66-25-1	Hexanaldehyde	(ppb)	*	0.85	0.73	1.05	0.87	0.04	0.03	4.10	1.55

ND : Compound below minimum detection limit (MDL) for entire data group
Stats : Overall statistics used MDL/2 when samples were below the MDL and do not include QA values.
* : Relatively low overall method precision for this compound

Table 19. Upwind vs. Downwind Summary of TO-11 Sampling

CAS No.	Compound			North Flow Upwind Site 9	North Flow Downwind Site 4	North Flow Gate B3 Site 1	South Flow Upwind Site 4	South Flow Downwind Site 9	South Flow Gate B3 Site 1
50-00-0	Formaldehyde	(ppb)		1.27	1.56	2.83	2.68	4.17	5.44
75-07-0	Acetaldehyde	(ppb)		1.06	1.56	1.46	1.79	2.44	3.22
107-02-8	Acrolein	(ppb)		ND	ND	0.17	0.82	7.01	9.93
123-38-6	Propionaldehyde	(ppb)		ND	ND	ND	ND	ND	ND
67-64-1	Acetone	(ppb)		1.69	1.68	1.97	2.71	2.63	2.61
4170-30-3	Crotonaldehyde	(ppb)		ND	ND	ND	ND	ND	ND
78-84-2	Isobutyraldehyde	(ppb)		ND	ND	ND	ND	1.09	0.87
78-93-3	Methyl Ethyl Ketone	(ppb)	*	1.25	1.24	1.52	3.42	4.69	0.61
100-52-7	Benzaldehyde	(ppb)		ND	ND	ND	0.66	1.09	1.20
110-62-3	Valeraldehdye	(ppb)	*	ND	ND	ND	0.65	0.92	1.16
529-20-4	o-Tolualdehyde	(ppb)		ND	ND	ND	ND	ND	ND
620-23-5	m-Tolualdehyde	(ppb)		ND	ND	ND	ND	ND	ND
104-87-0	p-Tolualdehyde	(ppb)		ND	ND	ND	ND	ND	ND
66-25-1	Hexanaldehyde	(ppb)	*	ND	ND	ND	1.42	2.06	1.67

ND : Compound below minimum detection limit (MDL) for entire data group
Stats : Overall statistics used MDL/2 when samples were below the MDL and do not include QA values.
* : Relatively low overall method precision for this compound
North : Average of samples on 10/25/93 & 10/26/93
South : Average of samples on 11/26/93 & 12/14/93

Table 20. Comparison of TO-11 Compounds with WDOE ASILs

Cas No.	Compound		Overall Results (ppb) mean	median	min	max	std dev	WDOE ASIL (ppb) annual	24-hr
50-00-0	Formaldehyde		2.99	3.03	1.12	6.90	1.79	0.063	
75-07-0	Acetaldehyde		1.92	1.67	0.89	3.89	0.89	0.250	
107-02-8	Acrolein		3.01	0.15	0.06	16.29	5.77		0.009
123-38-6	Propionaldehyde		ND	ND	ND	ND	ND		NA
67-64-1	Acetone		2.21	2.30	0.05	5.20	1.22		2485.4
4170-30-3	Crotonaldehyde		ND	ND	ND	ND	ND		7.0
78-84-2	Isobutyraldehyde		0.36	0.05	0.04	2.12	0.73		NA
78-93-3	Methyl Ethyl Ketone	*	2.12	1.17	0.04	9.34	2.92		339.3
100-52-7	Benzaldehyde		0.51	0.04	0.03	2.14	0.74		NA
110-62-3	Valeraldehdye	*	0.48	0.04	0.04	2.28	0.82		167.6
529-20-4	o-Tolualdehyde		ND	ND	ND	ND	ND		NA
620-23-5	m-Tolualdehyde		ND	ND	ND	ND	ND		NA
104-87-0	p-Tolualdehyde		ND	ND	ND	ND	ND		NA
66-25-1	Hexanaldehyde	*	0.87	0.04	0.03	4.10	1.55		NA

ND : Compound below minimum detection limit (MDL) for entire data group
Stats : Overall statistics used MDL/2 when samples were below the MDL and do not include QA values.
NA : Compound does not have a WDOE ASIL.
ASIL : Acceptable Source Impact Levels, revised 2/2/94 (WAC # 173-460), converted to ppb
* : Relatively low overall method precision for this compound

Table 21. Comparison of Selected TO-11 Compounds with Other Urban Data

City	Period	Formaldehyde			Acetaldehyde		
		No. of Samples	Mean (ppb)	Std Dev (ppb)	No. of Samples	Mean (ppb)	Std Dev (ppb)
Urban, Southern CA							
Downey	2-3/84	48	15.5	11.9	48	8.5	6.3
Anaheim	9/88-9/89	57	5.3		57	3.5	
Azusa	9/88-9/89	57	5.0		57	3.1	
Burbank	9/88-9/89	57	6.0		57	4.8	
Hawthorne	9/88-9/89	57	6.0		57	2.9	
Upland	9/88-9/89	57	5.3		57	3.9	
West LA	9/88-9/89	57	6.1		57	3.8	
Palm Springs	6/89-6/90	62	1.8		62	5.0	
Perris	6/89-6/90	62	2.8		62	10.3	
Atlanta, GA	7-8/92	217	2.9	1.3	217	3.0	1.3
Tucson, AZ	12/89-2/90	23	1.8		23	3.8	
St. Louis, MO	6/80	11	11.3	4.5			
Denver, CO	4/84	21	2.3	1.8	21	1.0	0.5
Staten Is., NY	4/81	17	14.3	9.1			
Chicago, IL	4/81	5	11.3	3.8	5	2.1	0.9
Houston, TX	3/84	11	3.8	8.3	11	2.2	1.7
Sea-Tac Airport	10-12/93	12	3.0	1.8	12	1.9	0.9

Reference: Grosjean, Williams, & Grosjean, 1993. Ambient Levels of Formaldehyde and Acetaldehyde in Atlanta, GA. JAWMA, 43:469-474.

4.0 Summary

This report presented the results of a survey of airborne toxic organic compounds and carbon monoxide collected in the vicinity of Sea-Tac Airport. The study was initiated in response to concern over the results of a screening analysis conducted by the WDOE which indicated that airport operations could be a significant source of toxic air pollutant emissions. Samples were collected during four periods in the late fall and early winter of 1993. Samples were collected at locations within the AOA, upwind of the airport, downwind of the airport, near International Blvd, and at a residential location in Normandy Park. The sampling periods corresponded to two mornings with generally northerly flow (October 25 and October 26, 1993) and two afternoons with southerly flow (November 26 and December 14, 1993). These periods were selected to contrast different meteorological conditions and corresponding modes of airport operation. While the study did not sample during a classical stagnation episode, dispersive conditions for three of the four periods were characterized by periods of light winds.

VOCs including benzene were sampled with evacuated canister systems according to EPA Method TO-14, while carbonyl compounds including formaldehyde were sampled with reagent-coated cartridges using EPA Method TO-11. The evacuated canister samples were also analyzed for CO and TPH. The laboratory also reported the other top 10 TICs found in each sample. Analytical and field QA/QC procedures outlined by the EPA were followed and the quality of the data collected for the primary compounds of concern was acceptable for the purposes of the survey.

Approximately 50 % of the VOCs considered in the study were detected in the evacuated canisters and benzene was found in every sample collected. Freon 12, freon 11, toluene, ethylbenzene, isomers of xylene, and 1,2,4-trimethylbenzene were found in all but a few canisters; ethyl alcohol (ethanol), acetone, isopropyl alcohol, butane, isopentane, and pentane were TICs frequently reported. In general the canister sampling data did not indicate variations with meteorology or mode of airport operation. Spatial differences were evident in the VOC data, with generally higher samples collected at Site 1 (Gate B3) and Site 2 (next to International Blvd), and the lowest concentrations were found at the residential location in Normandy Park. However, these trends were not consistent for every compound or sampling period. Significant differences in upwind versus downwind concentrations of the VOCs were not apparent in the study. Benzene levels were considerably below the values predicted in the WDOE screening study.

Concentrations of several of the VOCs collected at Sea-Tac were higher than the WDOE ASILs, which are often used as screening criteria for assessments of toxic pollutant emissions from a new stationary industrial source. Comparisons with the ASILs in this study were intended to identify the more important compounds and not to assess a regulatory limit. When compared to monitoring data from other studies, the levels of these compounds at Sea-Tac Airport were not atypical and within the range observed in other urban areas. The signature or ratios of several key VOCs were indicative of automobile exhaust and did not resemble the available VOC profiles associated with aircraft emissions.

Every evacuated canister sample collected in the study was analyzed for CO. The CO levels observed in the study did not follow any distinctive pattern that would indicate that Sea-Tac Airport aircraft operations were a significant source of CO. The highest levels observed were at the upwind sampling locations during northerly flow. All concentrations of CO in the survey were less than the 8-hour average national ambient air quality standard and the maximum predictions from the WDOE screening study.

The survey included measurements of formaldehyde and other carbonyl compounds at three locations representing a source area site, an upwind site, and a downwind site. Formaldehyde and acetaldehyde were present in all the samples and acrolein was always detected at Site 1 (Gate B3). The average concentrations of these compounds were higher when the airport was in a southerly mode of operation. Samples of formaldehyde, acetaldehyde, and acrolein were higher at Gate B3 than the other two sampling locations. Concentrations at the downwind monitoring site were typically higher than at the upwind location, suggesting that sources were potentially within the AOA.

Average formaldehyde and acetaldehyde concentrations at all locations were above the WDOE annual ASILs for these compounds and 50 % of the samples had acrolein concentrations greater than the 24-hour ASIL. Formaldehyde, acetaldehyde, and acrolein concentrations observed at Sea-Tac Airport were within the range reported for other urban areas. The formaldehyde and acetaldehyde samples at Sea-Tac were highly related while similar correlations with acrolein were not significant, indicating that different sources or reaction mechanisms may be influencing ambient concentrations of these compounds.

5.0 References

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Appendix A. Canister Sampling Results

Results from EPA Method TO-14

Date: October 25, 1993

Compound		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	QA Site 10	mean
Freon 12	(ppb)	0.63	0.75	0.57	0.72	0.60	0.73	0.30	0.67	0.72	0.30	0.63
Freon 114	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl chloride	(ppb)	0.24	0.26	ND	0.24	ND	ND	0.25	ND	ND	0.29	0.18
Vinyl chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl bromide	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 11	(ppb)	0.35	0.40	0.37	0.39	0.30	0.32	0.29	0.30	0.31	0.39	0.34
Vinylidene chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 113	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloromethane	(ppb)	ND	0.32	ND	0.23	0.33	ND	0.33	0.33	0.34	0.29	0.25
1,1-Dichloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethylene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	0.30	ND	0.13
Chloroform	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	(ppb)	0.25	0.47	0.33	0.35	0.30	0.32	0.20	0.27	0.30	0.28	0.31
Carbon tetrachloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	(ppb)	2.20	4.20	2.50	1.50	2.20	2.00	1.40	1.90	2.50	3.40	2.27
1,2-Dichloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	(ppb)	ND	ND	ND	ND	ND	0.33	ND	ND	1.20	0.27	0.25
1,2-Dichloropropane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	(ppb)	6.50	8.40	5.40	5.10	6.00	5.10	3.90	4.80	5.80	7.60	5.67
trans-1,3-Dichloropropene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	(ppb)	ND	ND	ND	0.18	ND	ND	ND	ND	ND	ND	0.12
1,2-Dibromoethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Benzene	(ppb)	1.10	1.40	0.77	0.78	0.84	0.72	0.63	0.72	0.89	1.30	0.87
m,p-Xylene	(ppb)	3.90	4.90	2.70	2.60	2.80	2.50	2.30	2.40	3.20	4.40	3.03
o-Xylene	(ppb)	1.40	1.70	0.97	0.99	0.97	0.85	0.86	0.87	1.20	1.60	1.09
Styrene	(ppb)	0.31	0.24	0.32	0.28	ND	0.25	0.30	ND	ND	0.44	0.23
1,1,2,2-Tetrachloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	(ppb)	0.41	0.44	ND	0.25	ND	ND	ND	ND	0.29	0.46	0.22
1,2,4-Trimethylbenzene	(ppb)	1.30	1.30	0.75	0.84	0.70	0.64	0.47	0.63	1.00	1.40	0.85
m-Dichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-Dichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzyl chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Dichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.26	ND
Hexachlorobutadiene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TO-14 Detection Limit	(ppb)	0.20	0.16	0.24	0.18	0.22	0.25	0.19	0.24	0.25	0.21	0.21
TPH	(ppb)	250	210	68	67	59	45	41	23	48	320	90
Carbon monoxide (CO)	(ppm)	4.3	5.4	5.8	6.5	5.4	5.5	5.0	5.7	7.3	4.5	5.7
Start Time	(PST)	06:10	06:35	06:55	08:09	07:36	07:20	07:42	07:10	06:55	06:06	07:10
Stop Time	(PST)	13:55	13:47	14:00	14:48	14:30	14:15	14:35	14:15	14:06	13:55	14:14
Sampling Duration	(hrs)	07:45	07:12	07:05	06:39	06:54	06:55	06:53	07:05	07:11	07:49	07:04

ND - Compound below minimum detection limit (MDL)
TPH - Total Petroleum hydrocarbons referenced to Jet Fuel
CO - Based on ASTM D-3416
Mean - When a sample was below the MDL, the sample's MDL/2 was used for the mean. Does not Include QA values.

