2.0 Ambient Air Monitoring

This section presents the findings of the ambient air monitoring component of this study, and contains six sub-sections.

- 2.1 Site Selection – Describes how the monitoring sites were identified.
- 2.2 Sampling Protocol – Describes how the ambient air monitoring samples were obtained.
- 2.3 Sample Analysis – Describes how the ambient air moniroting samples were analyzed at the laboratory.
- 2.4 Quality Assurance/Quality Control – This section describes the quality assurance and quality control (QA/QC) procedures employed during collection and analysis of the ambient air samples.
- 2.5 Ambient Air Monitoring Results – The results of the ambient air monitoring program are discussed in this section, including site-by-site study results.
- 2.6 Ambient Air Monitoring Conclusions – This section presents the conclusions of the ambient air monitoring program.

Ambient air is the air that people might expect to be exposed to at a road, school, or park near an air pollution emission source, such as a natural gas well pad or compressor station. Ambient air monitors are instruments that measure outdoor pollution levels in the ambient air. In this study, ambient air monitoring was conducted to assess the short-term prevalence and magnitude of concentrations of selected air toxics present in the air outside the property boundaries of air emissions sources such as a natural gas well pad or compressor station.

In this study, air pollution levels of nearly 140 pollutants (including over 40 Hazardous Air Pollutants (HAPs)) were measured over a two-month period with ambient air monitoring stations at eight different locations in Fort Worth. Sampling commenced on September 4, 2010, and concluded on October 31. Data obtained from this ambient air monitoring network can be used to:

- Assist in a better understanding of conclusions drawn from the point source sampling and analysis efforts.
- Characterize exposure to selected air toxics in ambient air at various locations in the city, as related to the proximity to certain natural gas activities (well pads, compressor stations, fracturing operations, etc.).
- Establish a representative determination of the concentration of air toxics, such as benzene, present in the ambient air in the area.
- Allow for a public health evaluation (See Section 5 for the full public health evaluation).

The ambient air monitoring network deployed in the field under this project was implemented in accordance with the *Ambient Air Monitoring Plan*, drafted in August 2010 and finalized on September 15, 2010. The *Ambient Air Monitoring Plan* identifies the goals and objectives of the ambient air monitoring network, provides technical background information (such as historical meteorological data) needed to identify candidate monitoring site locations, specifies the technical approach used to focus the list of candidate monitoring sites, and provides the final list of sites used in the study. Also, prior to implementation of the monitoring study, ERG prepared an approved Level 1 *Ambient Air Monitoring Quality Assurance Project Plan (QAPP)* which provided specific information on the sampling protocols, sampling analyses, and data reporting.

2.1 Site Selection

The final selection of eight monitoring sites occurred in two phases.

In Phase 1, geographic information system (GIS) data was obtained from the city of Fort Worth showing the locations of active and permitted natural gas activities, compressor stations, city property, nearby roadways, meteorological stations, and other features. These data and maps were overlaid to show natural gas activities in relation to residences, schools, businesses, existing (non-natural-gas) emission sources, and city-owned property. Monitoring on city-owned property was desirable for several reasons, including ensuring that the project team had site access seven days a week, maintaining the security of project staff and sampling equipment, and maintaining the integrity of the air sample by limiting the chance of vandalism or other tampering. During Phase 1, 20 potential monitoring site locations were identified.

In Phase 2, project staff visited each potential site to evaluate its suitability as a possible monitoring site location. During these visits, project staff interviewed site personnel and inspected the property, taking particular notice of potential obstructions (trees, buildings, etc.) or limitations (not enough land, no power, etc.) that would disqualify sites. At the end of Phase 2, and after consultation with city staff, eight locations were identified as suitable for inclusion in the ambient air monitoring network. These sites are listed below in Table 2.1-1.

Table 2.1-1. Final Ambient Air Network Monitoring Sites

Site ID	Site Type	Coordinates
S-1	Background	32° 49.114'N 97° 02.953'W
S-2	Mobile sources	32° 33.379'N 97° 13.164'W
S-3A	Pre-production	32° 45.897'N 97° 15.763'W
S-3B	Pre-production	32° 46.569'N 97° 29.638'W
S-4	High-level activity	32° 47.249'N 97° 19.715'W

Table 2.1-1. Final Ambient Air Network Monitoring Sites (Continued)

Site ID	Site Type	Coordinates
S-4C	High-level activity, collocated	32° 47.249'N 97° 19.715'W
S-5	High-level activity	32° 59.044'N 97° 23.131'W
S-5C	High-level activity, collocated	32° 59.044'N 97° 23.131'W
S-6	Moderate-level activity, fence line	32° 33.37'N 97° 18.820'W
S-7	Moderate-level activity, fence line	32° 34.223'N 97° 18.815'W

The technical approach used to finalize the site selection process is described in detail in the *Ambient Air Monitoring Plan*. Figure 2.1-1 shows the ambient air monitoring site locations; each site is described below, along with a figure showing its location in more detail.

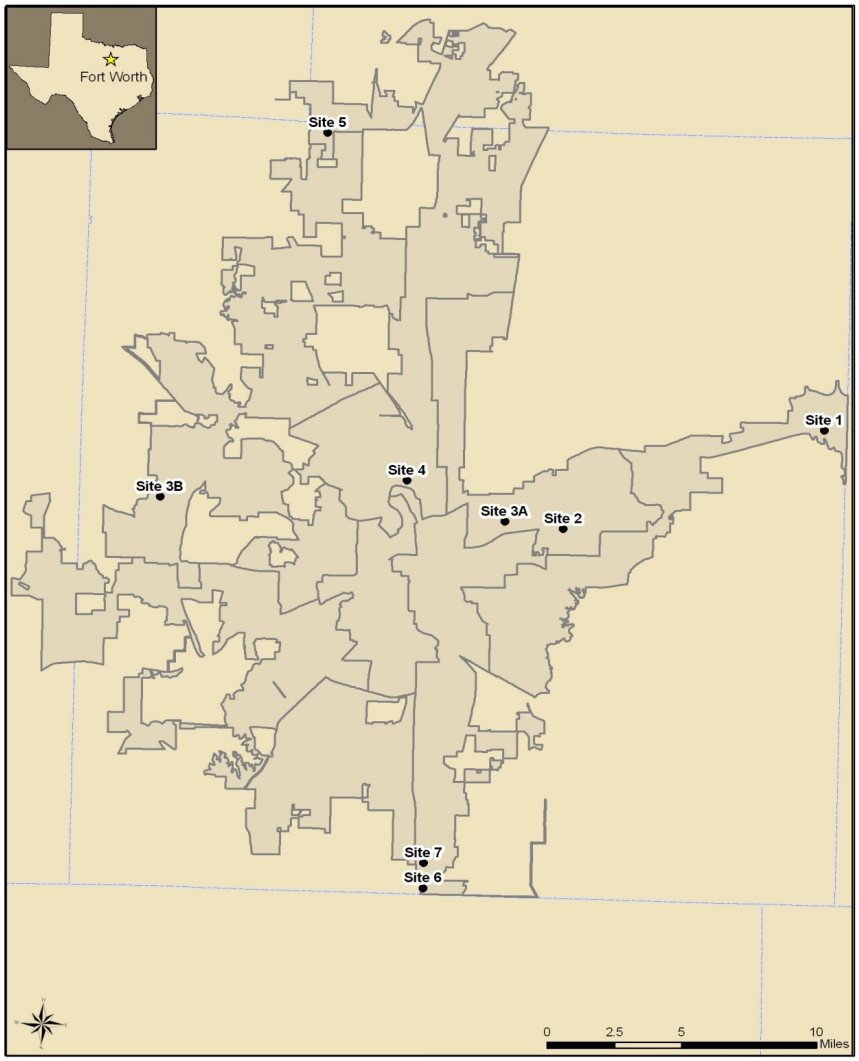
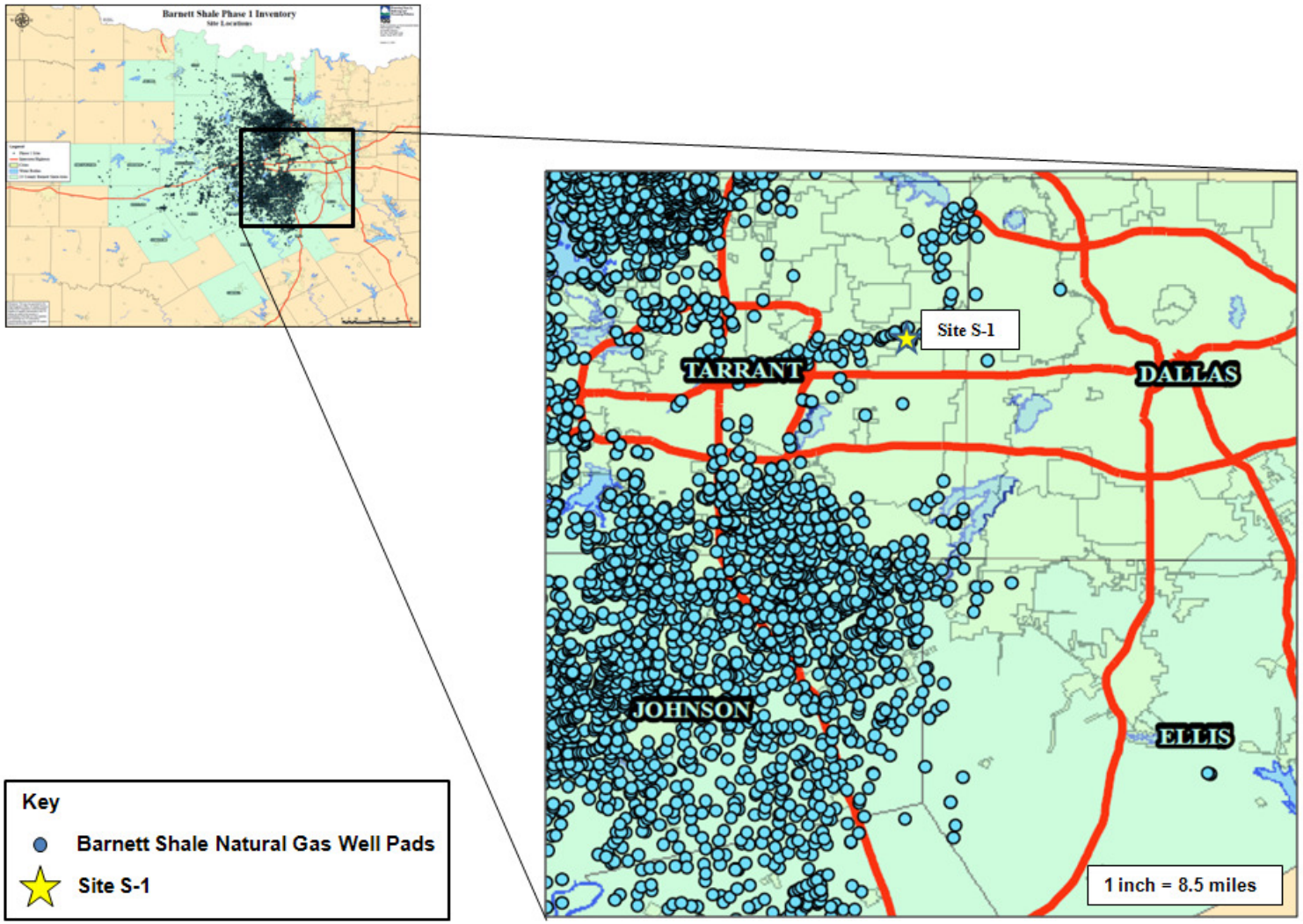


Figure 2.1-1. Ambient Air Monitoring Sites

2.1.1 Site S-1 (Background Site)

Site S-1 is located at Fort Worth Fire Station #33 (Figure 2.1-2), in the easternmost part of the city. Wind at this location predominantly blows from the south and southeast, meaning that there is expected to be minimal influence from natural gas exploration and production activities relative to areas further west (Figure 2.1-3). Therefore, this monitoring site is considered a "background" site, chosen to obtain background information on the air quality within the city of Fort Worth absent any impact from nearby natural gas sources. Speciated organic compounds were characterized at this site using the U.S. Environmental Protection Agency (EPA) Compendium Method TO-15 (see Section 2.3 for a description of EPA Compendium Method TO-15). Twenty samples were obtained from this location using a battery-operated system.

Figure 2.1-2. Aerial Map of Site S-1—Fire Station 33



Source: TCEQ Office of Chief Engineer. Barnett Shale Phase 1 Inventory (http://www.tceq.texas.gov/assets/public/implementation/air/ie/pseiforms/allsites.pdf)

Figure 2.1-3. Overview of Barnett Shale Well Pads Near Site S-1

2.1.2 Site S-2 (Mobile Sources Site)

Site S-2 is located at the city's Environmental Collection Center (Figure 2.1-4), within a half-mile of the intersection of Interstate 820 and Interstate 30. The closest natural gas activity to this site is upwind, approximately 2 miles south of this intersection. Thus, this site was chosen to characterize pollutant concentrations from mobile sources along the two interstates, and to help determine how mobile sources (vehicles) affect ambient air within Fort Worth. Speciated organic compounds were characterized at this site using EPA Compendium Method TO-15. Eighteen samples were obtained from this location using a battery-operated system.

Figure 2.1-4. Aerial Map of Site S-2—Environmental Collection Center

2.1.3 Site S-3 (Pre-Production Site)

Site S-3 was chosen to characterize ambient air quality impacts of "pre-production" activities such as fracturing and flowback operations. The site was moved from one location to another, as described below; speciated organic compounds were characterized at these two locations using EPA Compendium Method TO-15.