5.74

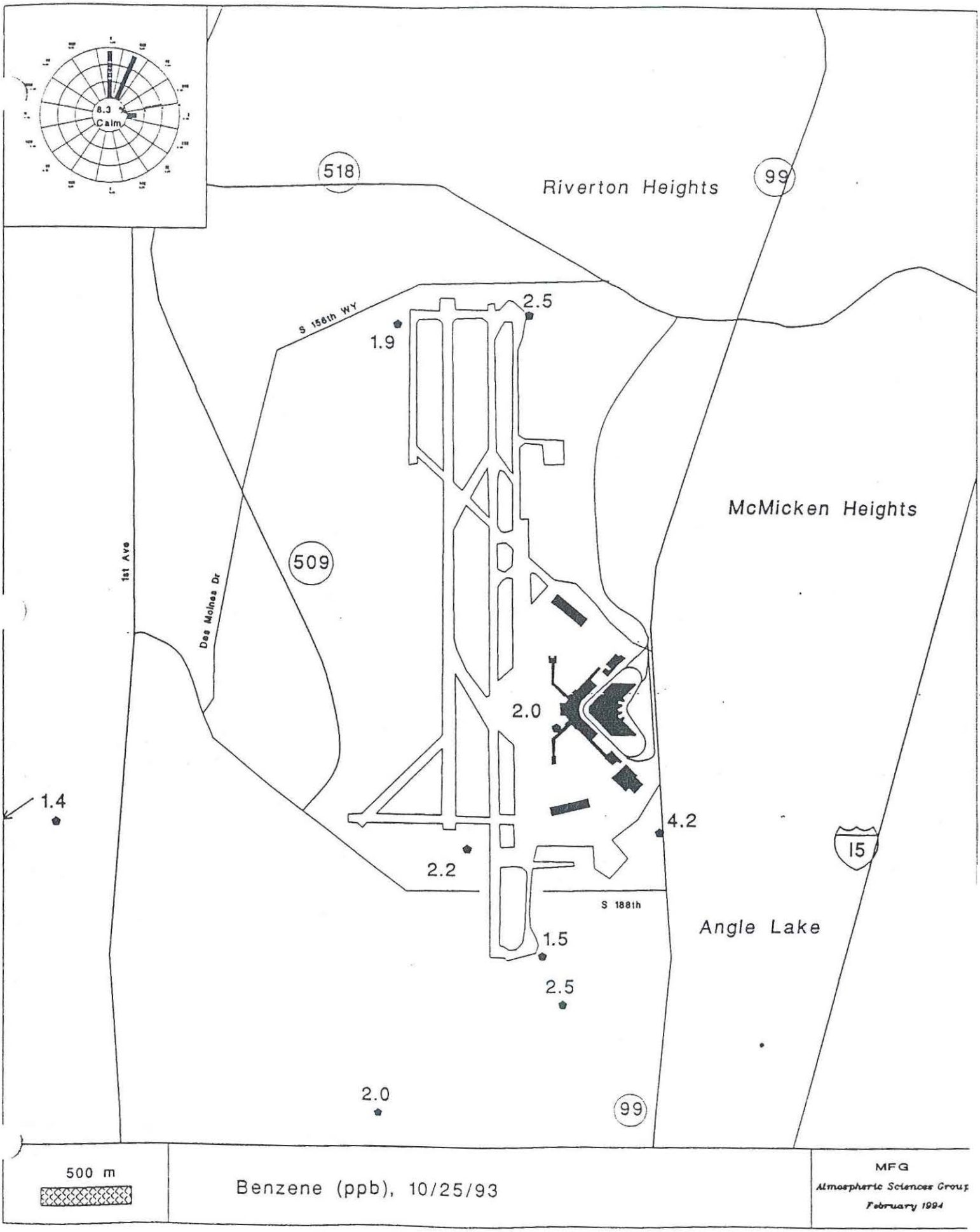
.06
4) .25
24
10

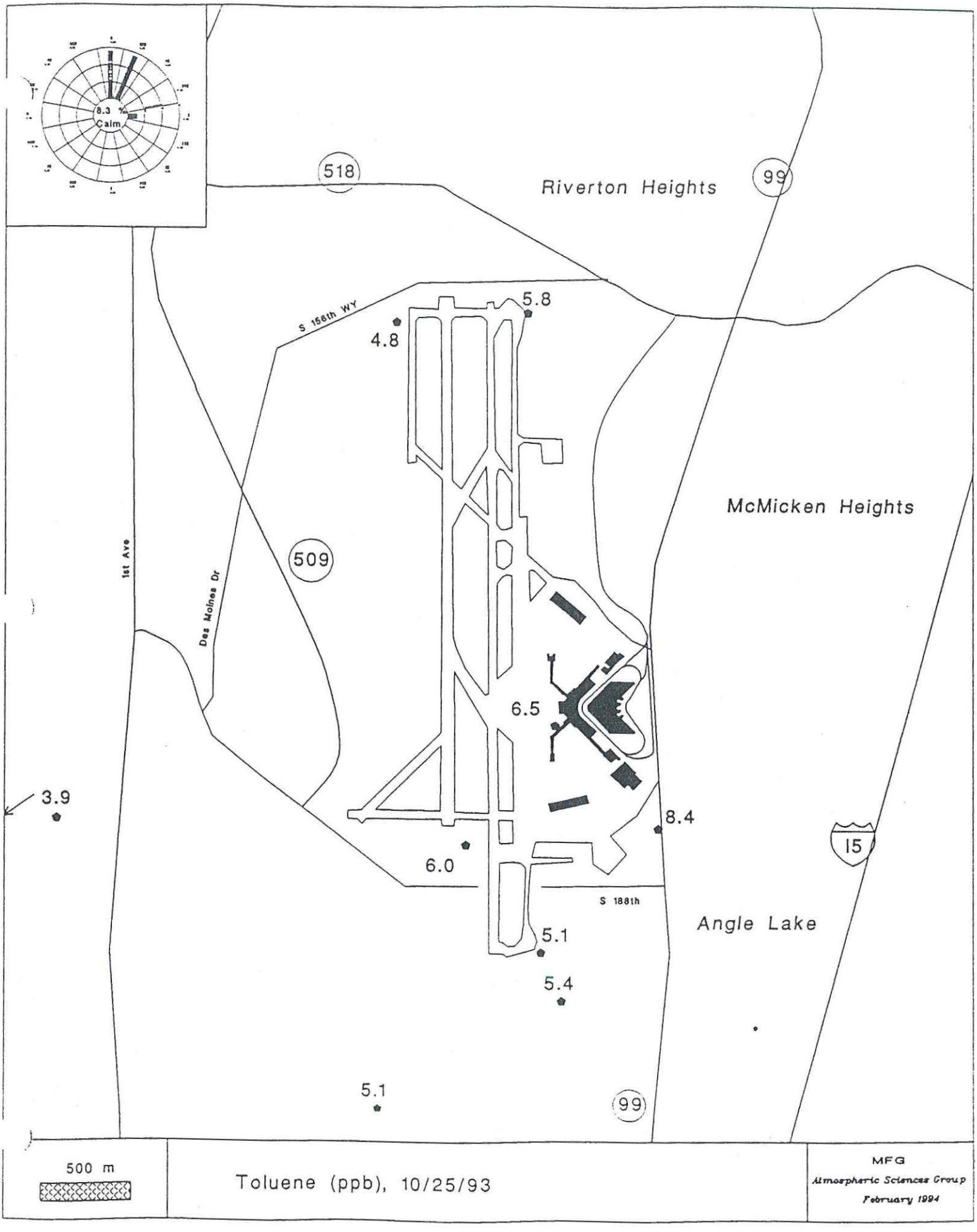
Tentatively Identified Compounds - Top 10 Reported

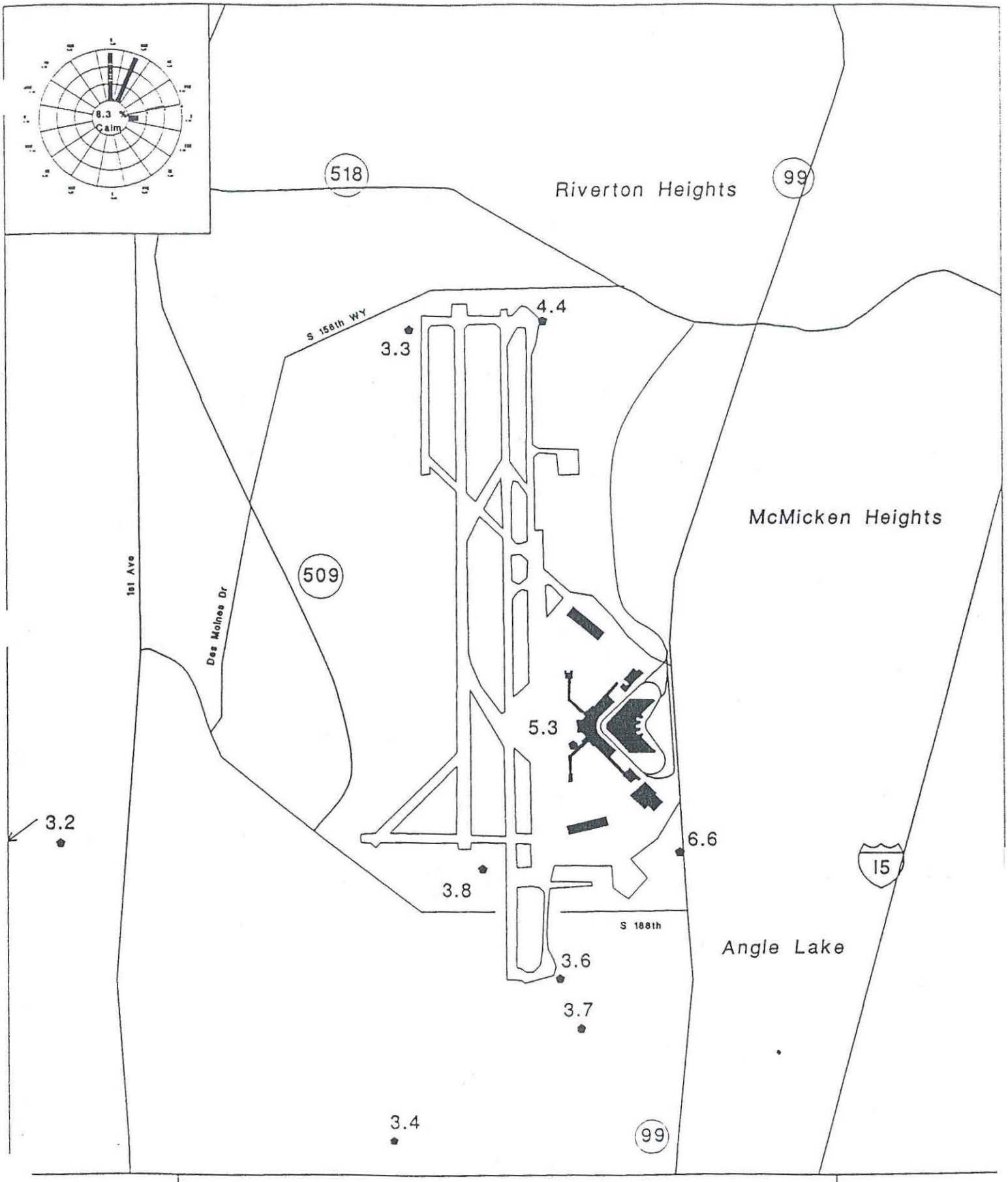
Date: October 25, 1993

Compound		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	QA Site 10	mean
Ethyl Alcohol	(ppb)	20.0		20.0	18.0	20.0	16.0	12.0	16.0	19.0	22.0	17.6
Acetone	(ppb)	13.0	16.0	12.0	14.0	11.0	16.0	11.0	13.0	8.3	11.0	12.7
Isopropyl Alcohol	(ppb)	3.8		2.4	2.8		8.1	1.7	2.6	2.6	8.0	3.4
Methyl Ethyl Ketone	(ppb)		3.2		3.7	2.5	2.8		2.7	2.5	2.7	2.9
Butane	(ppb)	12.0	14.0	13.0	8.4	7.4	6.8	5.8	6.5	8.7	11.0	9.2
Isopentane	(ppb)	6.7	7.5	5.1	4.2	3.7	3.2	2.9	3.2	4.2	7.1	4.5
Pentane	(ppb)	3.9	4.7	3.2	2.6	2.3	2.1	1.9	1.9	2.5	4.1	2.8
Hexane	(ppb)	1.6	3.1	8.6	2.4	7.9		3.7	6.1	5.4	1.8	4.9
Butyl Alcohol	(ppb)	1.8				4.9			2.8	4.6		3.5
Methyl Isobutyl Ketone	(ppb)		27.0	21.0			15.0	8.3				17.8
Benzaldehyde	(ppb)	1.5	4.9	3.8			5.1	2.8			10.0	3.6
Unknown Hydrocarbons	(ppb)	3.4	6.3	2.8	4.5	1.6	2.4	2.0	2.3	2.5	3.6	3.1

mean - includes only those samples reported. Does not include QA values.
unknown hydrocarbons - may include one or more peaks on the chromatograph


8.3
Calm
518
Riverton Heights
99
S 156th WY
2.5
1.9
McMicken Heights
509
1st Ave
Des Moines Dr
2.0
1.4
4.2
15
2.2
S 188th
Angle Lake
1.5
2.5
2.0
99
500 m
Benzene (ppb), 10/25/93
MFG
Atmospheric Sciences Group
February 1994

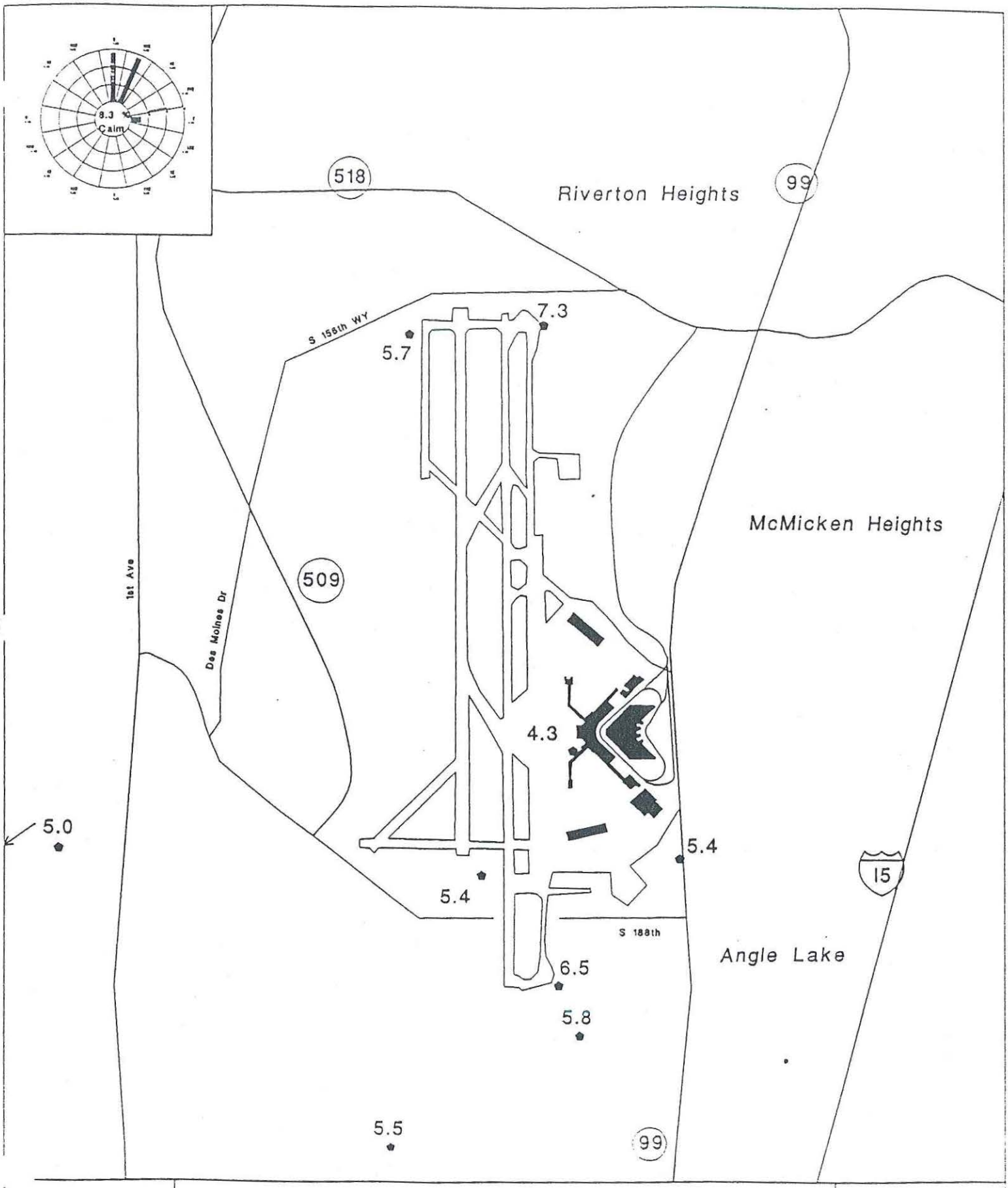

8.3
Calm
518
Riverton Heights
99
S 156th WY
5.8
4.8
McMicken Heights
509
1st Ave
Des Moines Dr
6.5
3.9
8.4
15
6.0
S 188th
Angle Lake
5.1
5.4
5.1
99
500 m
Toluene (ppb), 10/25/93
MFG
Atmospheric Sciences Group
February 1994



500 m

m,p,o Xylene (ppb), 10/25/93

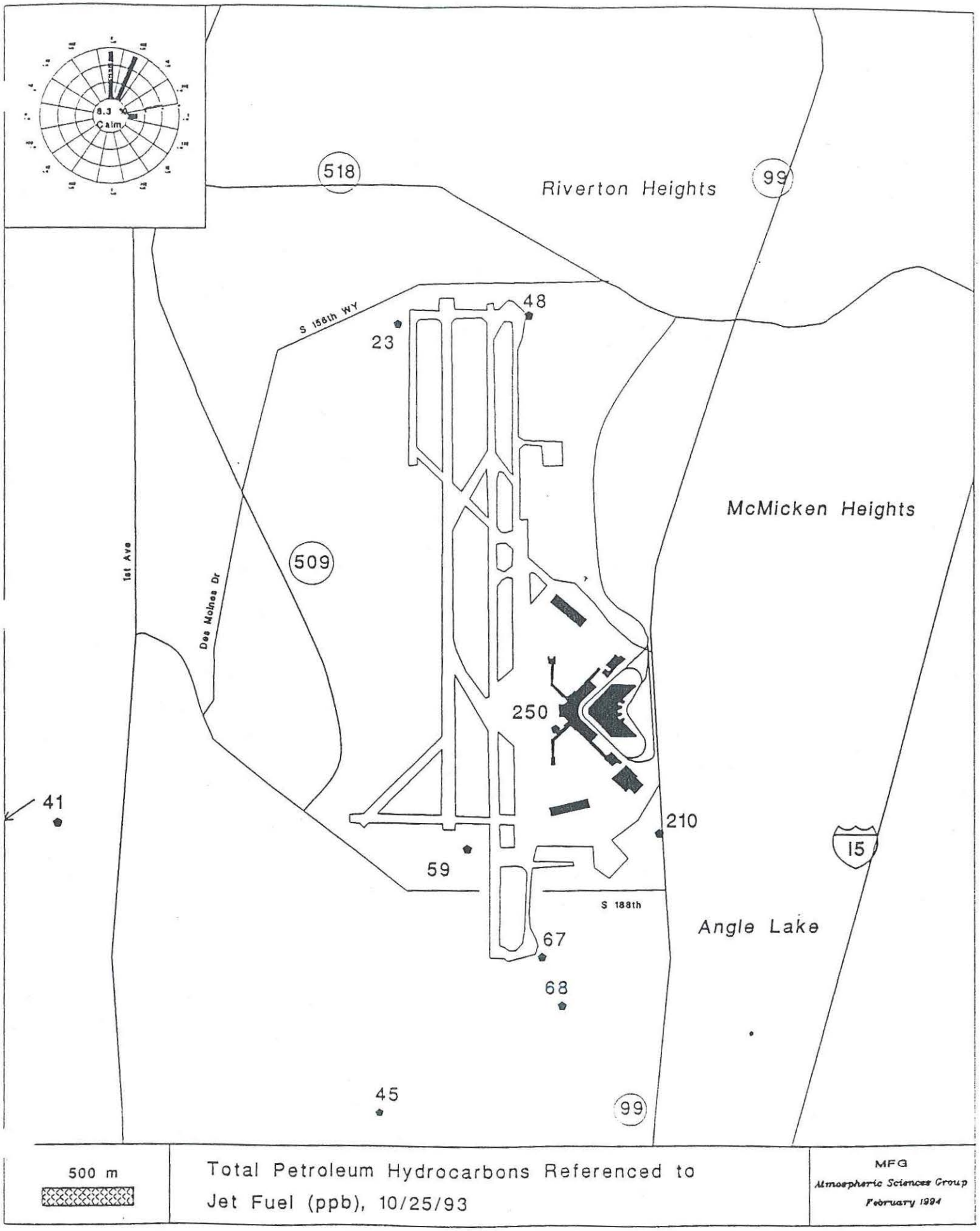
MFG
Atmospheric Sciences Group
February 1994



500 m

Carbon Monoxide (ppm), 10/25/93

MFG
Atmospheric Sciences Group
February 1994


8.3
Calm
518
Riverton Heights
99
S 156th WY
48
23
McMicken Heights
1st Ave
Des Moines Dr
509
250
41
210
15
59
S 188th
Angle Lake
67
68
45
99
500 m
Total Petroleum Hydrocarbons Referenced to
Jet Fuel (ppb), 10/25/93
MFG
Atmospheric Sciences Group
February 1994

Results from EPA Method TO-14

Date: October 26, 1993

Compound		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	mean
Freon 12	(ppb)	NA	ND	0.64	0.72	0.61	0.52	0.77	0.18	0.38	0.37	0.48
Freon 114	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl chloride	(ppb)	NA	ND	0.33	0.30	0.33	0.24	0.88	1.30	0.25	0.23	0.44
Vinyl chloride	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl bromide	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl chloride	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 11	(ppb)	NA	0.32	0.30	0.34	0.29	0.29	0.33	ND	0.32	0.31	0.29
Vinylidene chloride	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 113	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloromethane	(ppb)	NA	0.43	0.30	0.26	ND	ND	ND	ND	ND	4.20	0.63
1,1-Dichloroethane	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethylene	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	(ppb)	NA	0.23	23.00	0.50	0.28	0.24	ND	16.00	0.29	0.29	4.55
Carbon tetrachloride	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	(ppb)	NA	2.00	1.40	1.40	1.40	0.90	0.26	1.30	1.30	2.50	1.38
1,2-Dichloroethane	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	(ppb)	NA	4.90	4.40	3.60	4.80	5.80	ND	40.00	5.10	11.00	8.85
trans-1,3-Dichloropropene	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	(ppb)	NA	0.21	ND	0.17	0.25	0.18	ND	ND	0.19	0.26	0.17
1,2-Dibromoethane	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Benzene	(ppb)	NA	0.87	0.69	0.56	0.44	0.55	ND	0.51	0.66	1.20	0.62
m,p-Xylene	(ppb)	NA	3.10	2.30	1.90	1.50	1.80	ND	1.70	2.30	4.40	2.12
o-Xylene	(ppb)	NA	1.10	0.83	0.72	0.52	0.64	ND	0.64	0.78	1.50	0.76
Styrene	(ppb)	NA	ND	ND	ND	ND	ND	ND	0.20	0.20	0.37	0.14
1,1,2,2-Tetrachloroethane	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	(ppb)	NA	0.22	0.19	0.17	ND	ND	ND	ND	ND	0.44	0.16
1,2,4-Trimethylbenzene	(ppb)	NA	0.72	0.65	0.57	0.35	0.48	ND	0.46	0.54	1.40	0.58
m-Dichlorobenzene	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-Dichlorobenzene	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzyl chloride	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Dichlorobenzene	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	(ppb)	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TO-14 Detection Limit	(ppb)	NA	0.21	0.18	0.16	0.16	0.18	0.17	0.18	0.18	0.20	0.18
TPH	(ppb)	NA	320	260	240	110	170	61	190	33	250	182
Carbon monoxide (CO)	(ppm)	NA	3.5	3.0	5.3	4.4	3.8	ND	4.5	5.2	4.7	3.9
Start Time	(PST)	NA	06:20	06:38	06:23	07:14	06:54	07:20	06:55	06:45	05:44	06:41
Stop Time	(PST)	NA	14:20	14:38	14:34	14:54	14:54	15:20	15:09	15:17	14:24	14:50
Sampling Duration	(hrs)	NA	08:00	08:00	08:11	07:40	08:00	08:00	08:14	08:32	08:40	08:08

ND - Compound below minimum detection limit (MDL)
TPH - Total Petroleum hydrocarbons referenced to Jet Fuel
CO - Based on ASTM D-3416
Mean - When a sample was below the MDL, the sample's MDL/2 was used for the mean

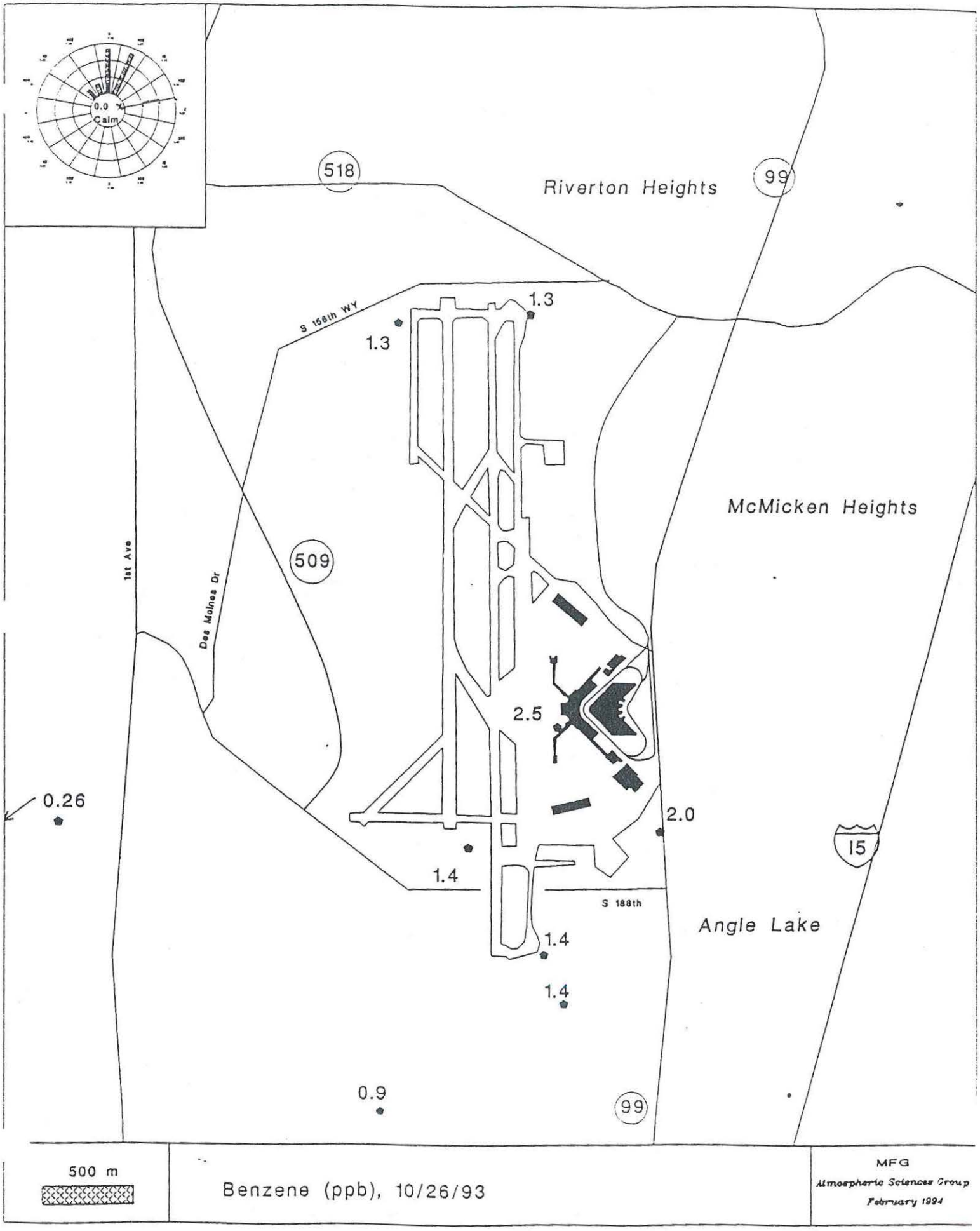
4.3

Tentatively Identified Compounds - Top 10 Reported

Date: October 26, 1993

Compound		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	mean
Ethyl Alcohol	(ppb)	NA	20.0	27.0	27.0	9.2	9.7	10.0		15.0	18.0	17.0
Acetone	(ppb)	NA	24.0	30.0	38.0	6.2	7.0	8.8	11.0	15.0	14.0	17.1
Isopropyl Alcohol	(ppb)	NA		4.9	4.3	1.2	2.4	1.9	2.0	9.5		3.8
Methyl Ethyl Ketone	(ppb)	NA		4.0	6.1	1.6	1.8	1.3		2.4	3.9	3.0
Butane	(ppb)	NA	8.3	9.8	7.0	4.8	6.1	4.6	5.0	6.7	12.0	7.1
Isopentane	(ppb)	NA		5.6	3.9	2.5	2.8	2.3		3.2	7.0	3.9
Pentane	(ppb)	NA		3.2		1.4	1.8	1.2	1.4	2.0	4.2	2.2
Hexane	(ppb)	NA				4.0	1.8			0.9	2.7	2.3
Methyl Isobutyl Ketone	(ppb)	NA	15.0	8.4			14.0					12.5
Benzaldehyde	(ppb)	NA	5.2	3.2			4.9		8.1	2.1	2.8	4.4
n,n-Dimethyl Acetamide	(ppb)	NA				2.2						2.2
Dimethyl Disulfide	(ppb)	NA							2.7			2.7
Hexanaldehyde	(ppb)	NA	9.1						1.4			5.3
m-Cresol	(ppb)	NA							2.6			2.6
4-Ethyl Toluene	(ppb)	NA								0.9		0.9
Valeraldehdye	(ppb)	NA	8.7	2.4								5.6
n-Heptaldehyde	(ppb)	NA	8.9									8.9
Octanal	(ppb)	NA	5.4									5.4
1,4-Dioxane	(ppb)	NA						1.3				1.3
Unknown Hydrocarbons	(ppb)	NA	6.2		14.0				11.5		7.3	9.8

mean - includes only those samples reported
unknown hydrocarbons - may include one or more peaks on the chromatograph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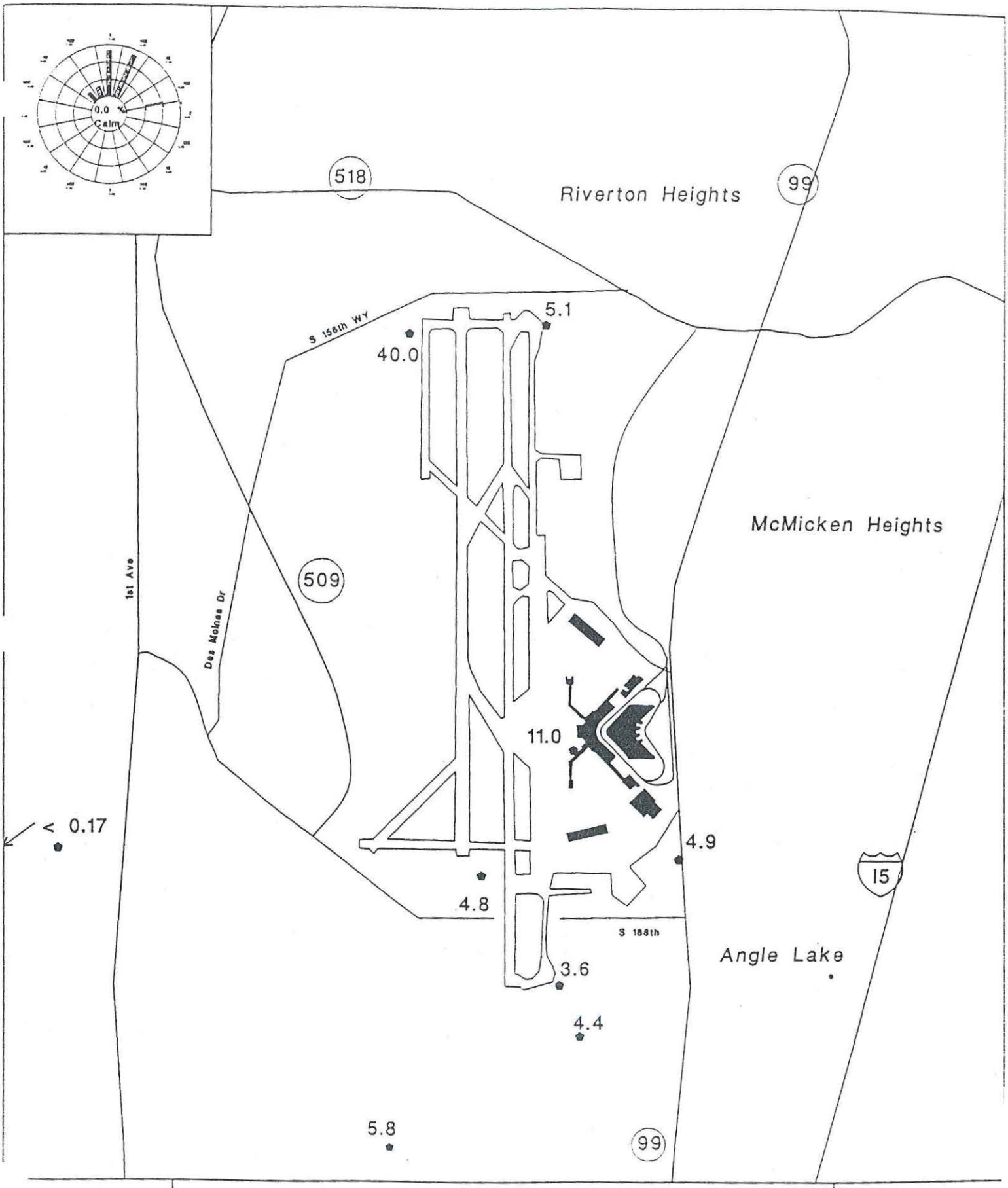
Calm
518
Riverton Heights
99
S 156th WY
1.3
1.3
1st Ave
Des Moines Dr
509
McMicken Heights
2.5
0.26
2.0
15
1.4
S 188th
Angle Lake
1.4
1.4
0.9
99
500 m
Benzene (ppb), 10/26/93
MFG
Atmospheric Sciences Group
February 1994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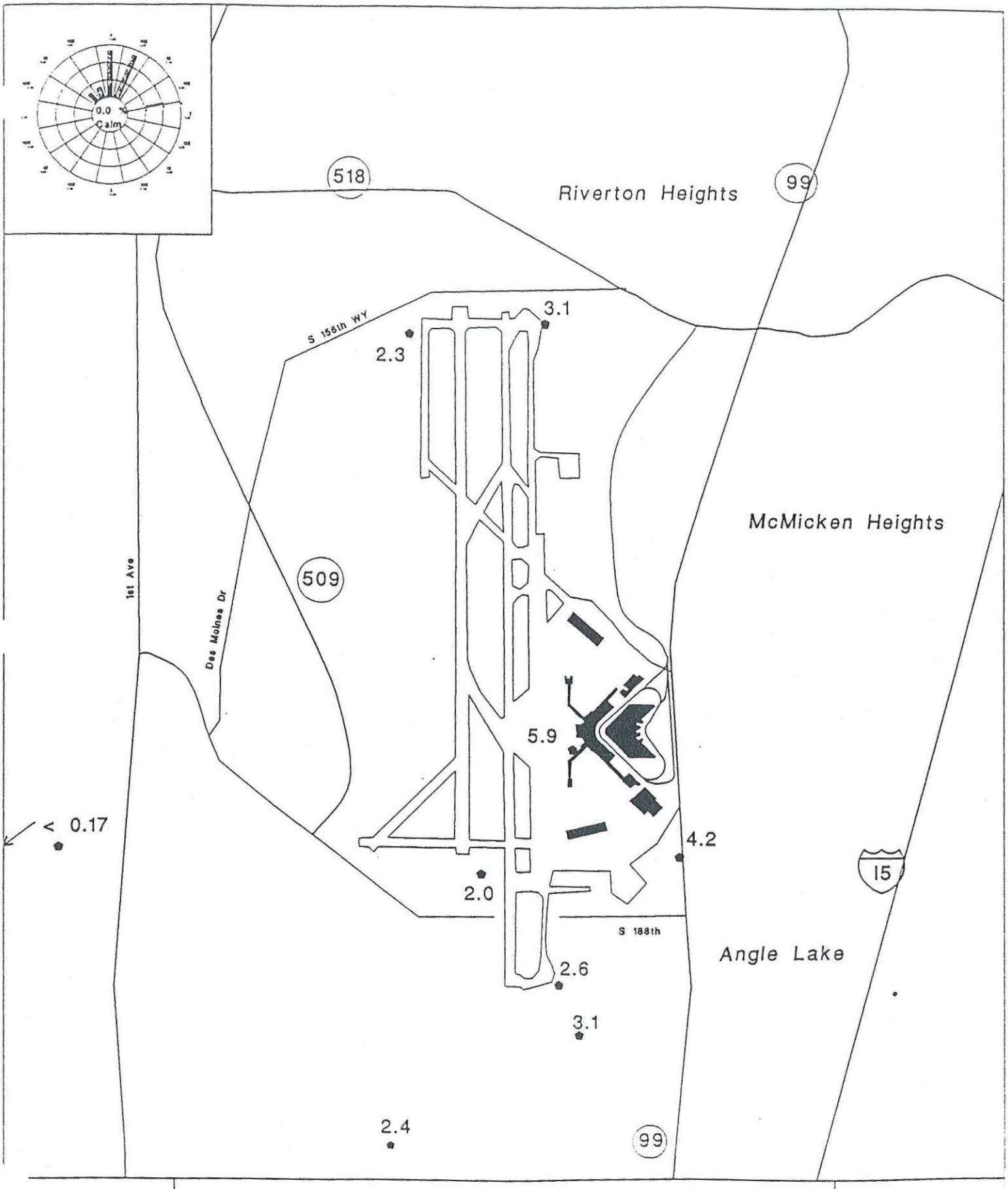
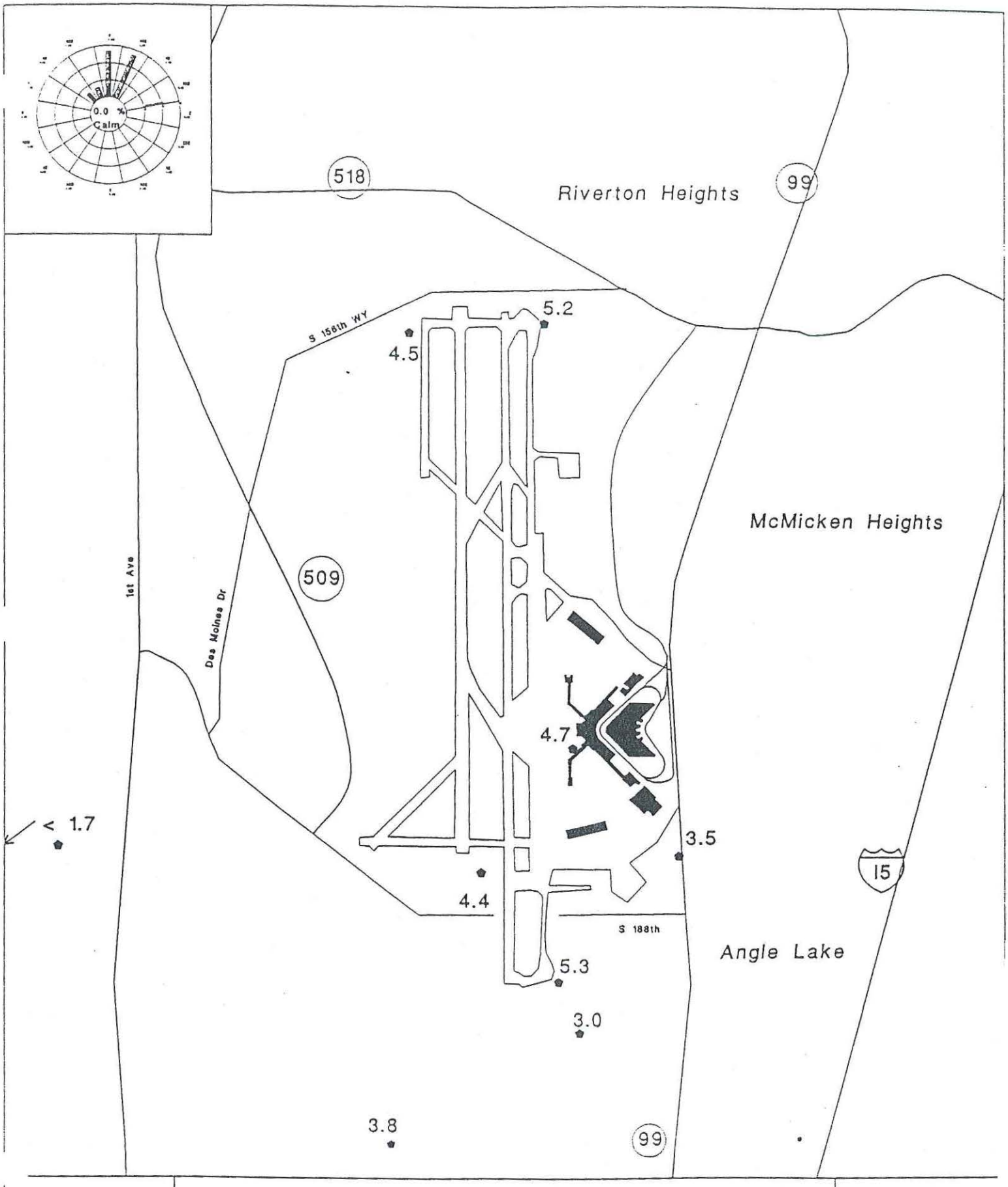
Riverton Heights
99
S 156th WY
5.1
40.0
McMicken Heights
1st Ave
Des Moines Dr
509
11.0
< 0.17
4.9
15
4.8
S 188th
Angle Lake
3.6
4.4
5.8
99
500 m
Toluene (ppb), 10/26/93
MFG
Atmospheric Sciences Group
February 1994