Initially, this monitor was located at the Eastside Landfill (Figure 2.1-5), a capped landfill located just off of Interstate 30 to the east of downtown Fort Worth. Depending upon wind direction, this site enabled acquisition of air samples affected by either a fracturing operation (less than a quarter-mile to the south) or the Brentwood Saltwater Disposal Site (0.35 miles to the north). Eight samples were obtained from this location using a battery-operated system. Upon completion of the fracturing job, this site was re-located as described below.

On October 9, 2010, this monitoring site was moved to a Devon Energy lease site west of Fort Worth, approximately 1 mile west of Interstate 820, where fracturing and flowback operations were in process. This was the only site that was not located on city property, but there were no issues of site access from the field technician. Eight samples were obtained from this location using a battery-operated system. The location of this monitor is shown in Figure 2.1-6.

Figure 2.1-5. Aerial Map of Site S-3A—Eastside Landfill

Figure 2.1-6. Aerial Map of Site S-3B—Devon Energy Lease

2.1.4 Site S-4 (High-Level Activity Site, Collocated)

Site S-4, the Brennan Service Center (Figure 2.1-7), was located at a city-owned site north of downtown, less than one-half mile west of Interstate 35. This facility formerly served as a Fire Department Fleet Service Center and currently serves as a residential garbage drop-off station. This site is located within 0.4 miles northwest of one combined well pad and compressor station site, 0.8 miles north of another combined well pad and compressor station site, and 0.2 miles southwest of a well pad site. Concentrations from these natural gas operations, as well as from other sources, were characterized at this site. Speciated organic compounds were characterized at this site using EPA Compendium Method TO-15, and carbonyl compounds (including formaldehyde) were characterized using EPA Compendium Method TO-11A. Twenty volatile organic compound (VOC) and 20 carbonyl samples were obtained from this location using a powered system. This site was also designated as a collocated site, meaning that duplicate VOC and carbonyl samples would be taken at this site periodically. Indicators of sample system data quality are determined using the collocated data.

Figure 2.1-7. Aerial Map of Site S-4—Brennan Service Center

2.1.5 Site S-5 (High-Level Activity Site, Collocated)

Site S-5 was located at Fort Worth Fire Station #34 (Figure 2.1-8), in a residential area in the northern part of Fort Worth. This site's location has a high level of natural gas activity and is within a mile of dozens of natural gas wells upwind of this station. Speciated organic compounds were characterized at this site using EPA Compendium Method TO-15, and carbonyl compounds (including formaldehyde) were characterized using EPA Compendium Method TO-11A. Nineteen VOC and 20 carbonyl samples were obtained from this location using a powered system. This site was also designated as a collocated site.

Figure 2.1-8. Aerial Map of Site S-5—Fire Station 34

2.1.6 Site S-6 (Moderate-Level Activity/Fence line Site)

Site S-6 was located at the Spinks Airport (Figure 2.1-9), in the southern reaches of the city. This site was chosen because the monitor could be placed within 350 feet of an active well pad, making it a useful way to help evaluate the city's setback provisions. Speciated organic compounds were characterized at this site using EPA Compendium Method TO-15, and methane emissions were characterized at this site using EPA Compendium Method TO-14 (see Section 2.3 for a description of EPA Compendium Method TO-14). Nineteen samples were obtained from this location using a battery-operated system.

Figure 2.1-9. Aerial Map of Site S-6—Spinks Airport (South)

2.1.7 Site S-7 (Moderate-Level Activity/Fence line Site)

Site S-7 was also located at the Spinks Airport (Figure 2.1-10) in the southern reaches of the city. This site was also chosen to help evaluate the city's setback provisions, as this monitor was situated within 200 feet of an active well pad. Speciated organic compounds were characterized at this site using EPA Compendium Method TO-15, and methane emissions were characterized at this site using EPA Compendium Method TO-14. Eighteen samples were obtained from this location using a battery-operated system.

Figure 2.1-10. Aerial Map of Site S-7—Spinks Airport (North)

2.2 Sampling Protocol

At each of the eight sites, ambient air samples were collected once every three days. This schedule ensured that samples were collected on both weekdays and weekend days. The schedule provided some insights on how air quality varies by day of the week—an important consideration given that traffic patterns and other emission sources can vary from one day to the next.

The collection and analysis of ambient air monitoring samples for this study was performed in accordance with EPA Compendium Methods TO-15,[1] TO-11A,[2] and TO-14.[3] As described in Section 2.1, each of the eight monitoring sites was chosen for a specific reason. Therefore, the sample collection procedure and analytical method used at each site varied. Table 2.2-1 identifies the original sample collection schedule and type of samples obtained at each site. Additional details on these can be found in the *Ambient Air Monitoring Plan*.

Table 2.2-1. Schedule of Collection Events

Date	Concurrent VOC/SNMOC Collection[a]	Carbonyl Collection[b]	VOC/SNMOC Duplicate Samples[a]	Carbonyl Duplicate Samples[b]	Concurrent VOC/Methane Collection[c]
9/4/10	Sites S-1 through S-5	Sites S-4 and S-5	—	—	Sites S-6 and S-7
9/7/10			—	—	
9/10/10			—	—	
9/13/10			From two sites	From two sites	
9/16/10			—	—	
9/19/10			—	—	
9/22/10			—	—	
9/25/10			From two sites	From two sites	
9/28/10			—	—	
10/1/10			—	—	
10/4/10			—	—	
10/7/10			From two sites	From two sites	
10/10/10			—	—	
10/13/10			—	—	
10/16/10			—	—	
10/19/10			From two sites	From two sites	
10/22/10			—	—	
10/25/10			—	—	
10/28/10			—	—	
10/31/10			From two sites	From two sites	

[a] Volatile organic compound/speciated non-methane organic compound (VOC/SNMOC) samples analyzed using EPA Compendium Method TO-15.
[b] Carbonyl samples analyzed using EPA Compendium Method TO-11A.
[c] VOC/methane samples analyzed using EPA Compendium Method TO-15 (VOCs) and EPA Compendium Method TO-14 (methane).

Sampling at Sites S-1 through S-3, S-6, and S-7 was conducted using vacuum-regulated systems. These systems were battery-operated/passive and used pre-cleaned SUMMA® canisters to collect VOC and methane samples. Sampling at Sites S-4 and S-5 was conducted using two automated, mass-flow control systems. These systems are electrically powered and used pre-cleaned, evacuated SUMMA® canisters to collect VOC samples and 2,4-dinitrophenylhydrazine (DNPH) cartridges to collect carbonyl samples. All seven systems incorporated digital timers to ensure that 24-hour integrated samples were obtained (i.e., 00:01 to 23:50).

In order to obtain an integrated air sample for VOC analysis, air was drawn into a cleaned and pre-evacuated passivated SUMMA® canister through a calibrated flow limiting orifice

assembly that regulated the rate and duration of sampling. After the air sample was collected, the canister valve was closed automatically. The day following the sample collection, project staff visited each site; inspected the sample media for any errors, inconsistencies, or signs of tampering; and completed a chain-of-custody (COC) form for each of the samples. For each sample that was deemed viable for analysis, the sample and the COC form were shipped together to the laboratory for analysis. The information on the COC form included the following:

- Sample ID number
- Sampling equipment identification
- Sampling date
- Sampling start time
- Sampling end time
- Elapsed time
- Initial flowrate
- End flowrate
- Average flowrate
- Sample volume (total liters)
- Comments (field observations and/or anomalies during sampling)
- Name and signature of field operator releasing samples for shipment
- Condition of custody seal upon receipt by laboratory
- Condition of samples upon receipt by laboratory
- Signature of laboratory representative receiving shipment
- Date of sample receipt at laboratory

The samples obtained at Sites S-1 through S-5 were analyzed at Eastern Research Group's (ERG's) laboratory in Morrisville, North Carolina, while the samples obtained at Sites S-6 and S-7 were analyzed at TestAmerica's™ laboratory in Austin, Texas. Appendix 2-A contains the COC forms for Sites S-1 through S-5, Appendix 2-B contains the analytical results for SNMOCs at Sites S-1 through S-5, Appendix 2-C contains the analytical results for EPA Compendium Method TO-15 at Sites S-1 through S-5, Appendix 2-D contains the analytical results for EPA Compendium Method TO-11A at Sites S-4 and S-5, and Appendix 2-E contains the COC forms and analytical results for Sites S-6 and S-7.

Upon receipt, the canister information was recorded and the sample stored until analysis. Storage times of up to 45 days without compound concentration losses have been demonstrated for many of the VOCs (e.g., benzene, toluene, ethylbenzene, and xylenes) found in urban atmospheres. Although the required turnaround time under the method guidelines is 45 days, an actual turnaround time of approximately 30 days from sample receipt to sample analysis was typical.

2.3 Sample Analysis

Air toxics and SNMOC concentration data for each sample was obtained in accordance with the guidelines presented in EPA Compendium Method TO-15.[1] Method TO-15 provides guidance on sampling and analytical procedures for the measurement of a subset of the 97 VOCs that are included in the 1989 HAPs listed in Title III of the Clean Air Act Amendments of 1990.[4] These VOCs are defined as organic compounds having a vapor pressure greater than 10^{-1} Torr at 25°C and 760 millimeter (mm) mercury (Hg), meaning that they are likely to exist in a gaseous phase under standard atmospheric conditions. Method TO-15 is used to analyze air samples for toxic compounds expected to be released from many air pollution sources, including natural gas production related activities.

Target air toxics species, and their corresponding method detection limits (MDLs) are presented in Table 2.3-1. Target SNMOC species and their corresponding MDLs are presented in Table 2.3-2.

Table 2.3-1. EPA Compendium Method TO-15 Target Compounds and Method Detection Limits

Target Compounds	ppbv [a]	Target Compounds	ppbv
1,1,1-Trichloroethane	0.020	Dibromochloromethane	0.011
1,1,2,2-Tetrachloroethane	0.011	Dichlorodifluoromethane	0.012
1,1,2-Trichloroethane	0.018	Dichlorotetrafluoroethane	0.012
1,1-Dichloroethane	0.017	Ethyl Acrylate	0.011
1,1-Dichloroethene	0.013	Ethyl *tert*-Butyl Ether	0.009
1,2,4-Trichlorobenzene	0.018	Ethylbenzene	0.012
1,2,4-Trimethylbenzene	0.011	Hexachloro-1,3-butadiene	0.012
1,2-Dibromoethane	0.012	*m,p*-Xylene	0.014
1,2-Dichloroethane	0.015	*m*-Dichlorobenzene	0.010
1,2-Dichloropropane	0.025	Methanol	0.255
1,3,5-Trimethylbenzene	0.010	Methyl Ethyl Ketone	0.026
1,3-Butadiene	0.010	Methyl Isobutyl Ketone	0.010
1,4-Dioxane	0.140	Methyl Methacrylate	0.021
Acetylene	0.025	Methyl *tert*-Butyl Ether	0.009
Acrylonitrile	0.027	Methylene Chloride	0.023
Allyl Chloride	0.110	*n*-Butanol	0.144
Benzene	0.019	*n*-Octane	0.011
Bromochloromethane	0.018	*o*-Dichlorobenzene	0.012
Bromodichloromethane	0.021	*o*-Xylene	0.010
Bromoform	0.011	*p*-Dichlorobenzene	0.010
Bromomethane	0.013	Propylene	0.028
Carbon Disulfide	0.011	Styrene	0.010
Carbon Tetrachloride	0.024	*tert*-Amyl Methyl Ether	0.013
Chlorobenzene	0.014	Tetrachloroethylene	0.011
Chloroethane	0.012	Toluene	0.013
Chloroform	0.017	*trans*-1,2-Dichloroethylene	0.014
Chloromethane	0.016	*trans*-1,3-Dichloropropene	0.016
Chloromethylbenzene	0.017	Trichloroethylene	0.017

Table 2.3-1. EPA Compendium Method TO-15 Target Compounds and Method Detection Limits (Continued)

Target Compounds	ppbv	Target Compounds	ppbv
Chloroprene	0.014	Trichlorofluoromethane	0.012
cis-1,2-Dichloroethylene	0.036	Trichlorotrifluoroethane	0.014
1,2-Dichloropropane	0.025	Vinyl Acetate	0.208
cis-1,3-Dichloropropene	0.015	Vinyl Chloride	0.013

[a] ppbv = parts per billion by volume

Table 2.3-2. SNMOC Target Compounds and Method Detection Limits

Target Compound	ppbC	ppbv	Target Compound	ppbC	ppbv
Ethylene	0.38	0.19	Cyclohexane	0.19	0.03
Ethane	0.12	0.06	2-Methylhexane	0.11	0.02
Propane	0.20	0.07	2,3-Dimethylpentane	0.37	0.05
Propyne	0.20	0.07	3-Methylhexane	0.15	0.02
Isobutane	0.13	0.03	1-Heptene	0.37	0.05
Isobutene/1-Butene	0.15	0.04	2,2,4-Trimethylpentane	0.17	0.02
n-Butane	0.17	0.04	*n*-Heptane	0.18	0.03
trans-2-Butene	0.14	0.04	Methylcyclohexane	0.19	0.03
cis-2-Butene	0.18	0.04	2,2,3-Trimethylpentane	0.28	0.04
3-Methyl-1-Butene	0.24	0.05	2,3,4-Trimethylpentane	0.14	0.02
Isopentane	0.19	0.04	2-Methylheptane	0.17	0.02
1-Pentene	0.12	0.02	3-Methylheptane	0.11	0.01
2-Methyl-1-Butene	0.24	0.05	1-Octene	0.28	0.04
n-Pentane	0.09	0.02	1-Nonene	0.24	0.03
Isoprene	0.24	0.05	*n*-Nonane	0.18	0.02
trans-2-Pentene	0.14	0.03	Isopropylbenzene	0.21	0.02
cis-2-Pentene	0.19	0.04	*alpha*-Pinene	0.24	0.02
2-Methyl-2-Butene	0.24	0.05	*n*-Propylbenzene	0.20	0.02
2,2-Dimethylbutane	0.20	0.03	*m*-Ethyltolune	0.15	0.02
Cyclopentene	0.24	0.05	*p*-Ethyltoluene	0.24	0.03
4-Methyl-1-Pentene	0.36	0.06	*o*-Ethyltoluene	0.18	0.02
Cyclopentane	0.12	0.02	*beta*-Pinene	0.24	0.02
2,3,-Dimethylbutane	0.20	0.03	1-Decene	0.24	0.02
2-Methylpentane	0.14	0.02	*n*-Decane	0.23	0.02
3-Methylpentane	0.20	0.03	1,2,3-Trimethylbenzene	0.17	0.02
2-Methyl-1-Pentene	0.36	0.06	*m*-Diethylbenzene	0.24	0.02
1-Hexene	0.36	0.06	*p*-Diethylbenzene	0.14	0.01
2-Ethyl-1-butene	0.36	0.06	1-Undecene	0.22	0.02
n-Hexane	0.24	0.04	*n*-Undecane	0.22	0.02
trans-2-Hexene	0.36	0.06	1-Dodecene	0.29	0.02
cis-2-Hexene	0.36	0.06	*n*-Dodecane	0.29	0.02
Methylcyclopentane	0.14	0.02	1-Tridecene	0.29	0.02
2,4-Dimethylpentane	0.23	0.03	*n*-Tridecane	0.29	0.02

The procedure used to analyze the sample under EPA Compendium Method TO-15 involves extracting a known volume of sample gas from the canister through a mass flow controller to a solid multi-sorbent concentrator. After the concentration step is completed, the VOCs are thermally desorbed, entrained in a carrier gas stream, and then focused in a small volume by trapping on a reduced temperature trap or small volume multi-sorbent trap. The sample is then released by thermal desorption and carried onto two gas chromatographic columns housed in a gas chromatograph (GC). This step separates the individual air toxics and SNMOC species. Air toxics are then measured using a mass spectrometer operated in the selected ion monitoring (SIM) mode. SNMOCs are measured concurrently using a flame ionization detector (FID).

Target carbonyl species from Method TO-11A[2] and their corresponding MDLs are presented in Table 2.3-3. Methane concentration data was obtained for Sites S-6 and S-7 using Method TO-14.[3] The MDL for methane from Method TO-14 is presented in Table 2.3-4.

Table 2.3-3. Carbonyl Target Compounds and Method Detection Limits

Compound	ppbv
Formaldehyde	0.004
Acetaldehyde	0.005
Acetone	0.006
Propionaldehyde	0.002
Crotonaldehyde	0.002
Butyr/Isobutyraldehyde	0.002
Benzaldehyde	0.002
Isovaleraldehyde	0.002
Valeraldehyde	0.002
Tolualdehydes	0.003
Hexaldehyde	0.001
2,5-dimethylbenzaldehyde	0.001

Table 2.3-4. Methane Method Detection Limit

Compound	ppmv
Methane	0.154

A detailed, technical description of the analytical procedures and sample handling procedures used for each sample can be found in the *Ambient Air Monitoring Plan* and in the *Ambient Air Monitoring Quality Assurance Project Plan*, which was originally submitted in August 2010 and revised in October 2010.

2.4 Quality Assurance/Quality Control

Throughout the process of ambient air network design, field implementation, sample collection, and sample analysis, QA/QC procedures were employed to ensure that the resultant data was of the highest quality and that the program would meet the Data Quality Objectives (DQOs) that were established at its onset. These procedures and steps are fully documented in the *Ambient Air Monitoring Plan* and the *Ambient Air Monitoring Quality Assurance Project Plan*. A summary of the QA/QC plan and results are provided below, including a discussion of DQOs, data completeness, measurement precision, and measurement accuracy.

The project DQOs answer the critical question of how good data must be in order to achieve the project goals. DQOs are used to develop the criteria that a data collection effort should satisfy, including where to conduct monitoring, how many sites to use, when to conduct

monitoring, what the measurement frequency should be, and acceptable measurement precision and accuracy. DQOs for this air quality study are presented in Table 2.4-1.

Table 2.4-1. Data Quality Objectives

Element	Objective
Where to conduct monitoring	All sites must be located in close proximity to the potentially impacted populations, with the exception of the remote site (Site S-1).
Number of sites required	Eight fixed-location (including two collocated) sampling sites will be used to represent the entire city. Sites will be at city-owned and/or public use areas. They will be recommended by ERG as representative of the potentially impacted area. Final site selection will be accomplished through concurrence of ERG and Fort Worth Transportation and Public Works Department staff.
When to conduct monitoring	Sample collection will be conducted for a two-month duration. Samples will be collected from 00:01 to 23:50 hours (24 hours +/- 1 hour).
Frequency of monitoring	Sample collection episodes will be conducted once every three days. This schedule ensures that sampling is conducted multiple times on all days of the week, across the two-month duration of the program.
Overall completeness	Overall completeness must be 75% data capture at each monitoring site or greater.
Acceptable measurement precision for carbonyls	+/- 30% relative standard deviation (RSD)
Acceptable measurement accuracy for carbonyls	+/- 20% bias
Acceptable measurement precision for VOCs/SNMOCs	+/- 30% RSD
Acceptable measurement accuracy for VOCs	+/- 30% bias

Prior to field deployment, all the measurement systems were certified to ensure that each system provided unbiased results.

2.4.1 Completeness

"Completeness" refers to the number of valid measurements collected compared to the number of scheduled sampling events. Data completeness requirements are included in the reference methods (see QAPP References, Section 21). Monitoring programs that consistently generate valid results have higher completeness than programs that consistently generate invalid samples. The completeness of an air monitoring program, therefore, is a qualitative measure of how effectively the program was managed.

During the two-month study period, the completeness of the monitoring network met or exceeded the DQO of 75% data capture at each site. Overall completeness was 96%. Table 2.4-2

summarizes the data completeness at each monitoring site by measurement system. As shown previously in Table 2.1-2, a total of 20 VOC/SNMOC samples were scheduled for each monitoring site and 20 carbonyl samples were scheduled for Sites S-4 and S-5.

Although the target number of valid samples was not obtained for Sites S-2, S-3, S-5, S-6, or S-7, the actual number of valid samples met or exceeded the DQO, thus providing sufficient data to calculate robust time-period averages. Invalid samples were due to a combination of equipment failure and human error, summarized below:

- On the first sample collection day (September 4), the sample collection program was incorrectly set, resulting in no sample collection at Sites S-2, S-5 (this affected the TO-15 sample only; the TO-11A carbonyl sample was collected successfully), and S-7.
- The sample collection systems at Sites S-6 and S-7 experienced gauge failure on September 7, so no samples were collected at those sites on that day.
- On September 10, the field operator did not fully open the canister valve at Site S-2, and no sample was collected.
- The October 31 sample collected at Site S-3 was never received at the laboratory, so no sample was analyzed for that site for that date.

A suitable location for Site S-3 (which targeted pre-production operations) was not identified until September 14. Therefore, this site only had 16 sample days. Additionally, due to the study duration (two months) and sampling frequency (1-in-3 days), it was not feasible to schedule make-up samples. Table 2.4-2 shows the final number of samples and completion percentage for each site.

Table 2.4-2. DQO: Overall Completeness

Monitoring Site	Measurement System	Number of Samples Collected	Number of Samples Scheduled	Completion Percentage
S-1	VOC/SNMOC	20	20	100%
S-2	VOC/SNMOC	18	20	90%
S-3	VOC/SNMOC	15	16	94%
S-4	VOC/SNMOC	20	20[a]	100%
S-4	Carbonyl	20	20[a]	100%
S-5	VOC/SNMOC	19	20[a]	95%
S-5	Carbonyl	20	20[a]	100%
S-6	VOC/SNMOC	19	20	95%
S-7	VOC/SNMOC	18	20	90%
Total		**169**	**176**	**96%**

[a] Sites S-4 and S-5 had a total target of 40 samples each: 20 VOC samples and 20 carbonyl samples.

2.4.2 Measurement Precision

Measurement precision for this project is defined as the ability to acquire the same concentration from different instruments or samples while they are sampling the same gas stream,

with an acceptable level of uncertainty. It is a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. For this monitoring program, measurement precision for the pollutants was assessed in two ways: system precision (across instrument samplers for collocated samples) and analytical precision (within instrument samplers for collocated and replicated samples).

Measurement precision is expressed as percent relative standard deviation (% RSD), which is calculated as follows:

$$\%RSD = \frac{\sigma}{\overline{X}} \times 100$$

Where:

σ is the standard deviation of the instrument-specific concentration determinations
$\overline{X}$ is the average of all instrument-specific concentration determinations

As summarized in Table 2.4-3, the *system precision* overall RSDs for VOCs, carbonyls, and SNMOCs easily met the DQO of 30% RSD.

Table 2.4-3. DQO: RSD Precision Calculation for Collocated VOC, Carbonyl, and SNMOC Instruments

Method	Number of Collocated Data Sets	RSD Pollutant Ranges (%)	Overall RSD (%)
VOCs	20	2.20–35.85	7.46
Carbonyls	20	6.15–44.43	23.99
SNMOCs	20	0.01–11.31	1.40

Analytical precision of the VOC and SNMOC methods was determined by collecting two sets of duplicate samples at Sites S-4 and S-5 and analyzing them in replicate. As summarized in Table 2.4-4, the analytical precision overall RSDs for VOCs, carbonyls, and SNMOCs easily met the DQO of 30% RSD.

Table 2.4-4. DQO: RSD Precision Calculation for Collocated and Replicate VOC and SNMOC Analyses

Method	Number of Replicate Data Sets	RSD Pollutant Ranges (%)	Overall RSD (%)
VOCs	20	0.01–21.32	4.57
Carbonyls	20	0.36–3.41	1.89
SNMOCs	20	1.07–34.11	9.21

2.4.3 Measurement Accuracy

Measurement accuracy for this project is defined as the ability to acquire the correct concentration data from an instrument or sample analysis with an acceptable level of uncertainty while measuring a reference gas stream of a known concentration. Bias is defined as the systematic or persistent distortion of a measurement process that causes error in one direction. Bias is determined by estimating the positive and negative deviation from the true value as a percentage of the true value.

Accuracy for the VOC and carbonyl analyses was established through audits that EPA prepared and submitted to ERG as a regular function of the EPA National Air Toxics Monitoring Program, which ERG manages and operates for EPA. The most recent audit for VOC HAPs was conducted in March 2010; the most recent audit for carbonyl HAPs was in May 2010. Table 2.4-5 summarizes the audit results for VOC and carbonyl HAPs. As the table shows, the overall percent differences are within 30% for VOC HAPs and 20% for carbonyl HAPs. This meets the DQOs presented in Table 2.4-1.

Table 2.4-5. VOC and Carbonyl HAP Audit Results

Pollutant Group	Method	Proficiency Test Date	Overall % Difference
VOC HAPs	TO-15	March 2010	-1.0
Carbonyl HAPs	TO-11A	May 2010	-11.4

2.5 Ambient Air Monitoring Results

This section presents ambient air concentrations, meteorological data, and spatial/temporal trends for the monitoring sites in this study. It first presents information for all the pollutants measured across the monitoring network, then by monitoring site. Finally, a more detailed analysis of a subset of key pollutants is presented by monitoring site. Nearly 140 different chemicals (including over 40 HAPs) were sampled for and analyzed in this study using EPA-approved sampling and analytical methodologies, as described in Section 2.3 of this report. It is important to note that, due to the configuration and purpose of each monitoring site, not all the same pollutants were sampled at each site. This is described in detail in Section 2.2.

2.5.1 Summary Statistics

This section reviews the monitoring data for the entire network. For each method type, it presents study-wide central tendency and variability statistics of the entire set of ambient air monitoring data collected. In total, over 15,000 data points were generated for this study. Individual measurements are presented in Appendix 2-F.

VOCs

A total of 59 VOCs were sampled, analyzed, and reported for in this study (Table 2.5-1). Eight VOCs had detection rates greater than 90%: benzene (94%), carbon tetrachloride (98%), chloromethane (100%), dichlorodifluoromethane (100%), methyl ethyl ketone (99%), propylene (98%), toluene (99%), and trichlorofluoromethane (100%). Acetone (2.807 ppbv), toluene (0.876 ppbv), and methyl ethyl ketone (0.827 ppbv) were the three VOCs with the highest average detected concentrations.

Table 2.5-1 also presents data distribution statistics, such as the minimum value, the maximum value, and the 25th, 50th, and 75th percentile values for the VOCs. As an indicator of variability of the VOC concentrations across the entire monitoring network, the coefficient of variation (CV) ratio is calculated. The CV ratio is the standard deviation divided by the mean, and is used to compare the relative dispersion in one set of data with the relative dispersion of another set of data. The lower the CV ratio, the less variability in the data measurements. The five VOCs with the lowest CV ratios and a minimum of 70% detects are trichlorofluoromethane (0.09), dichlorodifluoromethane (0.10), trichlorotrifluoroethane (0.10), dichlorotetrafluoroethane (0.13), and carbon tetrachloride (0.14). Conversely, the five VOCs with the highest CV ratios and a minimum of 70% detects are toluene (1.84), carbon disulfide (1.61), dichloromethane (1.39), *m,p*-xylene (1.24), and 1,2,4-trimethylbenzene (1.22).