500 m

m,p,o Xylene (ppb), 10/26/93

MFG
Atmospheric Sciences Group
February 1994


0.0 %
Calm
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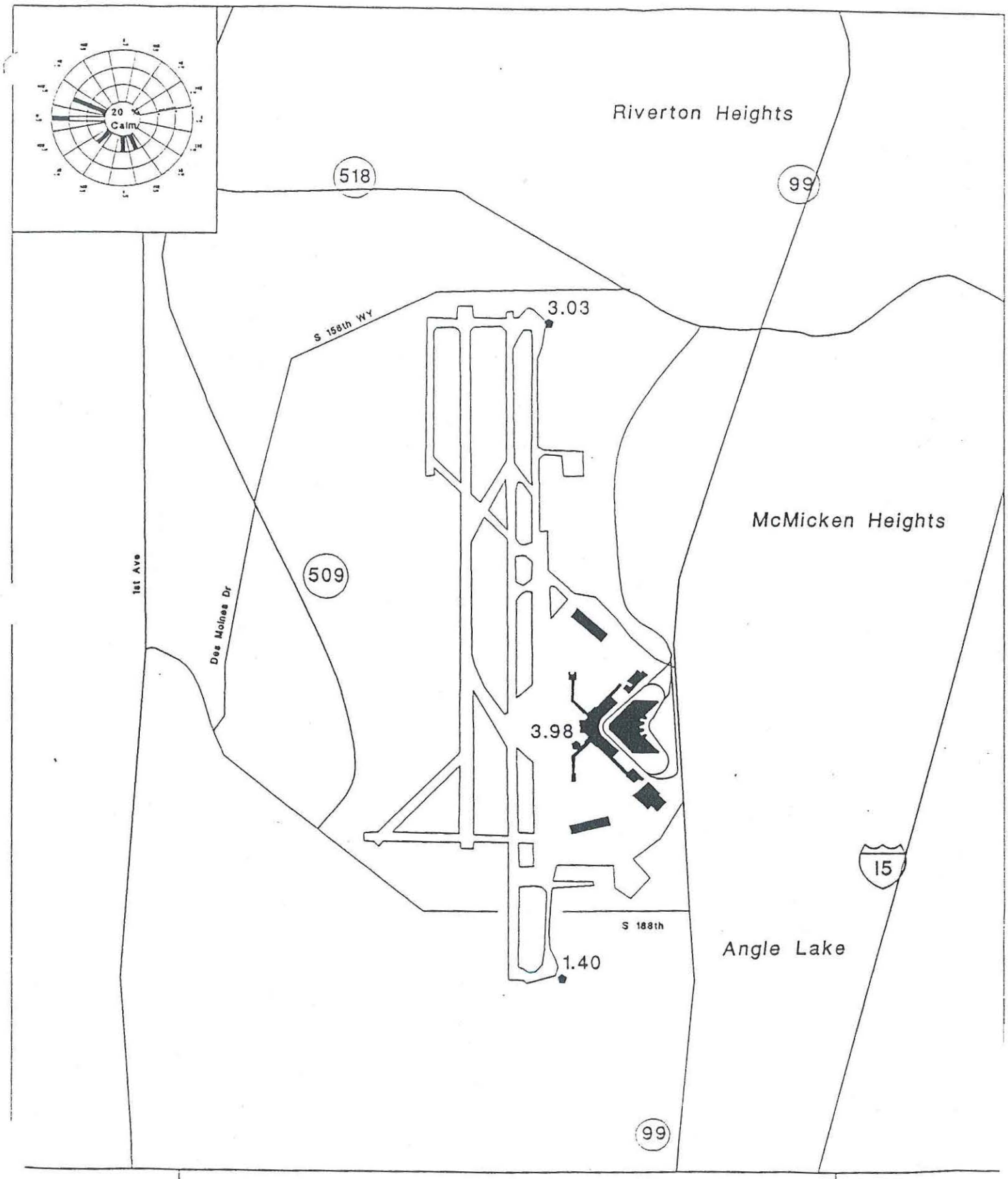
Riverton Heights
99
S 156th WY
5.2
4.5
McMicken Heights
509
1st Ave
Des Moines Dr
4.7
< 1.7
3.5
15
4.4
S 188th
Angle Lake
5.3
3.0
3.8
99
500 m
Carbon Monoxide (ppm), 10/26/93
MFG
Atmospheric Sciences Group
February 1994



500 m

Formaldehyde (ppb), 12/14/93

MFG
Atmospheric Sciences Group
February 1994

Results from EPA Method TO-14

Date: November 26, 1993

Compound		Site 1	Site 2	Site 4	Site 5	Site 7	Site 8	Site 9	Site 11	Site 12	QA Site 10	QA Site 13	mean
Freon 12	(ppb)	0.38	0.38	0.32	0.56	0.27	0.21	0.59	0.47	0.26	0.49	ND	0.38
Freon 114	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl chloride	(ppb)	0.25	0.20	0.18	0.21	0.23	0.25	0.23	0.25	0.23	0.25	0.22	0.23
Vinyl chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl bromide	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 11	(ppb)	0.33	0.33	0.34	0.29	0.28	0.31	0.30	0.27	0.29	0.33	0.43	0.30
Vinylidene chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 113	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloromethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethylene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	(ppb)	1.10	1.30	0.42	0.17	35.00	0.21	0.24	0.31	0.23	1.70	3.10	4.33
Carbon tetrachloride	(ppb)	ND	ND	ND	ND	ND	ND	0.19	ND	ND	ND	ND	0.10
Benzene	(ppb)	4.00	2.60	2.10	1.50	2.10	1.70	2.20	1.90	2.40	4.10	2.60	2.28
1,2-Dichloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	(ppb)	8.40	6.40	3.60	3.20	3.70	2.60	4.20	3.70	4.60	9.30	6.40	4.49
trans-1,3-Dichloropropen	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	(ppb)	0.18	ND	ND	0.19	ND	ND	0.19	ND	0.21	ND	ND	0.14
1,2-Dibromoethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Benzene	(ppb)	1.50	0.86	0.70	0.35	0.63	0.43	0.66	0.48	0.67	1.50	1.10	0.70
m,p-Xylene	(ppb)	5.40	3.00	2.40	1.10	2.10	1.40	2.20	1.60	2.20	5.20	3.90	2.38
o-Xylene	(ppb)	1.90	1.00	0.90	0.42	0.78	0.54	0.91	0.55	0.83	1.80	1.50	0.87
Styrene	(ppb)	ND	0.20	ND	ND	ND	ND	ND	ND	ND	0.16	0.19	0.10
1,1,2,2-Tetrachloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	(ppb)	0.67	0.22	0.30	ND	ND	ND	ND	ND	0.20	0.57	0.20	0.20
1,2,4-Trimethylbenzene	(ppb)	2.00	0.72	0.94	0.29	0.50	0.34	0.53	0.41	0.69	1.70	0.71	0.71
m-Dichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-Dichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzyl chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Dichlorobenzene	(ppb)	0.38	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.12
1,2,4-Trichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TO-14 Detection Limit	(ppb)	0.17	0.20	0.18	0.16	0.19	0.16	0.19	0.20	0.18	0.16	0.18	0.18
TPH	(ppb)	380	250	240	170	290	80	160	220	340	390	210	237
Carbon monoxide (CO)	(ppm)	4.4	5.0	3.6	3.7	4.8	4.1	4.4	5.0	3.9	4.9	3.2	4.3
Start Time	(PST)	10:45	10:30	10:54	11:50	10:50	11:36	11:20	11:10	11:55	10:34	11:55	11:12
Stop Time	(PST)	17:26	17:40	17:46	16:09	17:54	18:14	18:03	18:09	17:18	17:26	17:20	17:37
Sampling Duration	(hrs)	06:41	07:10	06:52	04:19	07:04	06:38	06:43	06:59	05:23	06:52	05:25	06:25

4.26

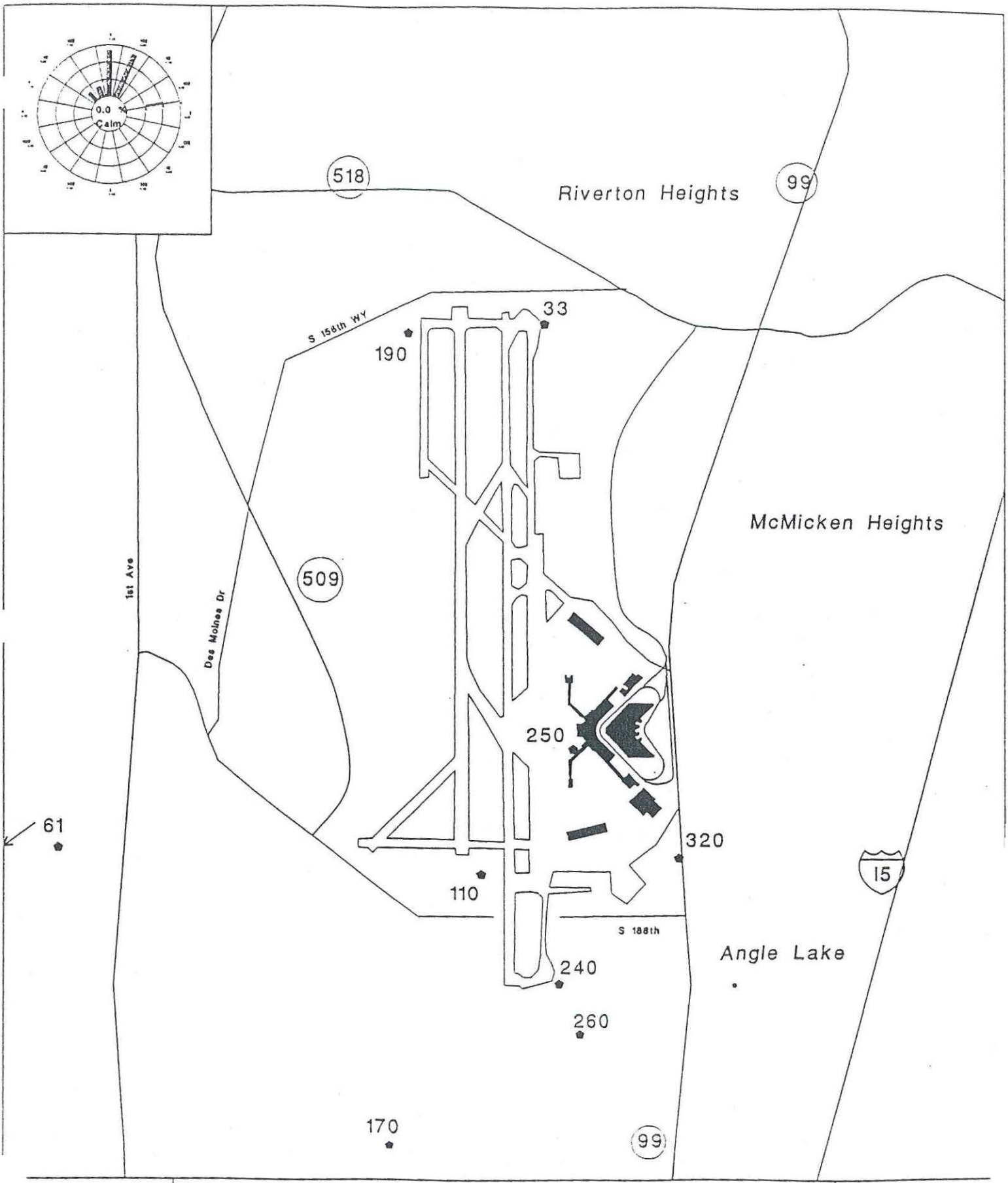
ND - Compound below minimum detection limit (MDL)
TPH - Total Petroleum hydrocarbons referenced to Jet Fuel
CO - Based on ASTM D-3416
Mean - When a sample was below the MDL, the sample's MDL/2 was used for the mean. Does not include QA sites

Tentatively Identified Compounds - Top 10 Reported

Date: November 26, 1993

Compound		Site 1	Site 2	Site 4	Site 5	Site 7	Site 8	Site 9	Site 11	Site 12	QA Site 10	QA Site 13	mean
Ethyl Alcohol	(ppb)	37.0	31.0	24.0	9.4	24.0	9.9	9.1	14.0	18.0	34.0	28.0	19.6
Acetone	(ppb)	12.0	7.4	21.0	6.4	39.0	6.9	5.9	6.6	14.0	8.6	26.0	13.2
Isopropyl Alcohol	(ppb)	5.0	7.6	25.0		5.1	0.9	1.0	4.8		4.7	12.0	7.1
Methyl Ethyl Ketone	(ppb)			2.9	25.0	5.9	1.1					18.0	8.7
Butane	(ppb)	23.0	11.0	8.1	5.4	7.2	5.2	6.9	6.9	9.0	20.0	11.0	9.2
Isopentane	(ppb)	11.0	4.8	3.8	2.2	3.6	2.7	3.2	2.9	4.2	12.0	5.0	4.3
Pentane	(ppb)	6.3	3.0	2.4	1.4		1.7	2.0			6.2	3.0	2.8
Hexane	(ppb)	8.9					2.5			4.2			5.2
Methyl Isobutyl Ketone	(ppb)		17.0			13.0			18.0	11.0		5.8	14.8
Benzaldehyde	(ppb)								3.3				3.3
Butyl Alcohol	(ppb)			2.5		2.9	1.5	0.9				5.1	2.0
Valeraldehdye	(ppb)				1.9	5.0							3.5
n,n-Dimethyl Acetamide	(ppb)				4.2				6.2	11.0			7.1
Hexanaldehyde	(ppb)												
n-Heptaldehyde	(ppb)				2.7								2.7
Methyl Phenyl Ketone	(ppb)		3.3										3.3
Vinyl Acetate	(ppb)			5.0									5.0
Heptane	(ppb)							0.9					0.9
Unknown Hydrocarbons	(ppb)	11.8	8.3	3.3		4.6		2.8	9.2	22.5	14.2	3.5	8.9

mean - includes only those samples reported. Does not QA include values.
unknown hydrocarbons - may include one or more peaks on the chromatograph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Des Moines Dr
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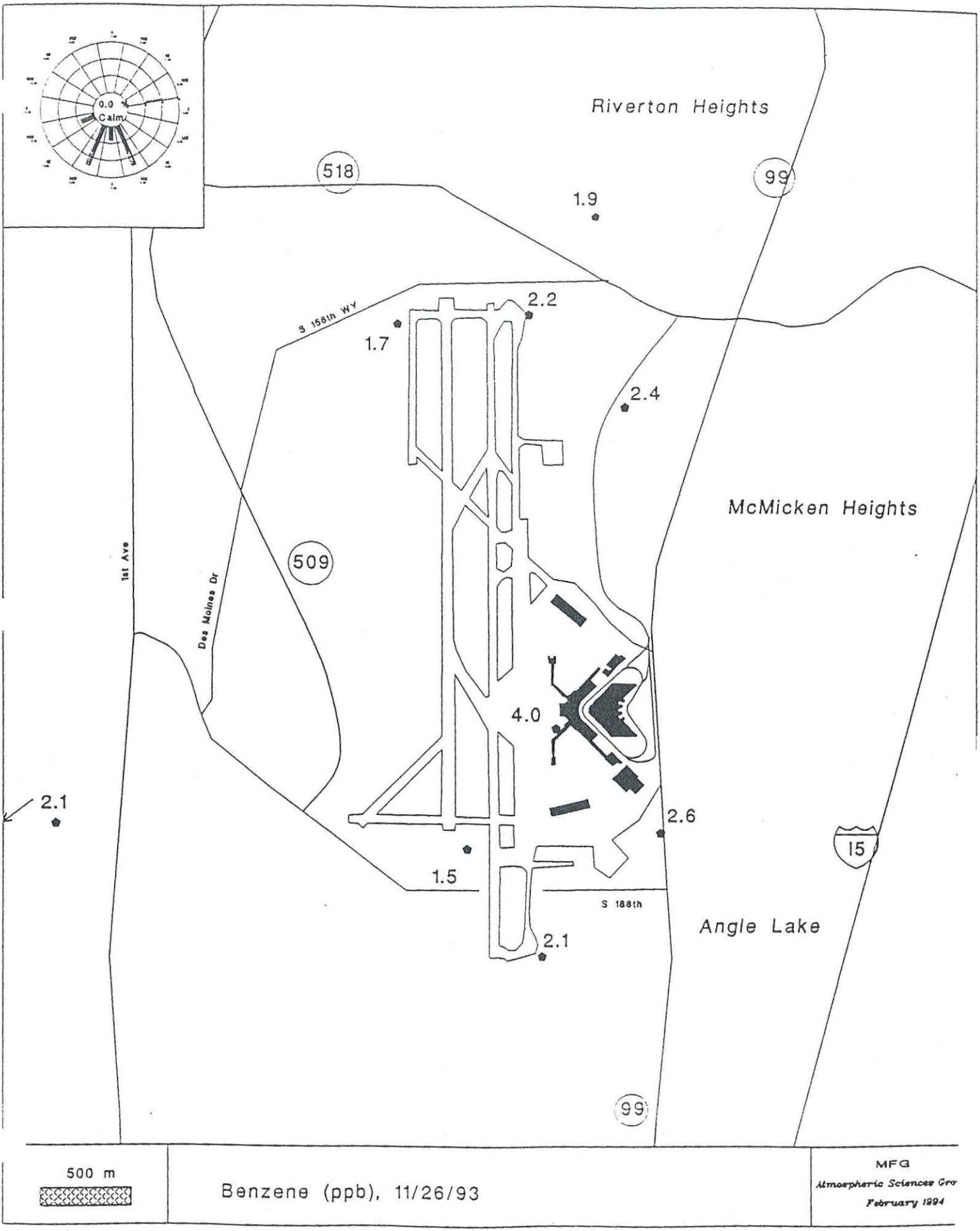
500 m
Total Petroleum Hydrocarbons Referenced to Jet Fuel (ppb), 10/26/93
MFG
Atmospheric Sciences Grou
February 1994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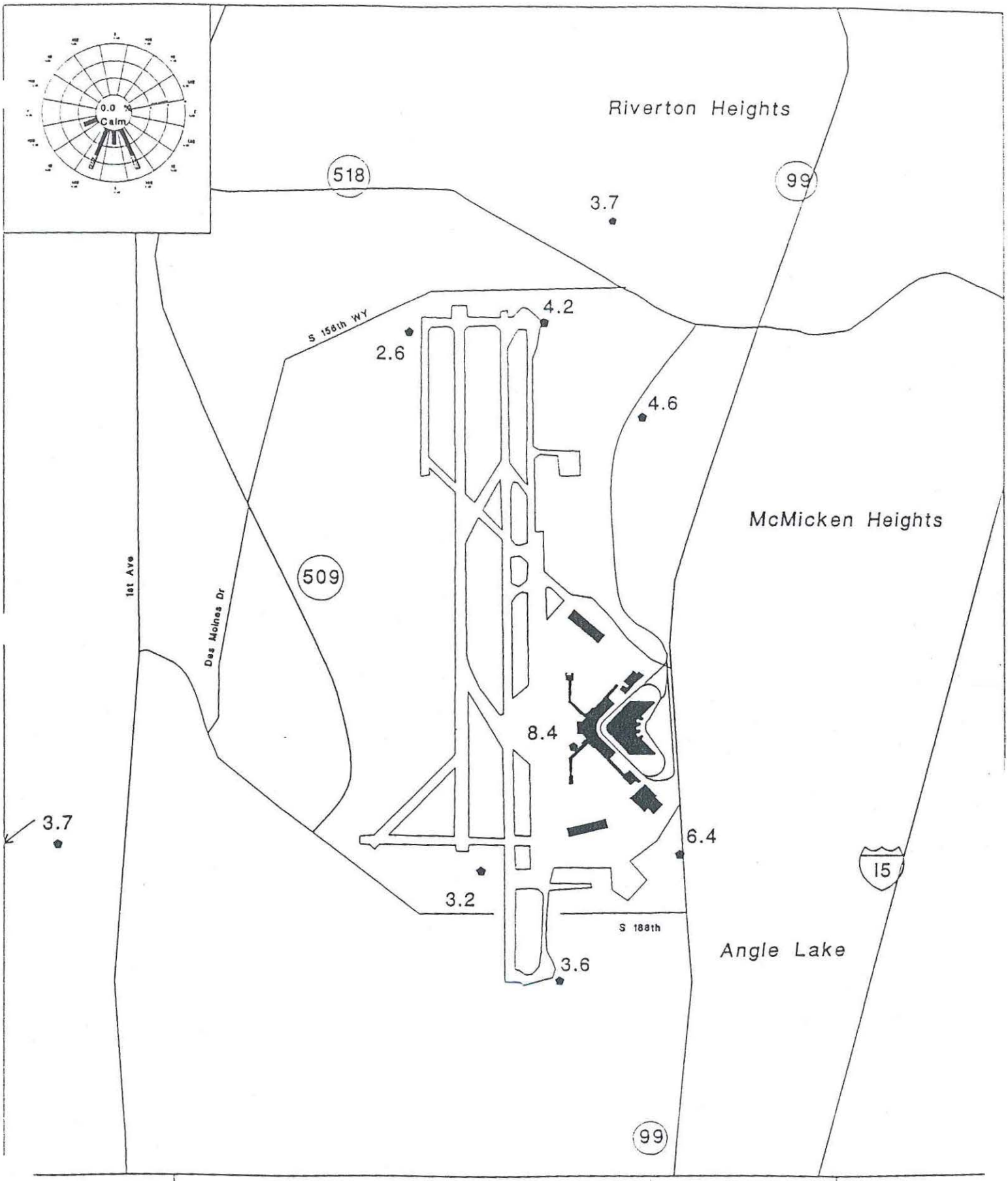
Benzene (ppb), 11/26/93
MFG
Atmospheric Sciences Grp
February 1994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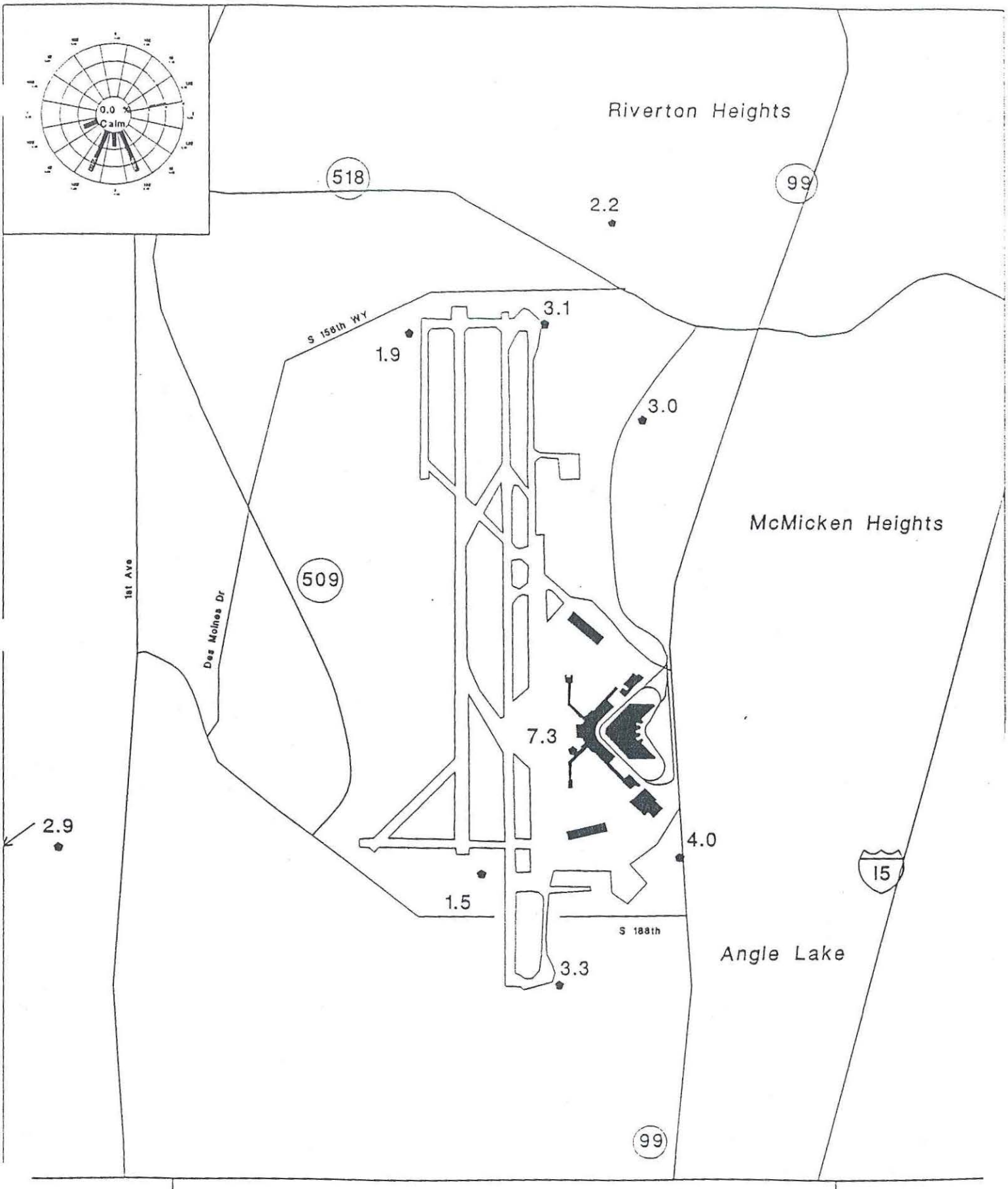
Toluene (ppb), 11/26/93
MFG
Atmospheric Sciences Grp
February 1994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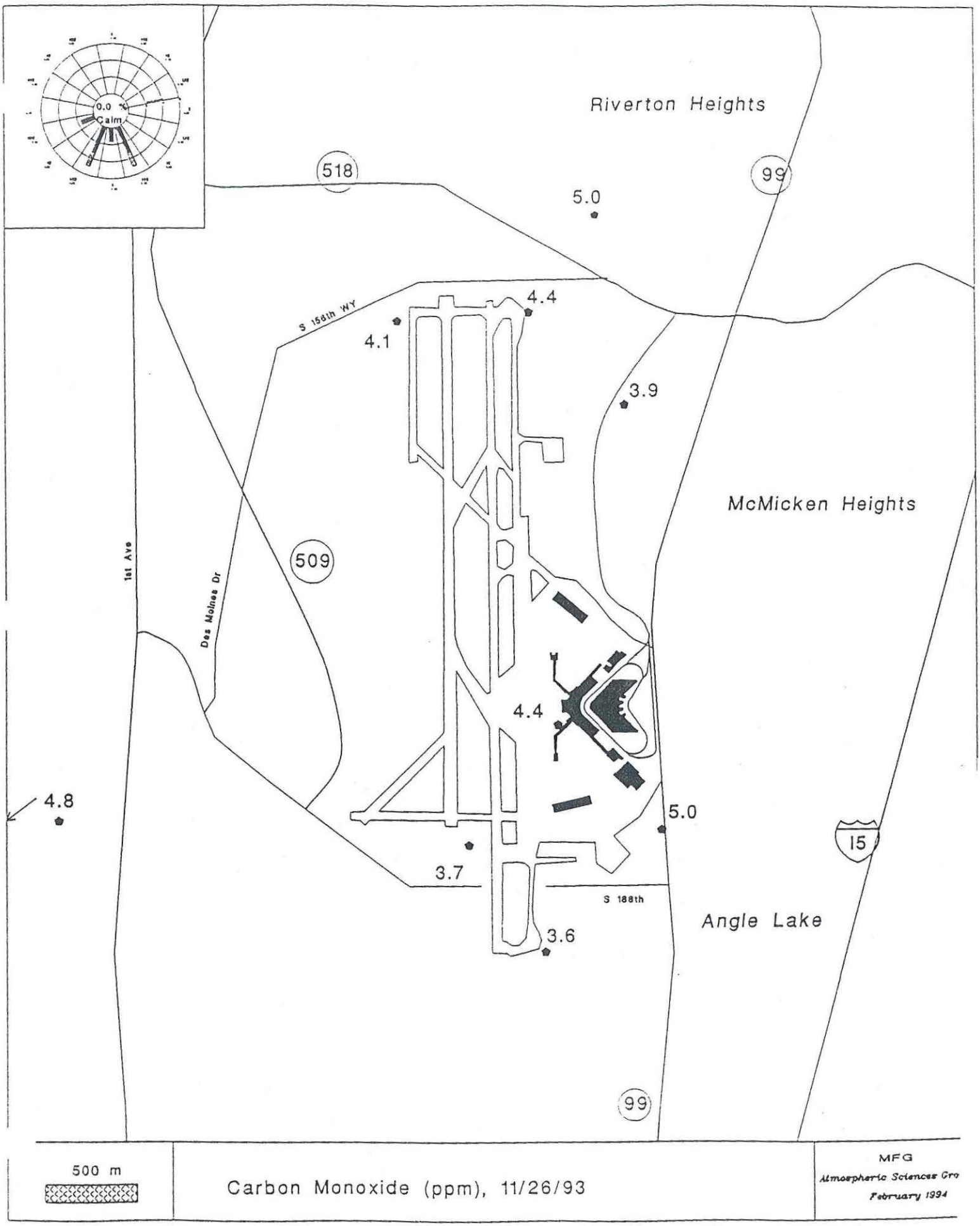
m,p,o Xylene (ppb), 11/26/93
MFG
Atmospheric Sciences Gr
February 1994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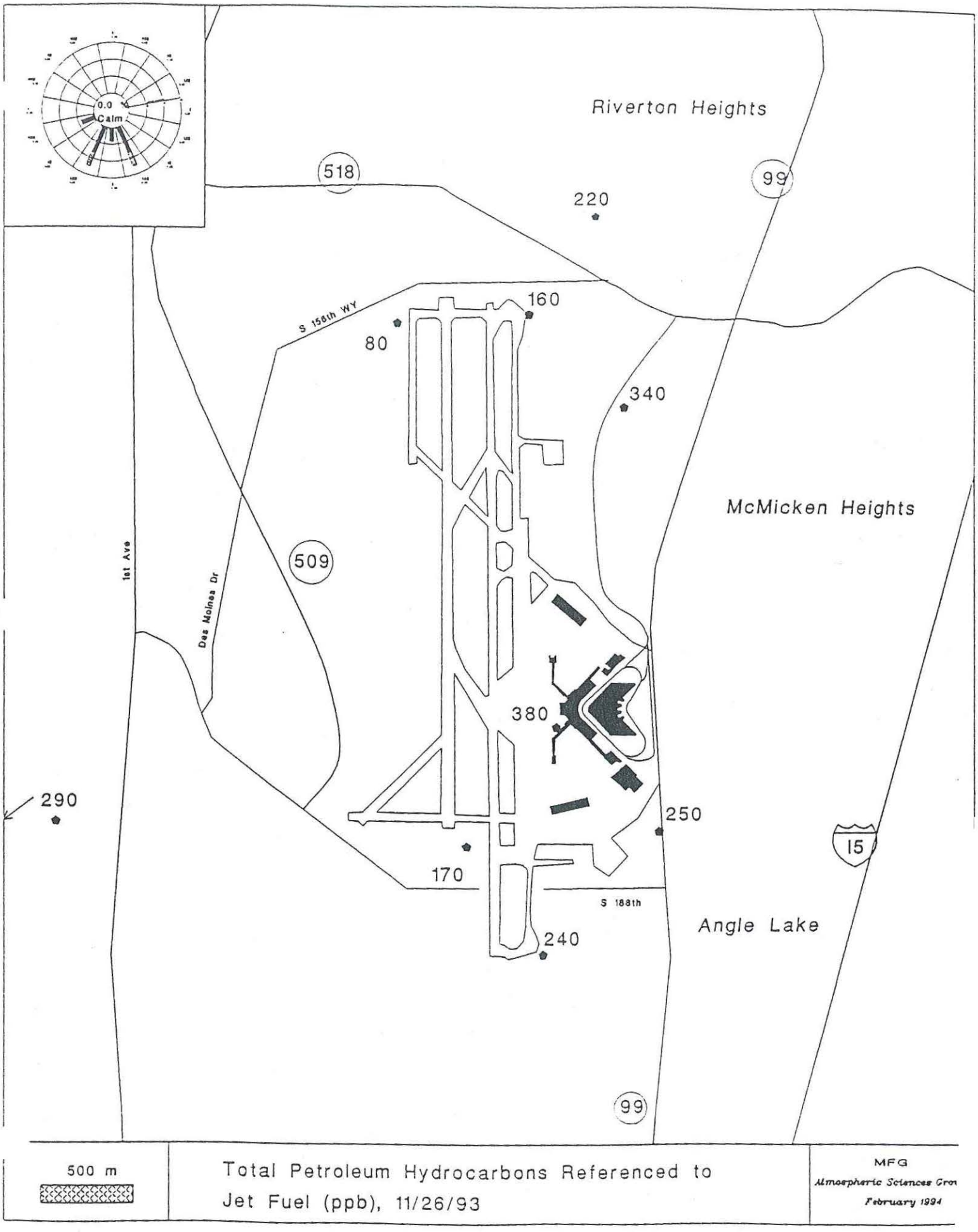
500 m
Carbon Monoxide (ppm), 11/26/93
MFG
Atmospheric Sciences Grp
February 1994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S 188th
Angle Lake
240
99
500 m
Total Petroleum Hydrocarbons Referenced to
Jet Fuel (ppb), 11/26/93
MFG
Atmospheric Sciences Gro
February 1994