Carbonyls

A total of 11 carbonyl pollutants were sampled, analyzed, and reported for in this study (Table 2.5-2). As described in Section 2.2, carbonyls were only sampled at Sites S-4 and S-5. Eight carbonyls had detection rates greater than 90%: acetaldehyde (100%), benzaldehyde (95%), butyraldehyde (100%), crotonaldehyde (100%), formaldehyde (100%), hexaldehyde (100%), propionaldehyde (100%), and valeradehyde (93%). Acetaldehyde (2.81 ppbv), formaldehyde (0.931 ppbv), and butyraldehyde (0.110 ppbv) were the three carbonyls with the highest average detected concentrations.

Table 2.5-2 also presents data distribution statistics and CV ratios for the carbonyls. The four carbonyls with the lowest CV ratios and a minimum of 70% detects are crotonaldehyde (0.59), formaldehyde (0.71), acetaldehyde (0.73), and propionaldehyde (0.96). Conversely, the four carbonyls with the highest CV ratios and a minimum of 70% detects are hexaldehyde (1.98), butyraldehyde (1.29), valeraldehyde (1.20), and benzaldehyde (1.11).

Two carbonyls were not detected at either Site S-4 or Site S-5: 2,5-dimethylbenzaldehyde and isovaleraldehyde.

Table 2.5-1. Summary of VOC Measurements Across the Entire Monitoring Network

Pollutant Name	Number of Detects	Average of Detects (ppbv)	Minimum Detected Value (ppbv)	Maximum Detected Value (ppbv)	25th Percentile Concentration (ppbv)	50th Percentile Concentration (ppbv)	75th Percentile Concentration (ppbv)	Coefficient of Variation
Acetone	77	2.807	0.262	8.2	1.23	2.4	4.0	0.64
Acetylene	92	0.716	0.252	3.57	0.445	0.547	0.725	0.74
Acrylonitrile	0	NA[a]						
Allyl Chloride	0	NA[a]						
Amyl Methyl Ether, *tert-*	1	NA[a]						
Benzene	121	0.291	0.0635	1.83	0.154	0.208	0.314	0.96
Bromochloromethane	0	NA[a]						
Bromodichloromethane	3	0.050	0.029	0.075	NA[a]			
Bromoform	0	NA[a]						
Bromomethane	54	0.014	0.01	0.03	0.012	0.014	0.016	0.26
Butadiene, 1,3-	86	0.057	0.01	0.304	0.025	0.039	0.066	0.92
Butanol, *n-*	0	NA[a]						
Carbon Disulfide	92	0.243	0.008	1.64	0.021	0.055	0.179	1.61
Carbon Tetrachloride	126	0.112	0.053	0.142	0.106	0.113	0.121	0.14
Chlorobenzene	1	NA[a]						
Chloroethane	9	0.091	0.015	0.237	0.017	0.086	0.097	0.89
Chloroform	91	0.031	0.014	0.105	0.021	0.026	0.033	0.51
Chloromethane	129	0.618	0.288	0.952	0.586	0.641	0.673	0.20
Chloromethylbenzene	1	NA[a]						
Chloroprene	0	NA[a]						
Dibromochloromethane	6	0.010	0.004	0.017	0.006	0.007	0.014	0.59
Dibromoethane, 1,2-	3	0.099	0.008	0.275	NA[a]			
Dichlorobenzene, *m-*	3	0.210	0.015	0.55	NA[a]			
Dichlorobenzene, *o-*	3	0.187	0.016	0.482	NA[a]			
Dichlorobenzene, *p-*	71	0.058	0.011	0.706	0.0195	0.031	0.0585	1.66

Table 2.5-1. Summary of VOC Measurements Across the Entire Monitoring Network (Continued)

Pollutant Name	Number of Detects	Average of Detects (ppbv)	Minimum Detected Value (ppbv)	Maximum Detected Value (ppbv)	25th Percentile Concentration (ppbv)	50th Percentile Concentration (ppbv)	75th Percentile Concentration (ppbv)	Coefficient of Variation
Dichlorodifluoromethane	129	0.555	0.276	0.667	0.52	0.562	0.596	0.10
Dichloroethane, 1,1-	1	NA[a]						
Dichloroethane, 1,2-	0	NA[a]						
Dichloroethene, 1,1-	2	0.006	0.005	0.007	NA[a]			
Dichloroethylene, *cis*-1,2-	0	NA[a]						
Dichloroethylene, *trans*-1,2-	0	NA[a]						
Dichloromethane (Methylene Chloride)	101	0.168	0.037	2.21	0.086	0.105	0.165	1.39
Dichloropropane, 1,2-	0	NA[a]						
Dichloropropene, *cis*-1,3-	1	NA[a]						
Dichloropropene, *trans*-1,3-	1	NA[a]						
Dichlorotetrafluoroethane	92	0.019	0.008	0.026	0.017	0.018	0.02	0.13
Dioxane, 1.4-	0	NA[a]						
Ethyl Acrylate	0	NA[a]						
Ethyl *tert*-Butyl Ether	1	NA[a]						
Ethylbenzene	94	0.142	0.023	0.935	0.051	0.089	0.173	1.06
Hexachloro-1,3-butadiene	4	0.124	0.008	0.369	NA[a]			
Methanol	37	6.64	3.30	19.40	4.84	5.75	7.69	0.475
Methyl Ethyl Ketone	128	0.827	0.155	8.85	0.405	0.593	0.979	1.15
Methyl Isobutyl Ketone	79	0.079	0.015	0.596	0.034	0.054	0.086	1.12
Methyl Methacrylate	4	0.188	0.031	0.451	NA[a]			
Methyl *tert*-Butyl Ether	0	NA[a]						
Octane, *n*-	94	0.105	0.023	0.844	0.047	0.07105	0.109	1.09
Propylene	127	0.450	0.055	2.38	0.226	0.376	0.547	0.78
Styrene	85	0.074	0.011	0.758	0.025	0.043	0.07	1.52

Table 2.5-1. Summary of VOC Measurements Across the Entire Monitoring Network (Continued)

Pollutant Name	Number of Detects	Average of Detects (ppbv)	Minimum Detected Value (ppbv)	Maximum Detected Value (ppbv)	25th Percentile Concentration (ppbv)	50th Percentile Concentration (ppbv)	75th Percentile Concentration (ppbv)	Coefficient of Variation
Tetrachloroethane, 1,1,2,2-	0	NA[a]						
Tetrachloroethylene	81	0.043	0.01	0.218	0.018	0.03	0.054	0.85
Toluene	128	0.876	0.079	12.6	0.251	0.393	0.828	1.84
Trichlorobenzene, 1,2,4-	8	0.176	0.014	0.842	0.029	0.0335	0.215	1.61
Trichloroethane, 1,1,1-	43	0.030	0.009	0.46	0.012	0.015	0.0215	2.32
Trichloroethane, 1,1,2-	1	NA[a]						
Trichloroethylene	13	0.029	0.008	0.093	0.013	0.014	0.026	0.96
Trichlorofluoromethane	129	0.269	0.128	0.334	0.259	0.273	0.284	0.09
Trichlorotrifluoroethane	103	0.089	0.042	0.107	0.087	0.090	0.093	0.10
Trimethylbenzene, 1,2,4-	94	0.084	0.010	0.732	0.033	0.047	0.097	1.22
Trimethylbenzene, 1,3,5-	90	0.054	0.009	0.584	0.0202	0.027	0.054	1.41
Vinyl Acetate	17	0.248	0.119	0.359	0.206	0.260	0.280	0.272
Vinyl chloride	3	0.031	0.008	0.052	NA[a]			
Xylene, *m,p-*	96	0.406	0.051	3.12	0.121	0.229	0.514	1.24
Xylene, *o-*	94	0.141	0.021	0.94	0.049	0.084	0.179	1.11

NA = not available

[a] Summary statistics were only calculated for pollutants detected in at least six samples.

Table 2.5-2. Summary of Carbonyl Measurements Across the Entire Monitoring Network

Pollutant Name	Number of Detects	Average of Detects (ppbv)	Minimum Detected Value (ppbv)	Maximum Detected Value (ppbv)	25th Percentile Concentration (ppbv)	50th Percentile Concentration (ppbv)	75th Percentile Concentration (ppbv)	Coefficient of Variation
Acetaldehyde	40	2.813	0.83	9.06	1.518	2.050	3.085	0.73
Benzaldehyde	38	0.018	0.01	0.11	0.009	0.011	0.017	1.11
Butyraldehyde	40	0.110	0.02	0.66	0.032	0.049	0.119	1.29
Crotonaldehyde	40	0.061	0.02	0.19	0.037	0.052	0.072	0.59
Dimethylbenzaldehyde, 2,5-	0	NA[a]						
Formaldehyde	40	0.931	0.41	4.45	0.598	0.847	0.981	0.71
Hexaldehyde	40	0.067	0.01	0.55	0.015	0.019	0.024	1.98
Isovaleraldehyde	0	NA[a]						
Propionaldehyde	40	0.088	0.02	0.38	0.023	0.0675	0.119	0.96
Tolualdehydes	10	0.016	0.01	0.05	0.009	0.012	0.017	0.82
Valeraldehyde	37	0.025	0.01	0.14	0.009	0.012	0.019	1.20

NA = not available

[a] Summary statistics were only calculated for pollutants detected in at least six samples.

Methane and Speciated Non-Methane Organics

Methane was detected in each sample taken (100%)—37 samples at Sites S-6 and S-7 (Table 2.5-3). Methane had the highest concentrations of the study analytes (average of detects = 5,686 ppbv). Methane is not a HAP, and the overall CV ratio was 0.24.

A total of 67 SNMOCs were sampled, analyzed, and reported for in this study (Table 2.5-3). Seven speciated organics had detection rates greater than 90%: *n*-butane (93%), ethane (100%), ethylene (99%), isobutane (97%), isobutene/1-butene (97%), *n*-pentane (98%), and propane (100%). Ethane (16.028 ppbv), propane (5.325 ppbv), and isopentane (4.028 ppbv) were the three SNMOCs with the highest average detected concentrations.

Data distribution statistics and CV ratios for methane and the SNMOCs are also presented in Table 2.5-3. The five SNMOCs with the lowest CV ratios and a minimum of 70% detects are 1-hexene (0.48), isoprene (0.63), ethylene (0.69), 3-methylehexane (0.77), and 2-methylheptane (0.85). Conversely, the five VOCs with the highest CV ratios and a minimum of 70% detects are *n*-decane (1.92), *n*-nonane (1.90), isopentane (1.84), *trans*-2-butene (1.83), and *n*-Pentane (1.80).

All SNMOCs were detected at least once during the study period.

2.5.2 Study Period Averaging

This section presents information on the average pollutant concentrations, at each monitoring site, for the study period. Non-detect observations were replaced with zeroes when calculating these averages. This section focuses only on pollutants that were detected in at least 70% of the samples, because average concentrations for these pollutants have the least influence from non-detect observations. Thus, study period averages for pollutants that had more than 30% of their samples as non-detects were not calculated. This averaging technique is consistent with the study period averaging EPA uses in its Schools Air Toxics Monitoring Program (SATMP)[5] and National-Scale Air Toxics Assessment (NATA) model-to-monitor comparison.[6] In addition to the study period average, this section presents the confidence intervals for the study period average concentrations. The confidence interval is calculated using Student's *T*-test at the 95th percentile confidence level.