Results from EPA Method TO-14

Date: December 14, 1993

Compound		Site 1	Site 2	Site 4	Site 5	Site 7	Site 8	Site 9	Site 11	Site 12	QA Site 10	QA Site 13	mean
Freon 12	(ppb)	0.55	ND	0.69	0.76	0.22	0.62	0.54	ND	0.46	ND	ND	0.45
Freon 114	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl chloride	(ppb)	0.22	ND	0.40	ND	ND	0.27	0.29	0.34	ND	0.25	0.30	0.22
Vinyl chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methyl bromide	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 11	(ppb)	0.29	0.29	0.30	0.30	0.34	0.29	0.29	0.31	0.30	0.39	0.29	0.30
Vinylidene chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freon 113	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichloromethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethylene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	(ppb)	ND	0.41	ND	ND	0.26	0.28	0.25	0.24	0.27	0.29	0.22	0.23
Carbon tetrachloride	(ppb)	ND	ND	ND	ND	ND	0.22	ND	ND	ND	ND	ND	0.12
Benzene	(ppb)	2.80	3.10	1.30	2.20	2.20	1.90	2.20	1.50	2.70	2.90	3.00	2.21
1,2-Dichloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	(ppb)	5.40	8.70	6.90	7.80	4.20	5.20	7.10	4.10	7.20	8.20	6.40	6.29
trans-1,3-Dichloropropen	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	(ppb)	0.28	0.29	0.33	ND	0.20	ND	ND	ND	ND	ND	ND	0.18
1,2-Dibromoethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethyl Benzene	(ppb)	1.00	1.80	1.50	0.87	0.80	1.20	0.76	0.81	1.50	1.60	1.10	1.14
m,p-Xylene	(ppb)	3.80	6.60	5.80	3.10	2.70	4.20	2.70	2.90	5.70	6.20	4.20	4.17
o-Xylene	(ppb)	1.40	2.60	2.30	1.10	1.00	1.60	0.92	0.96	2.40	2.10	1.60	1.59
Styrene	(ppb)	ND	0.38	ND	ND	0.54	0.23	0.26	0.24	0.39	0.42	0.29	0.27
1,1,2,2-Tetrachloroethane	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	(ppb)	0.41	0.44	0.24	0.45	0.20	0.30	ND	0.22	0.42	0.58	0.31	0.31
1,2,4-Trimethylbenzene	(ppb)	1.30	1.30	0.77	1.40	0.64	0.81	0.69	0.70	1.30	1.80	1.00	0.99
m-Dichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p-Dichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzyl chloride	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Dichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	(ppb)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TO-14 Detection Limit	(ppb)	0.21	0.24	0.24	0.25	0.16	0.22	0.24	0.19	0.20	0.17	0.20	0.22
TPH	(ppb)	420	480	430	390	390	370	310	440	340	480	630	397
Carbon monoxide (CO)	(ppm)	3.6	3.9	4.5	3.9	2.8	3.8	3.7	2.8	3.8	2.8	3.4	3.6
Start Time	(PST)	12:19	11:25	11:43	13:35	12:00	12:48	12:40	12:20	12:53	12:10	12:55	12:24
Stop Time	(PST)	18:22	18:30	18:36	19:44	18:45	19:30	19:15	19:07	19:21	18:22	17:21	18:51
Sampling Duration	(hrs)	06:03	07:05	06:53	06:09	06:45	06:42	06:35	06:47	06:28	06:12	04:26	06:24

3.79

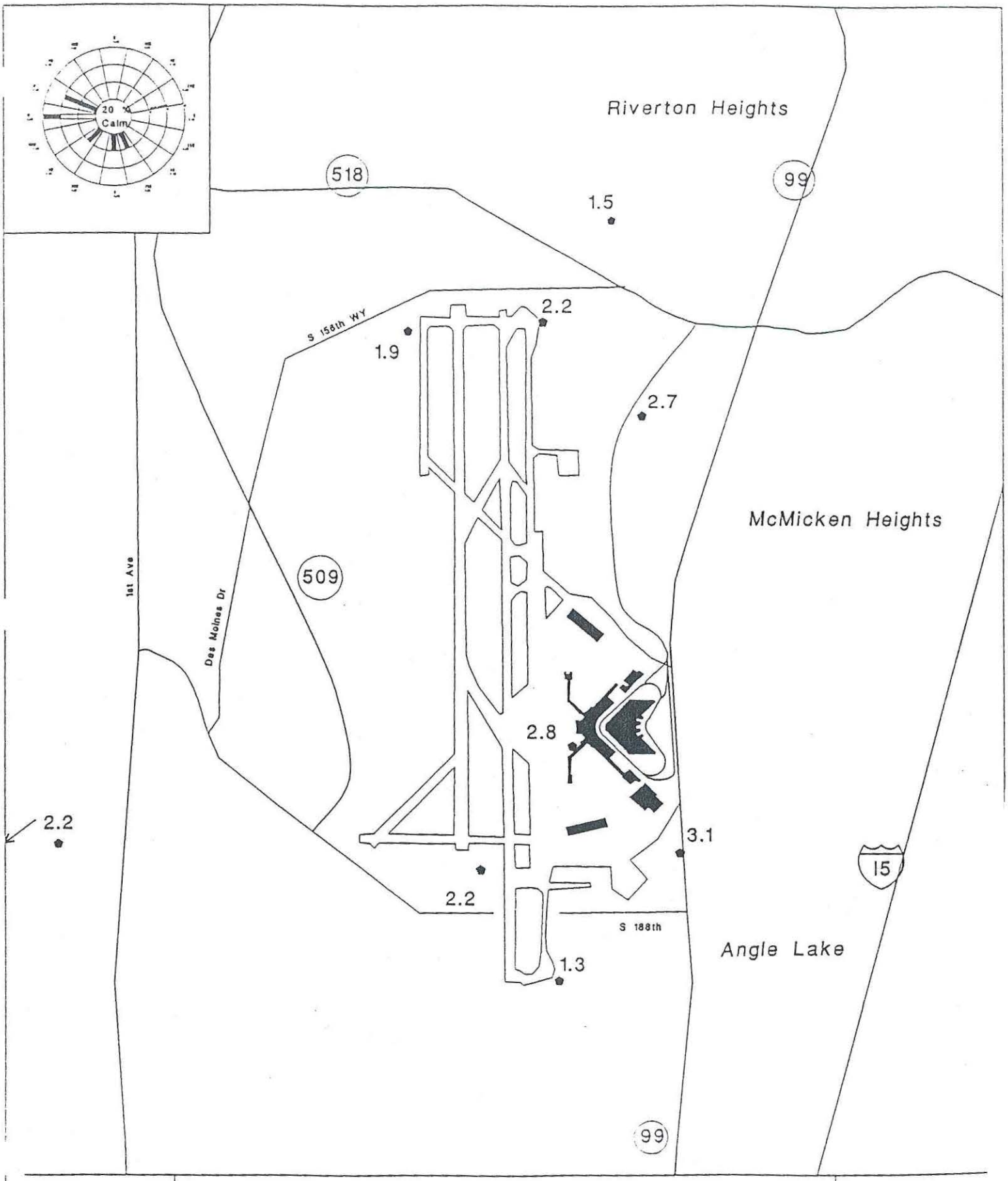
ND - Compound below minimum detection limit (MDL)
TPH - Total Petroleum hydrocarbons referenced to Jet Fuel
CO - Based on ASTM D-3416
Mean - When a sample was below the MDL, the sample's MDL/2 was used for the mean. Does not include QA sites

Tentatively Identified Compounds - Top 10 Reported

Date: December 14, 1993

Compound		Site 1	Site 2	Site 4	Site 5	Site 7	Site 8	Site 9	Site 11	Site 12	QA Site 10	QA Site 13	mean
Ethyl Alcohol	(ppb)	15.0	13.0	8.1	11.0	5.5	6.8	7.8	6.7	12.0	23.0	11.0	9.5
Acetone	(ppb)	4.9	7.4	15.0	8.8	1.4	4.5	3.7	5.5	14.0	6.3	12.0	7.2
Isopropyl Alcohol	(ppb)		4.4	1.9			51.0	2.5		1.6			12.3
Methyl Ethyl Ketone	(ppb)		5.8	13.0	3.2	220.0	11.0	1.6		2.1	57.0	420.0	36.7
Butane	(ppb)	14.0	12.0	4.3	6.6	9.2	6.5	6.9	12.0	10.0	17.0	9.0	9.1
Isopentane	(ppb)	7.0	5.2	2.2	3.3	2.5	3.0	3.4	5.2	5.1	12.0	5.6	4.1
Pentane	(ppb)	4.0	3.3	1.3	2.2		2.1	2.2	2.6	3.2	6.8	3.2	2.6
Hexane	(ppb)					10.0		1.0			3.8	10.0	5.5
Methyl Isobutyl Ketone	(ppb)		18.0			16.0			9.7	6.8		4.3	12.6
Benzaldehyde	(ppb)		4.5			3.6			3.6				3.9
Butyl Alcohol	(ppb)				1.6		1.2	1.0					1.3
Phenol	(ppb)		6.8						15.0				10.9
Methyl Phenyl Ketone	(ppb)					3.6			3.8				3.7
Sulfur Dioxide	(ppb)										17.0		
1,4-Dioxane	(ppb)	11.0											11.0
Octane	(ppb)							0.8					0.8
Unknown Hydrocarbons	(ppb)	18.2		11.4	22.4	3.8	4.7		2.4	4.5	10.1	22.5	9.6

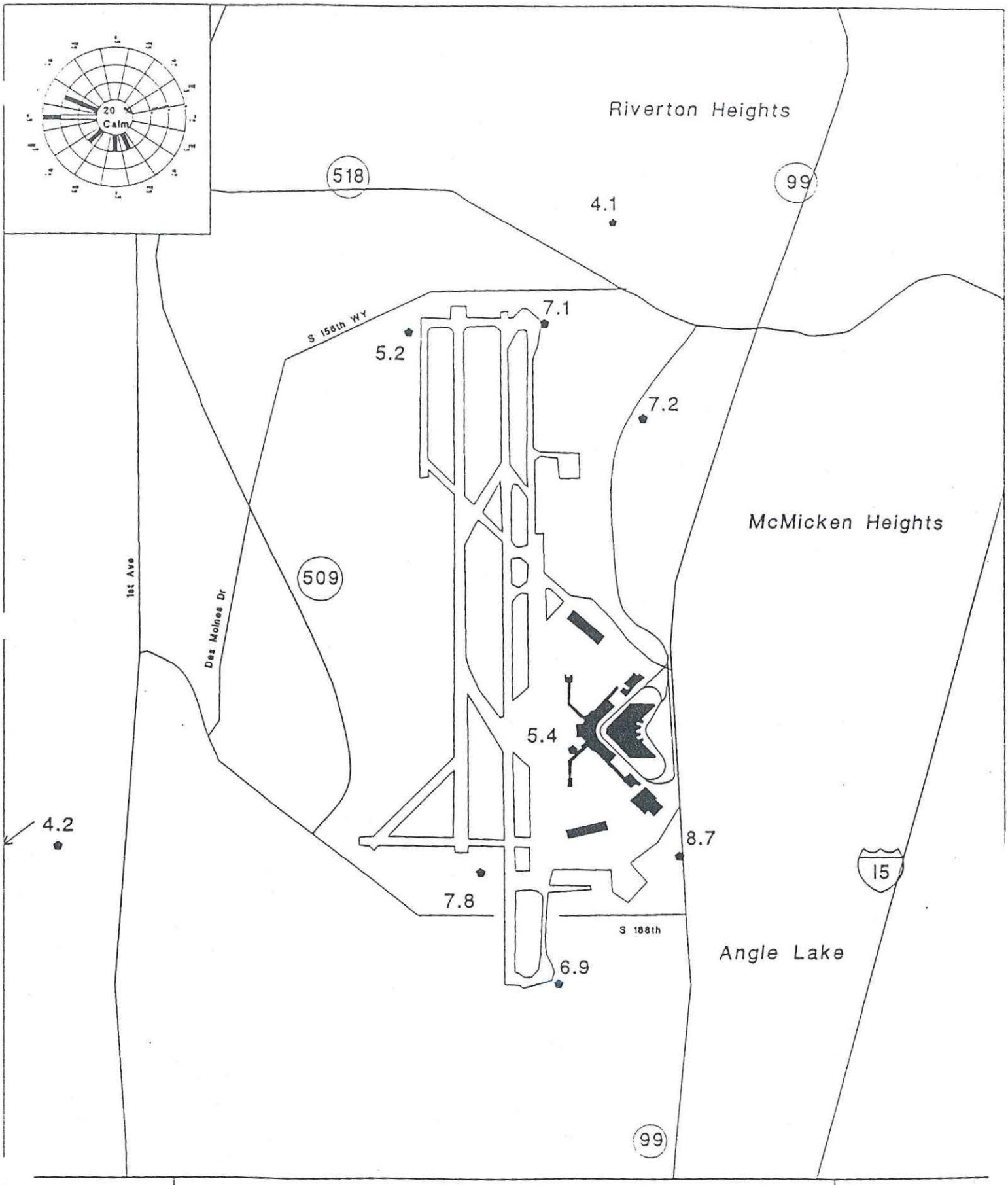
mean - includes only those samples reported. Does not QA include values.
unknown hydrocarbons - may include one or more peaks on the chromatograph



500 m

Benzene (ppb), 12/14/93

MFG
Atmospheric Sciences Grp
February 1994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Angle Lake
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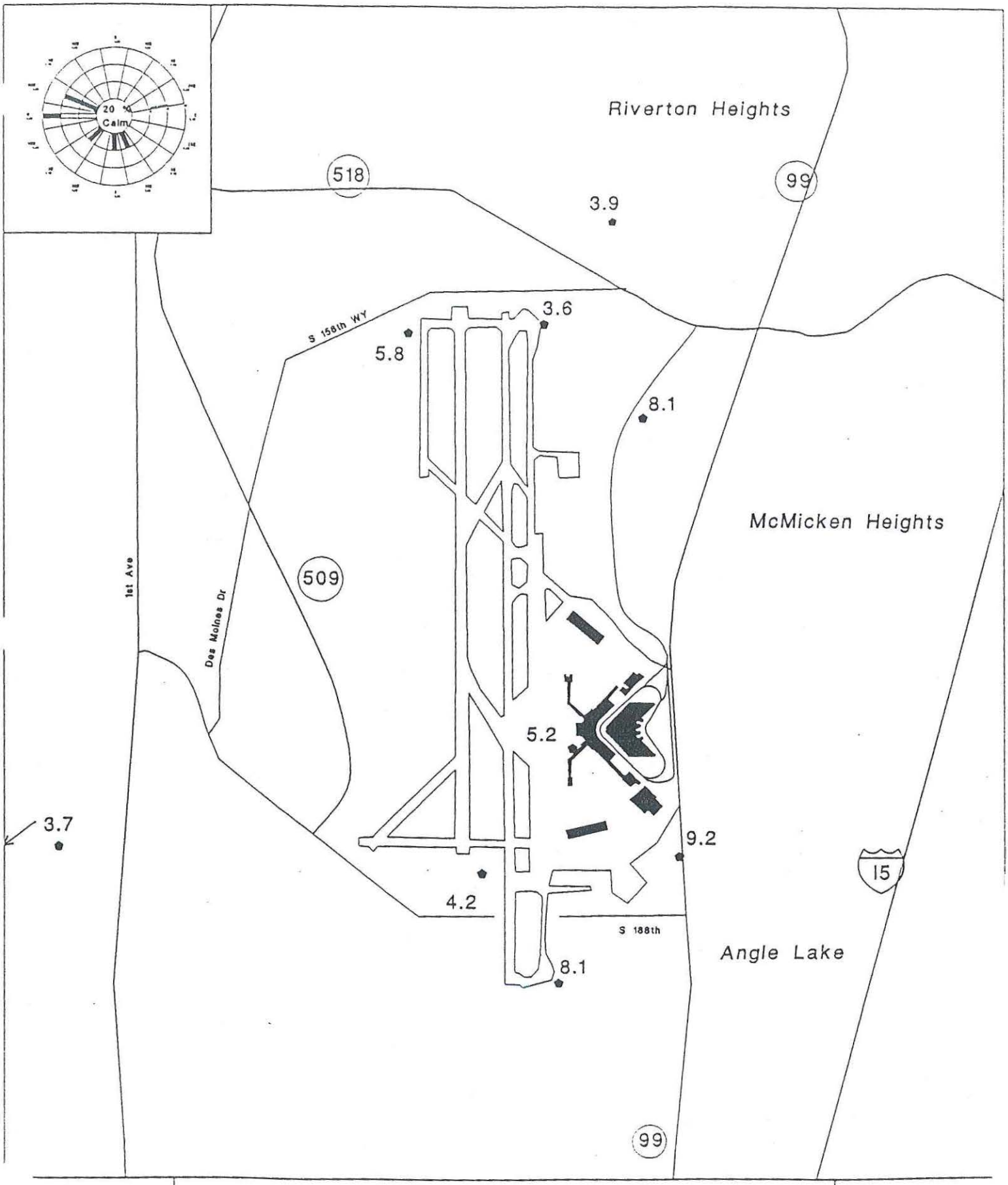
500 m
Toluene (ppb), 12/14/93
MFG
Atmospheric Sciences Gro
February 1994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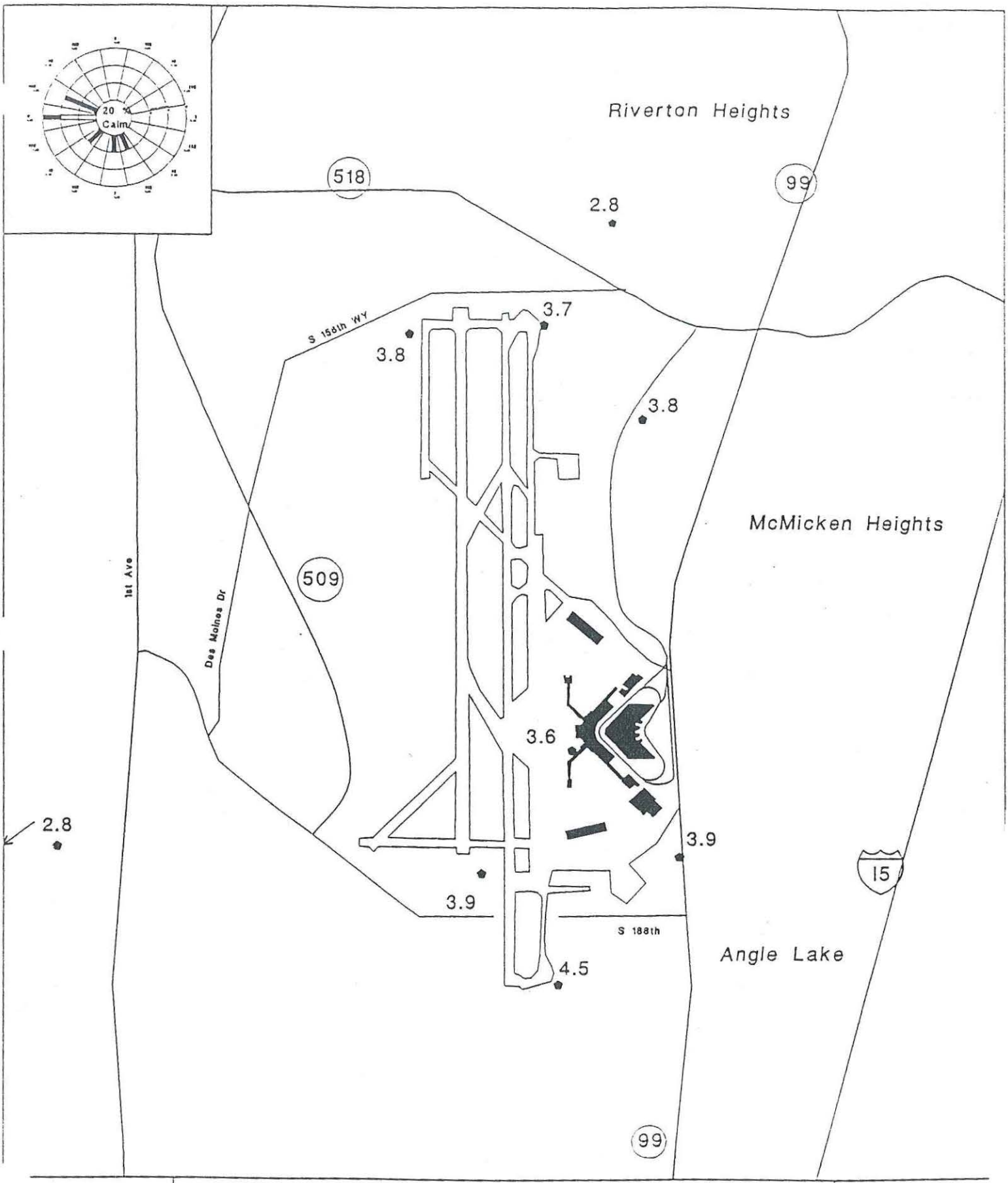
500 m
m,p,o Xylene (ppb), 12/14/93
MFG
Atmospheric Sciences Grou
February 1994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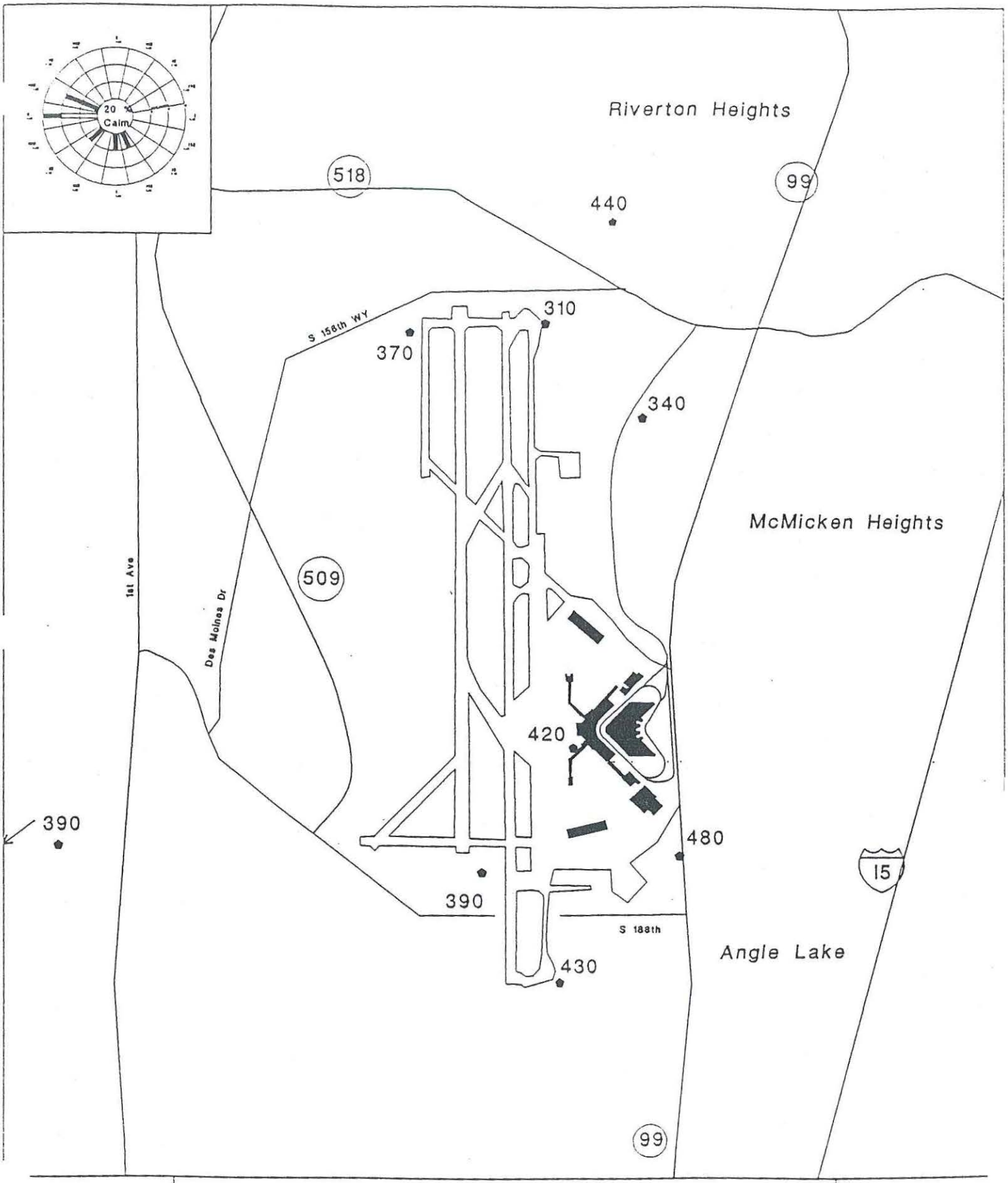
Carbon Monoxide (ppm), 12/14/93
MFG
Atmospheric Sciences Grou
February 1994



500 m

Total Petroleum Hydrocarbons Referenced to Jet Fuel (ppb), 12/14/93

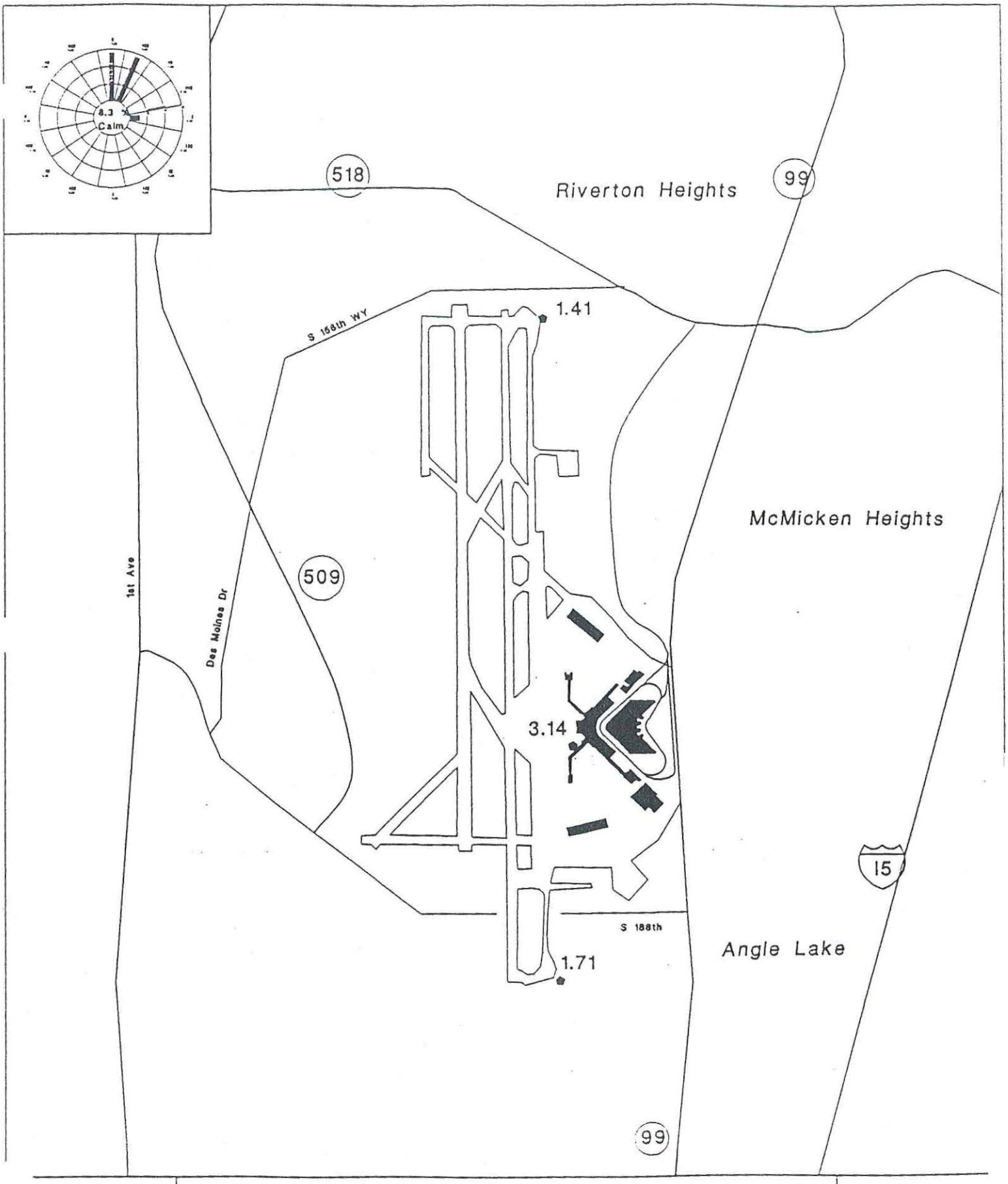
MFG
Atmospheric Sciences Grou
February 1994