Table 2.5-3. Summary of Methane and Speciated Non-Methane Organic Compounds Across the Entire Monitoring Network

Pollutant Name	Number of Detects	Average of Detects (ppbv)	Minimum Detected Value (ppbv)	Maximum Detected Value (ppbv)	25th Percentile Concentration (ppbv)	50th Percentile Concentration (ppbv)	75th Percentile Concentration (ppbv)	Coefficient of Variation
Methane	37	5686.486	4180	9890	4670	5570	5720	0.24
Speciated Non-Methane Organic Compounds								
Butane, *n*-	120	3.549	0.149	35.750	0.602	1.566	3.369	1.72
Butene, *cis*-2-	89	0.157	0.020	3.425	0.040	0.052	0.088	2.52
Butene, *trans-2*-	93	0.132	0.018	1.243	0.032	0.042	0.079	1.83
Cyclohexane	97	0.128	0.031	0.708	0.050	0.077	0.141	1.03
Cyclopentane	92	0.171	0.041	1.200	0.054	0.071	0.140	1.46
Cyclopentene	2	0.040	0.030	0.049	NA[a]			
Decane, *n*-	93	0.102	0.012	1.440	0.025	0.037	0.071	1.92
Decene, 1-	3	0.024	0.020	0.031	NA[a]			
Diethylbenzene, *m*-	17	0.020	0.009	0.082	0.011	0.017	0.020	0.85
Diethylbenzene, *p*-	40	0.028	0.009	0.102	0.015	0.022	0.032	0.76
Dimethylbutane, 2,2-	92	0.132	0.031	0.805	0.058	0.079	0.140	1.09
Dimethylbutane, 2,3-	92	0.306	0.040	2.517	0.070	0.098	0.230	1.65
Dimethylpentane, 2,3-	92	0.169	0.041	0.729	0.087	0.122	0.190	0.80
Dimethylpentane, 2,4-	92	0.114	0.020	0.821	0.033	0.045	0.114	1.42
Dodecane, *n*-	90	0.038	0.006	0.327	0.018	0.029	0.038	1.22
Dodecene, 1-	57	0.023	0.006	0.225	0.011	0.016	0.024	1.31
Ethane	129	16.028	2.08	93.2	5.2	9.45	20.7	1.00
Ethyl-1-butene, 2-	9	0.284	0.049	0.870	0.074	0.250	0.395	0.95
Ethylene	128	1.118	0.275	5.400	0.671	0.985	1.270	0.69
Ethyltoluene, *m*-	91	0.054	0.010	0.301	0.026	0.036	0.068	0.92
Ethyltoluene, *o*-	76	0.044	0.012	0.386	0.019	0.027	0.045	1.18
Ethyltoluene, *p*-	90	0.042	0.010	0.340	0.020	0.026	0.043	1.10

Table 2.5-3. Summary of Methane and Speciated Non-Methane Organic Compounds Across the Entire Monitoring Network (Continued)

Pollutant Name	Number of Detects	Average of Detects (ppbv)	Minimum Detected Value (ppbv)	Maximum Detected Value (ppbv)	25th Percentile Concentration (ppbv)	50th Percentile Concentration (ppbv)	75th Percentile Concentration (ppbv)	Coefficient of Variation
Heptane, *n*-	101	0.149	0.038	0.864	0.061	0.092	0.174	0.97
Heptene, 1-	20	0.075	0.016	0.769	0.026	0.028	0.032	2.23
Hexane, *n*-	105	0.445	0.070	3.483	0.131	0.220	0.393	1.46
Hexene, 1-	92	0.049	0.010	0.147	0.033	0.045	0.056	0.48
Hexene, *cis*-2-	26	0.042	0.014	0.262	0.022	0.029	0.035	1.18
Hexene, *trans*-2-	29	0.097	0.013	0.353	0.024	0.042	0.119	1.06
Isobutane	125	1.216	0.150	9.475	0.355	0.648	1.210	1.37
Isobutene/1-butene	125	0.291	0.057	2.285	0.131	0.191	0.281	1.11
Isopentane	92	4.028	0.314	36.400	0.672	1.048	2.925	1.84
Isoprene	92	0.167	0.032	0.498	0.083	0.144	0.228	0.63
Isopropylbenzene	66	0.016	0.008	0.050	0.012	0.015	0.018	0.42
Methyl-1-butene, 2-	72	0.186	0.018	1.656	0.029	0.049	0.117	1.81
Methyl-1-butene, 3-	1	NA[a]						
Methyl-1-pentene, 2-	25	0.077	0.015	0.258	0.022	0.046	0.109	0.95
Methyl-1-pentene, 4-	31	0.051	0.020	0.131	0.035	0.042	0.055	0.49
Methyl-2-butene, 2-	64	0.371	0.015	2.820	0.030	0.077	0.285	1.81
Methylcyclohexane	92	0.170	0.035	0.817	0.073	0.109	0.193	0.89
Methylcyclopentane	92	0.217	0.025	1.389	0.080	0.111	0.212	1.28
Methylheptane, 2-	92	0.065	0.016	0.295	0.032	0.043	0.070	0.85
Methylheptane, 3-	92	0.050	0.012	0.243	0.025	0.033	0.053	0.86
Methylhexane, 2-	92	0.204	0.034	1.786	0.076	0.104	0.183	1.31
Methylhexane, 3-	92	0.288	0.046	1.236	0.156	0.201	0.350	0.77
Methylpentane, 2-	87	0.979	0.091	6.450	0.298	0.460	0.962	1.35
Methylpentane, 3-	92	0.488	0.069	3.767	0.126	0.192	0.388	1.53

Table 2.5-3. Summary of Methane and Speciated Non-Methane Organic Compounds Across the Entire Monitoring Network (Continued)

Pollutant Name	Number of Detects	Average of Detects (ppbv)	Minimum Detected Value (ppbv)	Maximum Detected Value (ppbv)	25th Percentile Concentration (ppbv)	50th Percentile Concentration (ppbv)	75th Percentile Concentration (ppbv)	Coefficient of Variation
Nonane, *n*-	93	0.083	0.015	1.278	0.026	0.034	0.061	1.90
Nonene, 1-	41	0.037	0.009	0.247	0.017	0.021	0.049	1.10
Octene, 1-	52	0.024	0.011	0.055	0.017	0.022	0.027	0.41
Pentane, *n*-	127	1.532	0.131	15.680	0.368	0.620	1.220	1.80
Pentene, 1-	92	0.118	0.024	0.884	0.043	0.054	0.086	1.45
Pentene, *cis*-2-	87	0.123	0.019	1.070	0.028	0.038	0.073	1.76
Pentene, *trans*-2-	89	0.231	0.018	2.100	0.033	0.056	0.136	1.88
Pinene, *alpha*-	80	0.052	0.008	0.423	0.021	0.033	0.064	1.08
Pinene, *beta*-	34	0.040	0.011	0.211	0.015	0.027	0.046	0.99
Propane	129	5.325	0.423	34.667	1.857	2.833	6.333	1.13
Propylbenzene, *n*-	86	0.030	0.009	0.216	0.015	0.020	0.034	0.96
Propyne	1	NA[a]						
Tridecane, *n*-	7	0.017	0.005	0.056	0.008	0.012	0.014	1.06
Tridecene, 1-	5	0.022	0.007	0.068	NA[a]			
Trimethylbenzene, 1,2,3-	71	0.037	0.008	0.280	0.013	0.019	0.034	1.33
Trimethylpentane, 2,2,3-	85	0.078	0.012	0.563	0.025	0.036	0.085	1.24
Trimethylpentane, 2,2,4-	114	0.374	0.029	3.100	0.098	0.168	0.420	1.43
Trimethylpentane, 2,3,4-	92	0.109	0.011	0.785	0.036	0.059	0.121	1.24
Undecane, *n*-	92	0.068	0.009	0.689	0.027	0.038	0.061	1.53
Undecene, 1-	9	0.046	0.007	0.245	0.010	0.017	0.045	1.65

NA = not available

[a] Summary statistics were only calculated for pollutants detected in at least six samples.

The following observations were made:

> ***Key Point: Pollutant Concentrations***
> Concentrations measured at Site S-4 were generally higher than at other sites. Concentrations measured at Sites S-6 and S-7 were generally lower relative to other sites.

- *Site S-1 (background site):* A total of 71 out of 124 pollutants had at least 70% detects to compute study period averages (Table 2.5-4). The five pollutants with the highest average concentrations were ethane (6.474 ± 3.041 ppbv), propane (3.498 ± 1.207 ppbv), *n*-butane (2.262 ± 1.500 ppbv), isopentane (1.929 ± 1.172 ppbv), and isobutane (1.324 ± 0.727 ppbv). Site S-1 was located in an area with no natural gas wells typically upwind.
- *Site S-2 (mobile sources site):* A total of 73 out of 124 pollutants had at least 70% detects to compute study period averages (Table 2.5-5). The five pollutants with the highest average concentrations were ethane (10.437 ± 4.571 ppbv), propane (4.812 ± 3.222 ppbv), *n*-butane (2.729 ± 1.574 ppbv), toluene (2.311 ± 1.803 ppbv), and isopentane (1.680 ± 0.615 ppbv). Site S-2 was located in an area next to major roadways.
- *Site S-3A (pre-production activity site):* Note that this site conducted only nine samples over a three-week time frame. Thus, the average concentrations presented for this site may not be representative of the study period. Nevertheless, a total of 69 out of 124 pollutants had at least 70% detects to compute three-week averages (Table 2.5-6). The five pollutants with the highest average concentrations were ethane (16.133 ± 10.964 ppbv), propane (4.456 ± 3.073 ppbv), *n*-butane (1.408 ± 1.245 ppbv), ethylene (1.364 ± 0.528 ppbv), and isopentane (1.217 ± 0.627 ppbv). Site S-3A was located in an area downwind of fracturing fluid flowback operations.
- *Site S-3B (pre-production activity site):* When pre-production operations were completed at Site S-3A, this monitoring site was moved to an area where additional pre-production activities were occurring. Thus, this site conducted only six samples over a two-week time frame, and the average concentrations presented for this site may not be representative of the study period. Nevertheless, a total of 63 out of 124 pollutants had at least 70% detects to compute two-week averages (Table 2.5-7). The five pollutants with the highest average concentrations were ethane (22.592 ± 11.170 ppbv), propane (8.844 ± 4.215 ppbv), *n*-butane (3.195 ± 1.526 ppbv), isobutane (1.588 ± 0.769 ppbv), and isopentane (1.087 ± 0.444 ppbv). Site S-3B was located in an area downwind of hydraulic fracturing activities.
- *Site S-4 (high-level activity site):* A total of 82 out of 136 pollutants had at least 70% detects to compute study period averages (Table 2.5-8). The five pollutants with the highest average concentrations were ethane (18.229 ± 8.241 ppbv), isopentane (12.985 ± 5.511 ppbv), *n*-butane (10.993 ± 5.385 ppbv), propane (10.683 ± 4.918 ppbv), and *n*-pentane (5.491 ± 2.336 ppbv). Site S-4 was located in an area with high levels of well pad and compressor station activity.
- *Site S-5 (high-level activity site):* A total of 75 out of 136 pollutants had at least 70% detects to compute study period averages (Table 2.5-9). The five pollutants with the highest average concentrations were ethane (14.077 ± 4.074 ppbv), propane (5.049 ± 1.773 ppbv), *n*-butane (2.072 ± 1.109 ppbv), acetaldehyde (1.824 ± 0.408 ppbv), and

isopentane (1.297 ± 1.262 ppbv). Site S-5 was located in an area with high levels of well pad activity.

- *Site S-6 (medium-level activity site):* A total of 15 out of 137 pollutants had at least 70% detects to compute study period averages (Table 2.5-10). The five pollutants with the highest average concentrations were methane (5,758 ± 796 ppbv), ethane (21.412 ± 9.997 ppbv), propane (2.982 ± 1.154 ppbv), *n*-butane (1.015 ± 0.432 ppbv), and ethylene (0.632 ± 0.155 ppbv). Site S-6 was located in an area with moderate levels of well pad activity, including within 350 feet downwind of a well pad.
- *Site S-7 (medium-level activity site):* A total of 15 out of 137 pollutants had at least 70% detects to compute study period averages (Table 2.5-11). The five pollutants with the highest average concentrations were methane (5,672 ± 650 ppbv), ethane (23.979 ± 11.236 ppbv), propane (3.967 ± 1.854 ppbv), *n*-butane (1.230 ± 0.604 ppbv), and ethylene (0.690 ± 0.173 ppbv). Site S-7 was located in an area with moderate levels of well pad activity, including within 200 feet downwind of a well pad.

Table 2.5-4. Site S-1 Pollutant Study Averages

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Acetylene	20	0	0.665	0.177
Benzene	20	0	0.245	0.059
Butadiene, 1,3-	18	2	0.041	0.019
Butane, *n*-	18	2	2.262	1.500
Butene, *cis*-2-	20	0	0.080	0.041
Butene, *trans*-2-	20	0	0.077	0.045
Carbon Disulfide	20	0	0.043	0.026
Carbon Tetrachloride	20	0	0.118	0.006
Chloroform	20	0	0.041	0.011
Chloromethane	20	0	0.661	0.023
Cyclohexane	20	0	0.073	0.024
Cyclopentane	20	0	0.090	0.036
Decane, *n*-	20	0	0.044	0.011
Dichlorobenzene, *p*-	17	3	0.039	0.014
Dichlorodifluoromethane	20	0	0.577	0.020
Dichloromethane	20	0	0.161	0.048
Dichlorotetrafluoroethane	20	0	0.018	0.001
Dimethylbutane, 2,2-	20	0	0.085	0.023
Dimethylbutane, 2,3-	20	0	0.137	0.060
Dimethylpentane, 2,3-	20	0	0.112	0.020
Dimethylpentane, 2,4-	20	0	0.055	0.020
Dodecane, *n*-	20	0	0.035	0.014
Dodecene, 1-	15	5	0.014	0.007

Table 2.5-4. Site S-1 Pollutant Study Averages (Continued)

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Ethane	20	0	6.475	3.041
Ethylbenzene	20	0	0.082	0.023
Ethylene	20	0	1.181	0.271
Ethyltoluene, *m*-	20	0	0.035	0.009
Ethyltoluene, *o*-	16	4	0.024	0.009
Ethyltoluene, *p*-	20	0	0.025	0.005
Heptane, *n*-	20	0	0.086	0.028
Hexane, *n*-	20	0	0.204	0.084
Hexene, 1-	20	0	0.041	0.006
Isobutane	20	0	1.324	0.727
Isobutene/1-Butene	20	0	0.294	0.119
Isopentane	20	0	1.929	1.172
Isoprene	20	0	0.266	0.062
Methyl Ethyl Ketone	20	0	0.817	0.157
Methyl Isobutyl Ketone	18	2	0.046	0.013
Methyl-1-butene, 2-	16	4	0.064	0.047
Methylcyclohexane	20	0	0.106	0.031
Methylcyclopentane	20	0	0.121	0.042
Methylheptane, 2-	20	0	0.037	0.009
Methylheptane, 3-	20	0	0.028	0.007
Methylhexane, 2-	20	0	0.099	0.030
Methylhexane, 3-	20	0	0.202	0.050
Methylpentane, 2-	18	2	0.462	0.204
Methylpentane, 3-	20	0	0.220	0.091
Nonane, *n*-	20	0	0.032	0.008
Pentane, *n*-	20	0	0.939	0.454
Pentene, 1-	20	0	0.075	0.030
Pentene, *cis*-2-	19	1	0.050	0.027
Pentene, *trans*-2-	18	2	0.086	0.057
Pinene, *alpha*-	17	3	0.050	0.019
Propane	20	0	3.498	1.207
Propylbenzene, *n*-	19	1	0.018	0.004
Propylene	20	0	0.478	0.120
Styrene	19	1	0.170	0.095
Tetrachloroethylene	17	3	0.038	0.014
Toluene	20	0	0.544	0.202

Table 2.5-4. Site S-1 Pollutant Study Averages (Continued)

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Trichlorofluoromethane	20	0	0.283	0.011
Trichlorotrifluoroethane	20	0	0.091	0.002
Trimethylbenzene, 1,2,3-	14	6	0.016	0.008
Trimethylbenzene, 1,2,4-	20	0	0.077	0.024
Trimethylbenzene, 1,3,5-	20	0	0.029	0.008
Trimethylpentane, 2,2,3-	17	3	0.035	0.016
Trimethylpentane, 2,2,4-	20	0	0.198	0.086
Trimethylpentane, 2,3,4-	20	0	0.062	0.023
Undecane, *n*-	20	0	0.045	0.018
Xylene, *m,p*-	20	0	0.185	0.063
Xylene, *o*-	20	0	0.073	0.024

Table 2.5-5. Site S-2 Pollutant Study Averages

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Acetylene	18	0	0.707	0.156
Benzene	18	0	0.300	0.043
Butadiene, 1,3-	18	0	0.057	0.017
Butane, *n*-	17	1	2.729	1.574
Butene, *cis*-2-	17	1	0.056	0.011
Butene, *trans*-2-	18	0	0.050	0.009
Carbon Disulfide	18	0	0.034	0.018
Carbon Tetrachloride	18	0	0.117	0.005
Chloroform	18	0	0.025	0.004
Chloromethane	18	0	0.666	0.025
Cyclohexane	18	0	0.095	0.030
Cyclopentane	18	0	0.096	0.027
Decane, *n*-	18	0	0.257	0.174
Dichlorobenzene, *p*-	15	3	0.051	0.047
Dichlorodifluoromethane	18	0	0.584	0.026
Dichloromethane	18	0	0.370	0.244
Dichlorotetrafluoroethane	18	0	0.018	0.001
Dimethylbutane, 2,2-	18	0	0.098	0.021
Dimethylbutane, 2,3-	18	0	0.185	0.069
Dimethylpentane, 2,3-	18	0	0.156	0.037
Dimethylpentane, 2,4-	18	0	0.079	0.026
Dodecane, *n*-	18	0	0.037	0.012
Ethane	18	0	10.437	4.571
Ethylbenzene	18	0	0.239	0.127
Ethylene	18	0	1.379	0.259
Ethyltoluene, *m*-	18	0	0.079	0.034
Ethyltoluene, *o*-	18	0	0.083	0.045
Ethyltoluene, *p*-	18	0	0.069	0.038
Heptane, *n*-	18	0	0.152	0.060
Hexane, *n*-	18	0	0.333	0.140
Hexene, 1-	18	0	0.043	0.009
Isobutane	18	0	0.827	0.320
Isobutene/1-Butene	18	0	0.271	0.049
Isopentane	18	0	1.680	0.615
Isoprene	18	0	0.183	0.044
Methyl Ethyl Ketone	18	0	0.986	0.298
Methyl Isobutyl Ketone	17	1	0.123	0.073

Table 2.5-5. Site S-2 Pollutant Study Averages (Continued)

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Methyl-1-butene, 2-	18	0	0.070	0.024
Methyl-2-butene, 2-	18	0	0.095	0.051
Methylcyclohexane	18	0	0.191	0.080
Methylcyclopentane	18	0	0.152	0.048
Methylheptane, 2-	18	0	0.077	0.031
Methylheptane, 3-	18	0	0.062	0.024
Methylhexane, 2-	18	0	0.173	0.059
Methylhexane, 3-	18	0	0.269	0.070
Methylpentane, 2-	18	0	0.666	0.198
Methylpentane, 3-	18	0	0.321	0.119
Nonane, *n*-	18	0	0.212	0.153
Nonene, 1-	13	5	0.041	0.029
Octane, *n*-	18	0	0.187	0.105
Pentane, *n*-	18	0	0.923	0.297
Pentene, 1-	18	0	0.068	0.012
Pentene, *cis*-2-	18	0	0.055	0.018
Pentene, *trans*-2-	18	0	0.104	0.039
Pinene, *alpha*-	16	2	0.027	0.011
Propane	18	0	4.812	3.222
Propylbenzene, *n*-	18	0	0.047	0.025
Propylene	18	0	0.552	0.116
Styrene	16	2	0.044	0.017
Tetrachloroethylene	18	0	0.061	0.029
Toluene	18	0	2.311	1.803
Trichloroethane, 1,1,1-	13	5	0.050	0.053
Trichlorofluoromethane	18	0	0.281	0.011
Trichlorotrifluoroethane	18	0	0.091	0.003
Trimethylbenzene, 1,2,3-	15	3	0.044	0.033
Trimethylbenzene, 1,2,4-	18	0	0.210	0.116
Trimethylbenzene, 1,3,5-	18	0	0.077	0.042
Trimethylpentane, 2,2,3-	18	0	0.070	0.024
Trimethylpentane, 2,2,4-	18	0	0.345	0.120
Trimethylpentane, 2,3,4-	18	0	0.098	0.026
Undecane, *n*-	18	0	0.125	0.074
Xylene, *m,p*-	18	0	0.728	0.432
Xylene, *o*-	18	0	0.233	0.124

Table 2.5-6. Site S-3A Pollutant Study Averages

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Acetylene	9	0	0.735	0.399
Benzene	9	0	0.301	0.128
Butadiene, 1,3-	8	1	0.049	0.033
Butane, *n*-	7	2	1.408	1.245
Butene, *cis*-2-	8	1	0.046	0.021
Butene, *trans*-2-	9	0	0.139	0.221
Carbon Disulfide	9	0	0.050	0.053
Carbon Tetrachloride	9	0	0.118	0.007
Chloroform	9	0	0.029	0.006
Chloromethane	9	0	0.628	0.040
Cyclohexane	9	0	0.081	0.039
Cyclopentane	9	0	0.069	0.024
Decane, *n*-	9	0	0.034	0.013
Dichlorobenzene, *p*-	9	0	0.030	0.013
Dichlorodifluoromethane	9	0	0.570	0.017
Dichloromethane	9	0	0.169	0.034
Dichlorotetrafluoroethane	9	0	0.017	0.000
Dimethylbutane, 2,2-	9	0	0.070	0.025
Dimethylbutane, 2,3-	9	0	0.121	0.056
Dimethylpentane, 2,3-	9	0	0.122	0.028
Dimethylpentane, 2,4-	9	0	0.055	0.023
Dodecane, *n*-	9	0	0.031	0.008
Ethane	9	0	16.133	10.964
Ethylbenzene	9	0	0.090	0.035
Ethylene	9	0	1.364	0.528
Ethyltoluene, *m*-	9	0	0.044	0.017
Ethyltoluene, *o*-	8	1	0.029	0.012
Ethyltoluene, *p*-	9	0	0.025	0.009
Heptane, *n*-	9	0	0.098	0.053
Hexane, *n*-	9	0	0.241	0.139
Hexene, 1-	9	0	0.046	0.011
Isobutane	9	0	0.820	0.553
Isobutene/1-Butene	9	0	0.236	0.088
Isopentane	9	0	1.217	0.628
Isoprene	9	0	0.149	0.048
Methyl Ethyl Ketone	9	0	0.637	0.182

Table 2.5-6. Site S-3A Pollutant Study Averages (Continued)

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Methyl Isobutyl Ketone	9	0	0.043	0.011
Methyl-1-butene, 2-	8	1	0.041	0.024
Methylcyclohexane	9	0	0.113	0.051
Methylcyclopentane	9	0	0.116	0.042
Methylheptane, 2-	9	0	0.044	0.019
Methylheptane, 3-	9	0	0.035	0.014
Methylhexane, 2-	9	0	0.119	0.054
Methylhexane, 3-	9	0	0.208	0.062
Methylpentane, 2-	8	1	0.497	0.281
Methylpentane, 3-	9	0	0.214	0.107
Nonane, *n*-	9	0	0.030	0.011
Octane, *n*-	9	0	0.065	0.025
Pentane, *n*-	9	0	0.749	0.412
Pentene, 1-	9	0	0.057	0.017
Pentene, *cis*-2-	9	0	0.037	0.014
Pentene, *trans*-2-	9	0	0.067	0.028
Pinene, *alpha*-	9	0	0.114	0.098
Propane	9	0	4.456	3.074
Propylbenzene, *n*-	9	0	0.018	0.006
Propylene	9	0	0.525	0.221
Styrene	9	0	0.042	0.019
Tetrachloroethylene	7	2	0.025	0.014
Toluene	9	0	0.573	0.304
Trichlorofluoromethane	9	0	0.273	0.009
Trichlorotrifluoroethane	9	0	0.089	0.002
Trimethylbenzene, 1,2,4-	9	0	0.080	0.039
Trimethylbenzene, 1,3,5-	9	0	0.030	0.013
Trimethylpentane, 2,2,3-	9	0	0.044	0.022
Trimethylpentane, 2,2,4-	9	0	0.221	0.120
Trimethylpentane, 2,3,4-	9	0	0.071	0.036
Undecane, *n*-	9	0	0.035	0.010
Xylene, *m,p*-	9	0	0.213	0.103
Xylene, *o*-	9	0	0.081	0.038

Table 2.5-7. Site S-3B Pollutant Study Averages

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Acetylene	6	0	0.335	0.058
Benzene	6	0	0.165	0.028
Butane, *n*-	6	0	3.195	1.526
Butene, *cis*-2-	5	1	0.594	1.386
Butene, *trans*-2-	5	1	0.021	0.012
Carbon Disulfide	6	0	0.013	0.004
Carbon Tetrachloride	6	0	0.115	0.008
Chloroform	6	0	0.017	0.002
Chloromethane	6	0	0.641	0.039
Cyclohexane	6	0	0.106	0.034
Cyclopentane	6	0	0.063	0.015
Decane, *n*-	6	0	0.037	0.013
Dichlorodifluoromethane	6	0	0.598	0.031
Dichloromethane	6	0	0.086	0.020
Dichlorotetrafluoroethane	6	0	0.019	0.001
Dimethylbutane, 2,2-	6	0	0.073	0.017
Dimethylbutane, 2,3-	6	0	0.071	0.018
Dimethylpentane, 2,3-	6	0	0.081	0.013
Dimethylpentane, 2,4-	6	0	0.033	0.008
Dodecane, *n*-	5	1	0.017	0.014
Ethane	6	0	22.592	11.170
Ethylbenzene	6	0	0.039	0.008
Ethylene	6	0	0.723	0.329
Ethyltoluene, *m*-	6	0	0.019	0.007
Ethyltoluene, *o*-	5	1	0.021	0.012
Ethyltoluene, *p*-	6	0	0.020	0.006
Heptane, *n*-	6	0	0.143	0.054
Heptene, 1-	5	1	0.031	0.024
Hexane, *n*-	6	0	0.324	0.134
Hexene, 1-	6	0	0.033	0.006
Isobutane	6	0	1.588	0.769
Isobutene/1-Butene	6	0	0.138	0.047
Isopentane	6	0	1.087	0.444
Isoprene	6	0	0.138	0.112
Methyl Ethyl Ketone	6	0	0.484	0.239
Methylcyclohexane	6	0	0.140	0.047
Methylcyclopentane	6	0	0.079	0.018

Table 2.5-7. Site S-3B Pollutant Study Averages (Continued)

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Methylheptane, 2-	6	0	0.070	0.042
Methylheptane, 3-	6	0	0.042	0.013
Methylhexane, 2-	6	0	0.130	0.050
Methylhexane, 3-	6	0	0.173	0.039
Methylpentane, 2-	6	0	0.417	0.206
Methylpentane, 3-	6	0	0.201	0.075
Nonane, *n*-	6	0	0.039	0.010
Octane, *n*-	6	0	0.084	0.029
Pentane, *n*-	6	0	1.010	0.406
Pentene, 1-	6	0	0.038	0.007
Pentene, *trans*-2-	6	0	0.025	0.007
Pinene, *alpha*-	5	1	0.018	0.015
Propane	6	0	8.844	4.215
Propylene	6	0	0.257	0.089
Tetrachloroethylene	5	1	0.013	0.008
Toluene	6	0	0.230	0.055
Trichlorofluoromethane	6	0	0.277	0.015
Trichlorotrifluoroethane	6	0	0.093	0.004
Trimethylbenzene, 1,2,4-	6	0	0.037	0.014
Trimethylbenzene, 1,3,5-	6	0	0.019	0.005
Trimethylpentane, 2,2,3-	6	0	0.023	0.003
Trimethylpentane, 2,2,4-	6	0	0.049	0.013
Trimethylpentane, 2,3,4-	6	0	0.017	0.004
Undecane, *n*-	6	0	0.026	0.012
Xylene, *m,p*-	6	0	0.101	0.026
Xylene, *o*-	6	0	0.035	0.008