Results from EPA Method TO-11

Date: October 25, 1993

Compound		Site 1 MDL	Site 1 Conc.		Site 4 MDL	Site 4 Conc.		Site 9 MDL	Site 9 Conc.		Mean
Formaldehyde	(ppb)	0.24	3.14		0.27	1.71		0.25	1.41		2.09
Acetaldehyde	(ppb)	0.16	1.64		0.19	1.67		0.17	1.13		1.48
Acrolein	(ppb)	0.13	0.19		0.15	ND		0.13	ND		0.11
Propionaldehyde	(ppb)	0.12	ND		0.14	ND		0.13	ND		ND
Acetone	(ppb)	0.12	1.45	b	0.14	1.63	b	0.13	1.77	b	1.61
Crotonaldehyde	(ppb)	0.10	ND		0.12	ND		0.11	ND		ND
Isobutyraldehyde	(ppb)	0.10	ND		0.11	ND		0.10	ND		ND
Methyl Ethyl Ketone	(ppb)	0.10	0.71	b	0.11	0.76	b	0.10	0.82	b	0.76
Benzaldehyde	(ppb)	0.07	ND		0.08	ND		0.07	ND		ND
Valeraldehdye	(ppb)	0.08	ND		0.09	ND		0.09	ND		ND
o-Tolualdehyde	(ppb)	NA	ND		NA	ND		NA	ND		ND
m-Tolualdehyde	(ppb)	NA	ND		NA	ND		NA	ND		ND
p-Tolualdehyde	(ppb)	NA	ND		NA	ND		NA	ND		ND
Hexanaldehyde	(ppb)	0.07	ND		0.08	ND		0.07	ND		ND
Start Time	(PST)		06:15			08:07			06:53		07:05
Stop Time	(PST)		13:51			14:48			14:06		14:15
Sampling Duration	(hrs)		07:36			06:41			07:13		07:10

ND - Compound below minimum detection limit (MDL)
b - Corrected for amount in laboratory blank
Mean - When a sample was below the MDL, the sample's MDL/2 was used for the mean

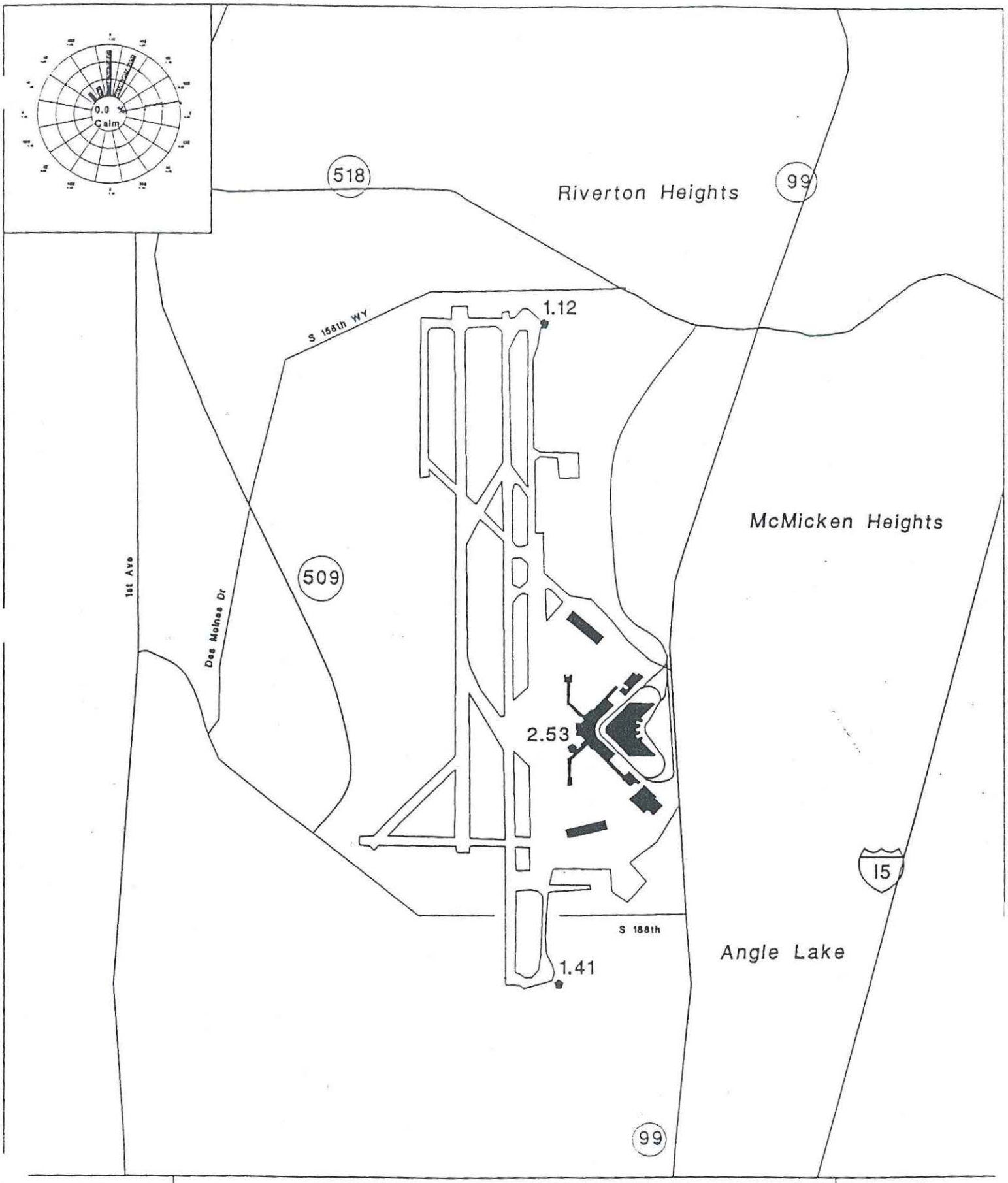

8.3
Calm
518
Riverton Heights
99
S 156th WY
1.41
1st Ave
Des Moines Dr
509
McMicken Heights
3.14
15
S 188th
Angle Lake
1.71
99
500 m
Formaldehyde (ppb), 10/25/93
MFG
Atmospheric Sciences Gro
February 1994

Results from EPA Method TO-11

Date: October 26, 1993

Compound		Site 1 MDL	Site 1 Conc.		Site 4 MDL	Site 4 Conc.		Site 9 MDL	Site 9 Conc.		Mean
Formaldehyde	(ppb)	0.21	2.53		0.22	1.41		0.21	1.12		1.69
Acetaldehyde	(ppb)	0.14	1.28		0.15	1.45		0.14	0.98		1.24
Acrolein	(ppb)	0.11	0.15		0.12	ND		0.11	ND		0.09
Propionaldehyde	(ppb)	0.11	ND		0.12	ND		0.11	ND		ND
Acetone	(ppb)	0.11	2.50	b	0.12	1.73	b	0.11	1.60	b	1.94
Crotonaldehyde	(ppb)	0.09	ND		0.10	ND		0.09	ND		ND
Isobutyraldehyde	(ppb)	0.09	ND		0.09	ND		0.09	ND		ND
Methyl Ethyl Ketone	(ppb)	0.09	2.33	b	0.09	1.73	b	0.09	1.69	b	1.92
Benzaldehyde	(ppb)	0.06	ND		0.06	ND		0.06	ND		ND
Valeraldehdye	(ppb)	0.07	ND		0.08	ND		0.07	ND		ND
o-Tolualdehyde	(ppb)	NA	ND		NA	ND		NA	ND		ND
m-Tolualdehyde	(ppb)	NA	ND		NA	ND		NA	ND		ND
p-Tolualdehyde	(ppb)	NA	ND		NA	ND		NA	ND		ND
Hexanaldehyde	(ppb)	0.06	ND		0.07	ND		0.06	ND		ND
Start Time	(PST)		05:48			06:28			06:46		06:20
Stop Time	(PST)		14:25			14:35			15:22		14:47
Sampling Duration	(hrs)		08:37			08:07			08:36		08:26

ND - Compound below minimum detection limit (MDL)
b - Corrected for amount in laboratory blank
Mean - When a sample was below the MDL, the sample's MDL/2 was used for the mean



500 m

Formaldehyde (ppb), 10/26/93

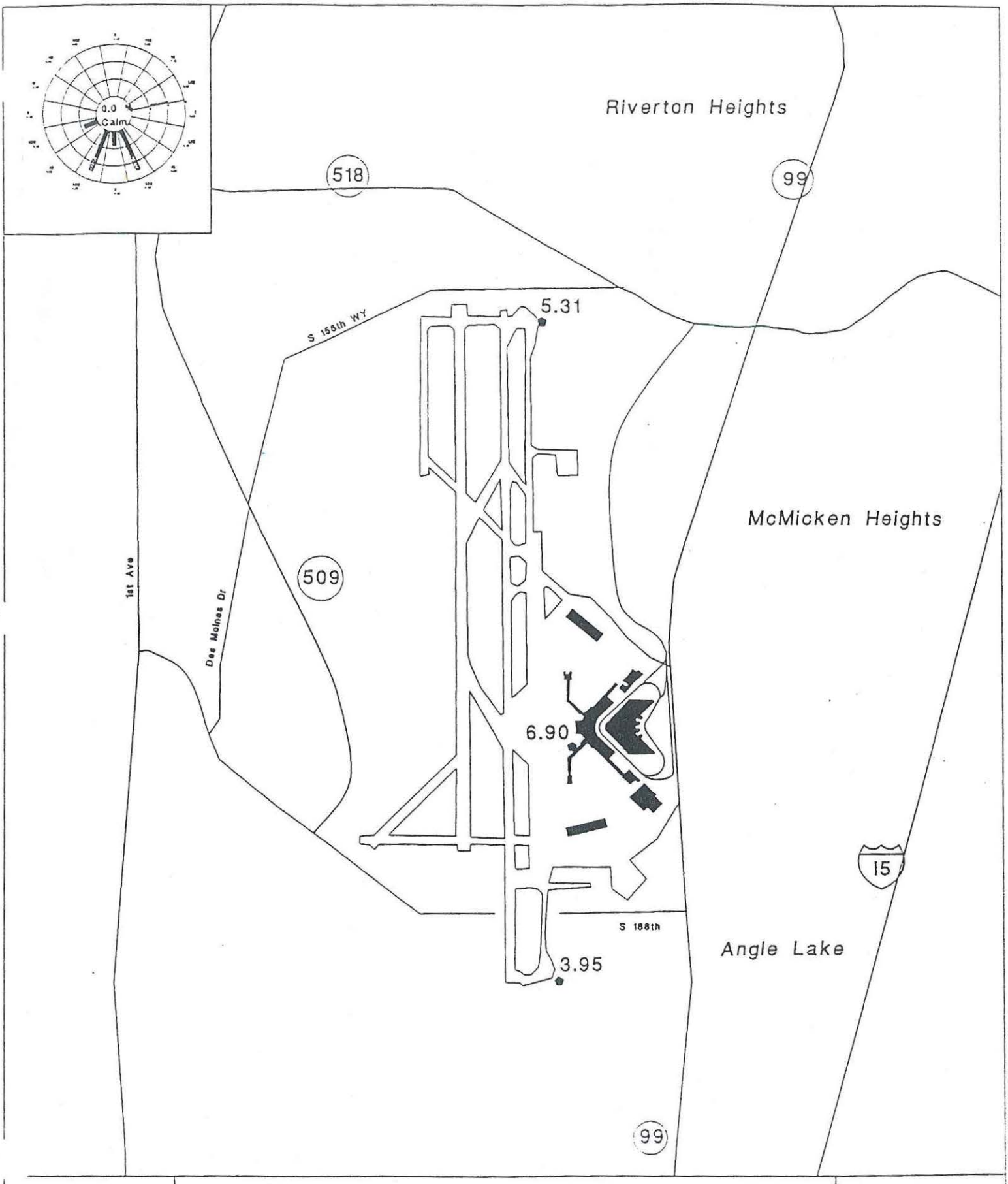
MFG
Atmospheric Sciences Group
February 1994

Results from EPA Method TO-11

Date: November 26, 1993

Compound		Site 1 MDL	Site 1 Conc.	Site 4 MDL	Site 4 Conc.	Site 9 MDL	Site 9 Conc.	Mean
Formaldehyde	(ppb)	0.24	6.90	0.26	3.95	0.21	5.31	5.38
Acetaldehyde	(ppb)	0.16	3.89	0.18	2.69	0.14	2.61	3.06
Acrolein	(ppb)	0.13	3.57	0.14	ND	0.11	ND	1.23
Propionaldehyde	(ppb)	0.12	ND	0.14	ND	0.11	ND	ND
Acetone	(ppb)	0.12	2.30 b	0.14	2.82 b	0.11	ND b	1.72
Crotonaldehyde	(ppb)	0.10	ND	0.11	ND	0.09	ND	ND
Isobutyraldehyde	(ppb)	0.10	1.68	0.11	ND	0.09	2.12	1.29
Methyl Ethyl Ketone	(ppb)	0.10	ND	0.11	ND	0.09	ND	ND
Benzaldehyde	(ppb)	0.07	1.14	0.07	ND	0.06	ND	0.40
Valeraldehdye	(ppb)	0.08	ND	0.09	ND	0.07	ND	ND
o-Tolualdehyde	(ppb)	NA	ND	NA	ND	NA	ND	ND
m-Tolualdehyde	(ppb)	NA	ND	NA	ND	NA	ND	ND
p-Tolualdehyde	(ppb)	NA	ND	NA	ND	NA	ND	ND
Hexanaldehyde	(ppb)	0.07	ND	0.08	ND	0.06	ND	ND
Start Time	(PST)		10:45		11:00		11:20	11:01
Stop Time	(PST)		17:26		17:58		18:05	17:49
Sampling Duration	(hrs)		06:41		06:58		06:45	06:48

ND - Compound below minimum detection limit (MDL)
b - Corrected for amount in laboratory blank
Mean - When a sample was below the MDL, the sample's MDL/2 was used for the mean



500 m

Formaldehyde (ppb), 11/26/93

MFG
Atmospheric Sciences Group
February 1994

Results from EPA Method TO-11

Date: December 14, 1993

Compound		Site 1 MDL	Site 1 Conc.	Site 4 MDL	Site 4 Conc.	Site 9 MDL	Site 9 Conc.	Site 10 (QA) MDL	Site 10 (QA) Conc.	Mean
Formaldehyde	(ppb)	0.23	3.98	0.23	1.40	0.30	3.03	0.23	3.52	2.80
Acetaldehyde	(ppb)	0.16	2.55	0.15	0.89	0.21	2.27	0.16	2.08	1.91
Acrolein	(ppb)	0.13	16.29	0.12	1.58	0.16	13.96	0.13	15.08	10.61
Propionaldehyde	(ppb)	0.12	ND	0.12	ND	0.16	ND	0.12	ND	ND
Acetone	(ppb)	0.12	2.93 b	0.12	2.60 b	0.16	5.20 b	0.12	2.33 b	3.57
Crotonaldehyde	(ppb)	0.10	ND	0.10	ND	0.13	ND	0.10	ND	ND
Isobutyraldehyde	(ppb)	0.10	ND	0.09	ND	0.13	ND	0.10	ND	ND
Methyl Ethyl Ketone	(ppb)	0.10	1.17	0.09	6.79	0.13	9.34	0.10	4.59	5.76
Benzaldehyde	(ppb)	0.07	1.26	0.06	1.28	0.09	2.14	0.07	1.19	1.56
Valeraldehdye	(ppb)	0.08	2.28	0.08	1.26	0.11	1.80	0.08	0.31	1.78
o-Tolualdehyde	(ppb)	NA	ND	NA	ND	NA	ND	NA	ND	ND
m-Tolualdehyde	(ppb)	NA	ND	NA	ND	NA	ND	NA	ND	ND
p-Tolualdehyde	(ppb)	NA	ND	NA	ND	NA	ND	NA	ND	ND
Hexanaldehyde	(ppb)	0.07	3.30	0.07	2.79	0.09	4.10	0.07	1.59	3.40
Start Time	(PST)		12:07		11:40		12:37		12:08	12:08
Stop Time	(PST)		18:58		18:45		19:20		18:58	19:01
Sampling Duration	(hrs)		06:51		07:05		06:43		06:50	06:53

ND - Compound below minimum detection limit (MDL)
b - Corrected for amount in laboratory blank
Mean - When a sample was below the MDL, the sample's MDL/2 was used for the mean. Does not include QA values.