Table 2.5-8. Site S-4 Pollutant Study Averages

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Acetaldehyde	20	0	3.802	1.125
Acetone	20	0	1.823	0.589
Acetylene	20	0	1.023	0.392
Benzaldehyde	20	0	0.025	0.012
Benzene	20	0	0.686	0.221
Butadiene, 1,3-	20	0	0.092	0.040
Butane, *n*-	20	0	10.993	5.385
Butene, *cis*-2-	20	0	0.318	0.136
Butene, *trans*-2-	20	0	0.369	0.175
Butyraldehyde	20	0	0.172	0.076
Carbon Disulfide	20	0	0.119	0.022
Carbon Tetrachloride	20	0	0.113	0.006
Chloroform	20	0	0.026	0.004
Chloromethane	20	0	0.688	0.050
Crotonaldehyde	20	0	0.072	0.018
Cyclohexane	20	0	0.296	0.094
Cyclopentane	20	0	0.446	0.172
Decane, *n*-	20	0	0.137	0.092
Dichlorobenzene, *p*-	19	1	0.060	0.022
Dichlorodifluoromethane	20	0	0.581	0.020
Dichloromethane	20	0	0.122	0.032
Dichlorotetrafluoroethane	20	0	0.020	0.001
Dimethylbutane, 2,2-	20	0	0.304	0.106
Dimethylbutane, 2,3-	20	0	0.948	0.366
Dimethylpentane, 2,3-	20	0	0.330	0.094
Dimethylpentane, 2,4-	20	0	0.326	0.114
Dodecane, *n*-	20	0	0.046	0.028
Ethane	20	0	18.229	8.241
Ethylbenzene	20	0	0.238	0.056
Ethylene	20	0	1.778	0.632
Ethyltoluene, *m*-	20	0	0.084	0.028
Ethyltoluene, *p*-	20	0	0.059	0.021
Formaldehyde	20	0	1.140	0.408
Heptane, *n*-	20	0	0.299	0.106
Hexaldehyde	20	0	0.114	0.083
Hexane, *n*-	20	0	1.301	0.507

Table 2.5-8. Site S-4 Pollutant Study Averages (Continued)

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Hexene, 1-	20	0	0.074	0.015
Hexene, *trans*-2-	18	2	0.124	0.054
Isobutane	20	0	2.860	1.397
Isobutene/1-Butene	20	0	0.666	0.275
Isopentane	20	0	12.985	5.511
Isoprene	20	0	0.143	0.030
Isopropylbenzene	19	1	0.018	0.005
Methyl Ethyl Ketone	20	0	1.554	0.948
Methyl Isobutyl Ketone	20	0	0.100	0.040
Methyl-1-butene, 2-	20	0	0.499	0.234
Methyl-2-butene, 2-	20	0	0.992	0.430
Methylcyclohexane	20	0	0.309	0.098
Methylcyclopentane	20	0	0.566	0.195
Methylheptane, 2-	20	0	0.111	0.036
Methylheptane, 3-	20	0	0.087	0.027
Methylhexane, 2-	20	0	0.499	0.207
Methylhexane, 3-	20	0	0.538	0.143
Methylpentane, 2-	20	0	2.543	0.930
Methylpentane, 3-	20	0	1.423	0.541
Nonane, *n*-	20	0	0.102	0.048
Octane, *n*-	20	0	0.146	0.045
Octene, 1-	14	6	0.016	0.006
Pentane, *n*-	20	0	5.491	2.336
Pentene, 1-	20	0	0.328	0.127
Pentene, *cis*-2-	20	0	0.382	0.155
Pentene, *trans*-2-	20	0	0.763	0.310
Pinene, *alpha*-	17	3	0.038	0.015
Propane	20	0	10.683	4.918
Propionaldehyde	20	0	0.129	0.035
Propylbenzene, *n*-	20	0	0.040	0.011
Propylene	20	0	0.811	0.264
Styrene	19	1	0.044	0.011
Tetrachloroethylene	20	0	0.048	0.013
Toluene	20	0	1.663	0.540

Table 2.5-8. Site S-4 Pollutant Study Averages (Continued)

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Trichlorofluoromethane	20	0	0.276	0.008
Trichlorotrifluoroethane	20	0	0.090	0.002
Trimethylbenzene, 1,2,3-	20	0	0.051	0.026
Trimethylbenzene, 1,2,4-	20	0	0.218	0.084
Trimethylbenzene, 1,3,5-	20	0	0.073	0.026
Trimethylpentane, 2,2,3-	20	0	0.183	0.067
Trimethylpentane, 2,2,4-	20	0	1.137	0.403
Trimethylpentane, 2,3,4-	20	0	0.279	0.094
Undecane, *n*-	20	0	0.068	0.026
Valeraldehyde	20	0	0.039	0.017
Xylene, *m,p*-	20	0	0.758	0.189
Xylene, *o*-	20	0	0.255	0.066

Table 2.5-9. Site 5 Pollutant Study Averages

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Acetaldehyde	20	0	1.824	0.408
Acetone	20	0	1.263	0.332
Acetylene	19	0	0.567	0.165
Benzaldehyde	18	2	0.009	0.002
Benzene	19	0	0.197	0.035
Butadiene, 1,3-	15	4	0.018	0.007
Butane, *n*-	15	4	2.072	1.109
Butene, *cis*-2-	19	0	0.048	0.007
Butene, *trans*-2-	18	1	0.033	0.008
Butyraldehyde	20	0	0.048	0.035
Carbon Disulfide	19	0	0.944	0.153
Carbon Tetrachloride	19	0	0.108	0.011
Chloroform	18	1	0.033	0.008
Chloromethane	19	0	0.642	0.063
Crotonaldehyde	20	0	0.050	0.014
Cyclohexane	19	0	0.096	0.033
Cyclopentane	19	0	0.119	0.108
Decane, *n*-	19	0	0.031	0.013
Dichlorodifluoromethane	19	0	0.534	0.040
Dichloromethane	19	0	0.102	0.035
Dichlorotetrafluoroethane	19	0	0.019	0.002
Dimethylbutane, 2,2-	19	0	0.080	0.027
Dimethylbutane, 2,3-	19	0	0.081	0.019
Dimethylpentane, 2,3-	19	0	0.117	0.025
Dimethylpentane, 2,4-	19	0	0.039	0.007
Dodecane, *n*-	18	1	0.038	0.034
Ethane	19	0	14.077	4.074
Ethylbenzene	19	0	0.076	0.024
Ethylene	19	0	0.985	0.202
Ethyltoluene, *m*-	18	1	0.033	0.008
Ethyltoluene, *o*-	15	4	0.019	0.012
Ethyltoluene, *p*-	17	2	0.025	0.013
Formaldehyde	20	0	0.723	0.096
Heptane, *n*-	19	0	0.090	0.021
Hexaldehyde	20	0	0.020	0.002
Hexane, *n*-	19	0	0.200	0.056

Table 2.5-9. Site S-5 Pollutant Study Averages (Continued)

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Hexene, 1-	19	0	0.046	0.008
Isobutane	19	0	1.063	0.598
Isobutene/1-Butene	19	0	0.171	0.036
Isopentane	19	0	1.297	1.262
Isoprene	19	0	0.092	0.023
Isopropylbenzene	18	1	0.016	0.003
Methyl Ethyl Ketone	19	0	0.775	0.307
Methylcyclohexane	19	0	0.105	0.024
Methylcyclopentane	19	0	0.106	0.034
Methylheptane, 2-	19	0	0.045	0.006
Methylheptane, 3-	19	0	0.030	0.004
Methylhexane, 2-	19	0	0.094	0.020
Methylhexane, 3-	19	0	0.207	0.066
Methylpentane, 2-	16	3	0.316	0.107
Methylpentane, 3-	19	0	0.160	0.040
Nonane, *n*-	19	0	0.031	0.004
Octane, *n*-	19	0	0.063	0.011
Pentane, *n*-	19	0	1.087	0.929
Pentene, 1-	19	0	0.046	0.009
Pentene, *cis*-2-	18	1	0.032	0.005
Pentene, *trans*-2-	18	1	0.041	0.012
Pinene, *alpha*-	15	4	0.039	0.021
Propane	19	0	5.049	1.773
Propionaldehyde	20	0	0.048	0.035
Propylbenzene, *n*-	16	3	0.019	0.007
Propylene	19	0	0.368	0.084
Styrene	18	1	0.042	0.015
Toluene	18	1	0.446	0.166
Trichlorofluoromethane	19	0	0.255	0.020
Trichlorotrifluoroethane	19	0	0.087	0.007
Trimethylbenzene, 1,2,4-	19	0	0.057	0.017
Trimethylbenzene, 1,3,5-	18	1	0.026	0.007
Trimethylpentane, 2,2,3-	15	4	0.021	0.008
Trimethylpentane, 2,2,4-	19	0	0.103	0.031
Trimethylpentane, 2,3,4-	19	0	0.039	0.010
Undecane, *n*-	19	0	0.064	0.073
Valeraldehyde	17	3	0.008	0.002

Table 2.5-9. Site S-5 Pollutant Study Averages (Continued)

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Xylene, *m,p-*	19	0	0.198	0.060
Xylene, *o-*	19	0	0.071	0.020

Table 2.5-10. Site S-6 Pollutant Study Averages

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Benzene	15	4	0.097	0.036
Butane, *n*-	19	0	1.015	0.432
Carbon Tetrachloride	18	1	0.097	0.013
Chloromethane	19	0	0.510	0.061
Dichlorodifluoromethane	19	0	0.511	0.017
Ethane	19	0	21.412	9.997
Ethylene	18	1	0.632	0.155
Isobutane	17	2	0.418	0.180
Methane	17	0	5758.824	795.537
Methanol	10	0	6.545	1.681
Methyl Ethyl Ketone	18	1	0.427	0.121
Pentane, *n*-	18	1	0.399	0.146
Propane	19	0	2.982	1.154
Propylene	18	1	0.210	0.074
Toluene	19	0	0.305	0.083
Trichlorofluoromethane	19	0	0.257	0.008

Table 2.5-11. Site S-7 Pollutant Study Averages

Pollutant Name	Number of Detects	Number of Non-detects	Study Average (ppbv)	Confidence Interval (ppbv)
Benzene	14	4	0.109	0.043
Butane, *n*-	18	0	1.230	0.604
Carbon Tetrachloride	16	2	0.098	0.019
Chloromethane	18	0	0.523	0.071
Dichlorodifluoromethane	18	0	0.520	0.017
Ethane	18	0	23.979	11.236
Ethylene	18	0	0.690	0.173
Isobutane	16	2	0.481	0.246
Methane	17	0	5672.353	650.290
Methanol	18	0	6.740	1.403
Methyl Ethyl Ketone	18	0	0.512	0.183
Pentane, *n*-	17	1	0.468	0.217
Propane	18	0	3.967	1.854
Propylene	17	1	0.234	0.107
Toluene	18	0	0.314	0.128
Trichlorofluoromethane	18	0	0.259	0.007

2.5.3 Key Pollutants

At the conclusion of the ambient air monitoring data collection, ERG conducted an initial public health screening to determine whether selected pollutants were found at levels indicating an urgent health hazard. This screening was conducted using the same health screening values that EPA uses in its NATA (see Appendix 2-G), which are available for 40 pollutants in this study. In Section 5 of this report, ERG presents a broader health evaluation that considers health screening values for all 138 pollutants considered in the monitoring program, as well as the results of the air dispersion modeling effort discussed in Section 4.

> ***Key Point: Key Pollutants***
> The key pollutants, based on the ambient monitoring data, were:
> - Acetaldehyde
> - Benzene
> - 1,3-Butadiene
> - Carbon tetrachloride
> - *p*-Dichlorobenzene
> - Formaldehyde
> - Tetrachloroethylene

In reviewing this initial screening of key pollutants, note that:

- With one exception, ERG found no pollutant concentrations that exceeded any published short-term health benchmark published by the Texas Commission on Environmental Quality (TCEQ), EPA, or the Agency for Toxic Substances and Disease Registry (ATSDR). A single sample was found to have a hexachloro-1,3-butadiene concentration of 0.369 ppb, which is higher than TCEQ's short-term effects screening level (0.2 ppb). However, this particular sample was not analyzed within the method's required holding time, and the testing laboratory cautioned that the measurement is of limited reliability. Further discussion of this pollutant is found in Section 5.2.
- It is only appropriate to compare annual average concentrations, not individual measurements, to long-term health benchmark values such as the EPA NATA values.
- The study period was only for two months at eight sites; the study period averages at these eight sites are assumed to be an estimate of typical annual conditions. This approach is similar to EPA's SATMP study.
- The initial screening presented in this report only addresses 40 pollutants. The health evaluation in Section 5 presents interpretations for all pollutants considered in this monitoring program.

Tables 2.5-12 through 2.5-19 present average concentration summaries of the key pollutants of interest for each site. Key pollutants are ones whose average concentrations were greater than the Lowest Comparison Levels (LCLs) used in this study. Thus, these tables present a "factor of LCL" for each pollutant, and pollutants with a "factor of LCL" greater than 1 are identified as key. Additionally, Figures 2.5-1 through 2.5-7 present each key pollutant's study average confidence interval, which is useful in identifying statistically significant differences.

The following observations were made:

- Benzene and carbon tetrachloride were key HAPs at each site.
- The average acetaldehyde concentration at Site S-4 was considerably higher than the average acetaldehyde concentration at Site S-5 (Figure 2.5-1).
- The average benzene concentration at Site S-4 was considerably higher than all other average benzene concentrations at the other sites. The average benzene concentrations at Sites S-6 and S-7 were also considerably lower than those for Sites S-1, S-2, S-3A, and S-5 (Figure 2.5-2).
- The average 1,3-butadiene concentrations at Sites S-2 and S-4 were considerably higher than the average 1,3-butadiene concentration at Site S-5 (Figure 2.5-3).
- The average carbon tetrachloride concentration at Site S-1 was only considerably higher than the average carbon tetrachloride concentration at Site S-6 (Figure 2.5-4).
- There were no statistically significant differences in average *p*-dichlorobenzene concentrations across Sites S-1, S-2, S-3A, and S-4 (Figure 2.5-5).
- There were no statistically significant differences in average formaldehyde concentrations across Sites S-4 and S-5 (Figure 2.5-6).
- There were no statistically significant differences in average tetrachloroethylene concentrations across Sites S-1, S-2, S-3A, and S-4 (Figure 2.5-7).

2.5.4 Integration with Meteorology

Meteorological observations, such as wind speed and wind direction, can be useful in helping characterize the behavior of the ambient air monitoring data. For this study, no meteorological towers were placed at the monitoring locations, largely because more than 40 National Weather Service (NWS) and TCEQ meteorological stations in and around the city of Fort Worth operated during this monitoring program. Additionally, another dozen meteorological stations from the Weatherbug Network were available to be used.

Closest Meteorological Station

For each monitoring site, ERG identified the closest meteorological station that was operating during the monitoring timeframe. Table 2.5-20 identifies those stations. If observations were missing, or if a significant portion of a day's observations were identified as "calm" (less than 5 miles per hour), surrogate data was used to supplement the meteorological observations. Surrogate data sources include the NWS 1-minute data, TCEQ meteorological stations, and the Weatherbug Network. Table 2.5-20 also presents the surrogate data locations relative to the monitoring sites. All meteorological observations of wind speed, wind direction, temperature, and precipitation are presented in Appendix 2-H.

Table 2.5-12. Site S-1 Key Pollutant Averages

Pollutant	Units	Mean of Measurements	95% Confidence Interval on the Mean	Factor of EPA LCL[a]
Benzene	ppbv	0.245[b]	0.187–0.304	6.11
1,3-Butadiene	ppbv	0.041[c]	0.022–0.059	2.69
Carbon Tetrachloride	ppbv	0.118[d]	0.112–0.123	4.38
p-Dichlorobenzene	ppbv	0.039[e]	0.025–0.053	2.58
Tetrachloroethylene	ppbv	0.038[f]	0.024–0.052	1.52

[a] LCL refers to the Lowest Comparison Level of cancer and/or noncancer values, as used in EPA's NATA. LCLs for this study are presented in Appendix 2-G. "Factor of EPA LCL" is the pollutant study average (or mean of measurements) divided by its LCL.

[b] The mean of measurements for benzene is the average of all sample results, which include 20 detections that ranged from 0.135 to 0.563 ppbv.

[c] The mean of measurements for 1,3-butadiene is the average of all sample results, which include 18 detections that ranged from 0.01 to 0.137 ppbv, as well as two samples in which no chemical was registered by the laboratory analytical equipment.

[d] The mean of measurements for carbon tetrachloride is the average of all sample results, which include 20 detections that ranged from 0.083 to 0.139 ppbv.

[e] The mean of measurements for *p*-dichlorobenzene is the average of all sample results, which include 17 detections that ranged from 0.013 to 0.118 ppbv, as well as three samples in which no chemical was registered by the laboratory analytical equipment.

[f] The mean of measurements for tetrachloroethylene is the average of all sample results, which include 17 detections that ranged from 0.015 to 0.109 ppbv, as well as three samples in which no chemical was registered by the laboratory analytical equipment.

Table 2.5-13. Site S-2 Key Pollutant Averages

Pollutant	Units	Mean of Measurements	95% Confidence Interval on the Mean	Factor of EPA LCL[a]
Benzene	ppbv	0.300[b]	0.257–0.343	7.48
1,3-Butadiene	ppbv	0.057[c]	0.040–0.073	3.75
Carbon Tetrachloride	ppbv	0.117[d]	0.112–0.122	4.36
p-Dichlorobenzene	ppbv	0.051[f]	0.004–0.098	3.38
Tetrachloroethylene	ppbv	0.061[g]	0.032–0.090	2.44

[a] LCL refers to the Lowest Comparison Level of cancer and/or noncancer values, as used in EPA's NATA. LCLs for this study are presented in Appendix 2-G. "Factor of EPA LCL" is the pollutant study average (or mean of measurements) divided by its LCL.

[b] The mean of measurements for benzene is the average of all sample results, which include 18 detections that ranged from 0.180 to 0.501 ppbv.

[c] The mean of measurements for 1,3-butadiene is the average of all sample results, which include 18 detections that ranged from 0.024 to 0.147 ppbv.

[d] The mean of measurements for carbon tetrachloride is the average of all sample results, which include 18 detections that ranged from 0.090 to 0.133 ppbv.

[e] The mean of measurements for *p*-dichlorobenzene is the average of all sample results, which include 15 detections that ranged from 0.014 to 0.416 ppbv, as well as three samples in which no chemical was registered by the laboratory analytical equipment.

[f] The mean of measurements for tetrachloroethylene is the average of all sample results, which include 18 detections that ranged from 0.012 to 0.218 ppbv.

Table 2.5-14. Site S-3A Key Pollutant Averages

Pollutant	Units	Mean of Measurements	95% Confidence Interval on the Mean	Factor of EPA LCL[a]
Benzene	ppbv	0.301[b]	0.173–0.428	7.50
1,3-Butadiene	ppbv	0.049[c]	0.016–0.082	3.23
Carbon Tetrachloride	ppbv	0.118[d]	0.111–0.125	4.38
p-Dichlorobenzene	ppbv	0.030[e]	0.017–0.043	2.01
Tetrachloroethylene	ppbv	0.025[f]	0.011–0.039	1.00

[a] LCL refers to the Lowest Comparison Level of cancer and/or noncancer values, as used in EPA's NATA. LCLs for this study are presented in Appendix 2-G. "Factor of EPA LCL" is the pollutant study average (or mean of measurements) divided by its LCL.

[b] The mean of measurements for benzene is the average of all sample results, which include nine detections that ranged from 0.157 to 0.636 ppbv.

[c] The mean of measurements for 1,3-butadiene is the average of all sample results, which include eight detections that ranged from 0.023 to 0.123 ppbv, as well as one sample in which no chemical was registered by the laboratory analytical equipment.

[d] The mean of measurements for carbon tetrachloride is the average of all sample results, which include nine detections that ranged from 0.104 to 0.134 ppbv.

[e] The mean of measurements for *p*-dichlorobenzene is the average of all sample results, which include nine detections that ranged from 0.011 to 0.056 ppbv.

[f] The mean of measurements for tetrachloroethylene is the average of all sample results, which include seven detections that ranged from 0.013 to 0.056 ppbv, as well as two samples in which no chemical was registered by the laboratory analytical equipment.

Table 2.5-15. Site S-3B Key Pollutant Averages

Pollutant	Units	Mean of Measurements	95% Confidence Interval on the Mean	Factor of EPA LCL[a]
Benzene	ppbv	0.165[b]	0.137–0.193	4.11
Carbon Tetrachloride	ppbv	0.115[c]	0.107–0.122	4.26

[a] LCL refers to the Lowest Comparison Level of cancer and/or noncancer values, as used in EPA's NATA. LCLs for this study are presented in Appendix 2-G. "Factor of EPA LCL" is the pollutant study average (or mean of measurements) divided by its LCL.

[b] The mean of measurements for benzene is the average of all sample results, which include six detections that ranged from 0.132 to 0.214 ppbv.

[c] The mean of measurements for carbon tetrachloride is the average of all sample results, which include six detections that ranged from 0.103 to 0.122 ppbv.

Table 2.5-16. Site S-4 Key Pollutant Averages

Pollutant	Units	Mean of Measurements	95% Confidence Interval on the Mean	Factor of EPA LCL[a]
Acetaldehyde	ppbv	3.802[b]	2.677–4.927	15.07
Benzene	ppbv	0.686[c]	0.465–0.906	17.08
1,3-Butadiene	ppbv	0.092[d]	0.051–0.132	6.08
Carbon Tetrachloride	ppbv	0.113[e]	0.107–0.118	4.19
p-Dichlorobenzene	ppbv	0.060[f]	0.038–0.083	3.99
Formaldehyde	ppbv	1.140[g]	0.731–1.548	17.50
Tetrachloroethylene	ppbv	0.048[h]	0.034–0.061	1.90

[a] LCL refers to the Lowest Comparison Level of cancer and/or noncancer values, as used in EPA's NATA. LCLs for this study are presented in Appendix 2-G. "Factor of EPA LCL" is the pollutant study average (or mean of measurements) divided by its LCL.

[b] The mean of measurements for acetaldehyde is the average of all sample results, which include 20 detections that ranged from 1.35 to 9.06 ppbv.

[c] The mean of measurements for benzene is the average of all sample results, which include 20 detections that ranged from 0.200 to 1.83 ppbv.

[d] The mean of measurements for 1,3-butadiene is the average of all sample results, which include 18 detections that ranged from 0.015 to 0.304 ppbv.

[e] The mean of measurements for carbon tetrachloride is the average of all sample results, which include 20 detections that ranged from 0.094 to 0.142 ppbv.

[f] The mean of measurements for *p*-dichlorobenzene is the average of all sample results, which include 19 detections that ranged from 0.019 to 0.178 ppbv, as well as one sample in which no chemical was registered by the laboratory analytical equipment.

[g] The mean of measurements for formaldehyde is the average of all sample results, which include 20 detections that ranged from 0.412 to 4.45 ppbv.

[h] The mean of measurements for tetrachloroethylene is the average of all sample results, which include 20 detections that ranged from 0.015 to 0.116 ppbv.

Table 2.5-17. Site S-5 Key Pollutant Averages

Pollutant	Units	Mean of Measurements	95% Confidence Interval on the Mean	Factor of EPA LCL[a]
Acetaldehyde	ppbv	1.824[b]	1.416–2.231	7.23
Benzene	ppbv	0.197[c]	0.162–0.232	4.90
1,3-Butadiene	ppbv	0.018[d]	0.011–0.025	1.20
Carbon Tetrachloride	ppbv	0.108[e]	0.097–0.119	4.03
Formaldehyde	ppbv	0.723[f]	0.626–0.819	11.09

[a] LCL refers to the Lowest Comparison Level of cancer and/or noncancer values, as used in EPA's NATA. LCLs for this study are presented in Appendix 2-G. "Factor of LCL" is the pollutant study average (or mean of measurements) divided by its LCL.

[b] The mean of measurements for acetaldehyde is the average of all sample results, which include 20 detections that ranged from 0.831 to 4.93 ppbv.

[c] The mean of measurements for benzene is the average of all sample results, which include 19 detections that ranged from 0.104 to 0.359 ppbv.

[d] The mean of measurements for 1,3-butadiene is the average of all sample results, which include 15 detections that ranged from 0.011 to 0.051 ppbv, as well as four samples in which no chemical was registered by the laboratory analytical equipment.

[e] The mean of measurements for carbon tetrachloride is the average of all sample results, which include 19 detections that ranged from 0.053 to 0.140 ppbv.

[f] The mean of measurements for formaldehyde is the average of all sample results, which include 20 detections that ranged from 0.474 to 1.32 ppbv.

Table 2.5-18. Site S-6 Key Pollutant Averages

Pollutant	Units	Mean of Measurements	95% Confidence Interval on the Mean	Factor of EPA LCL[a]
Benzene	ppbv	0.097[b]	0.061–0.134	2.42
Carbon Tetrachloride	ppbv	0.097[c]	0.083–0.110	3.59

[a] LCL refers to the Lowest Comparison Level of cancer and/or noncancer values, as used in EPA's NATA. LCLs for this study are presented in Appendix 2-G. "Factor of EPA LCL" is the pollutant study average (or mean of measurements) divided by its LCL.

[b] The mean of measurements for benzene is the average of all sample results, which include 15 detections that ranged from 0.070 to 0.263 ppbv, as well as four samples in which no chemical was registered by the laboratory analytical equipment.

[c] The mean of measurements for carbon tetrachloride is the average of all sample results, which include 18 detections that ranged from 0.071 to 0.127 ppbv, as well as one sample in which no chemical was registered by the laboratory analytical equipment.

Table 2.5-19. Site S-7 Key Pollutant Averages

Pollutant	Units	Mean of Measurements	95% Confidence Interval on the Mean	Factor of EPA LCL[a]
Benzene	ppbv	0.109[b]	0.066–0.152	2.71
Carbon Tetrachloride	ppbv	0.098[c]	0.079–0.117	3.65

[a] LCL refers to the Lowest Comparison Level of cancer and/or noncancer values, as used in EPA's NATA. LCLs for this study are presented in Appendix 2-G. "Factor of EPA LCL" is the pollutant study average (or mean of measurements) divided by its LCL.

[b] The mean of measurements for benzene is the average of all sample results, which include 14 detections that ranged from 0.064 to 0.282 ppbv, as well as four samples in which no chemical was registered by the laboratory analytical equipment.

[c] The mean of measurements for carbon tetrachloride is the average of all sample results, which include 16 detections that ranged from 0.077 to 0.142 ppbv, as well as two samples in which no chemical was registered by the laboratory analytical equipment.

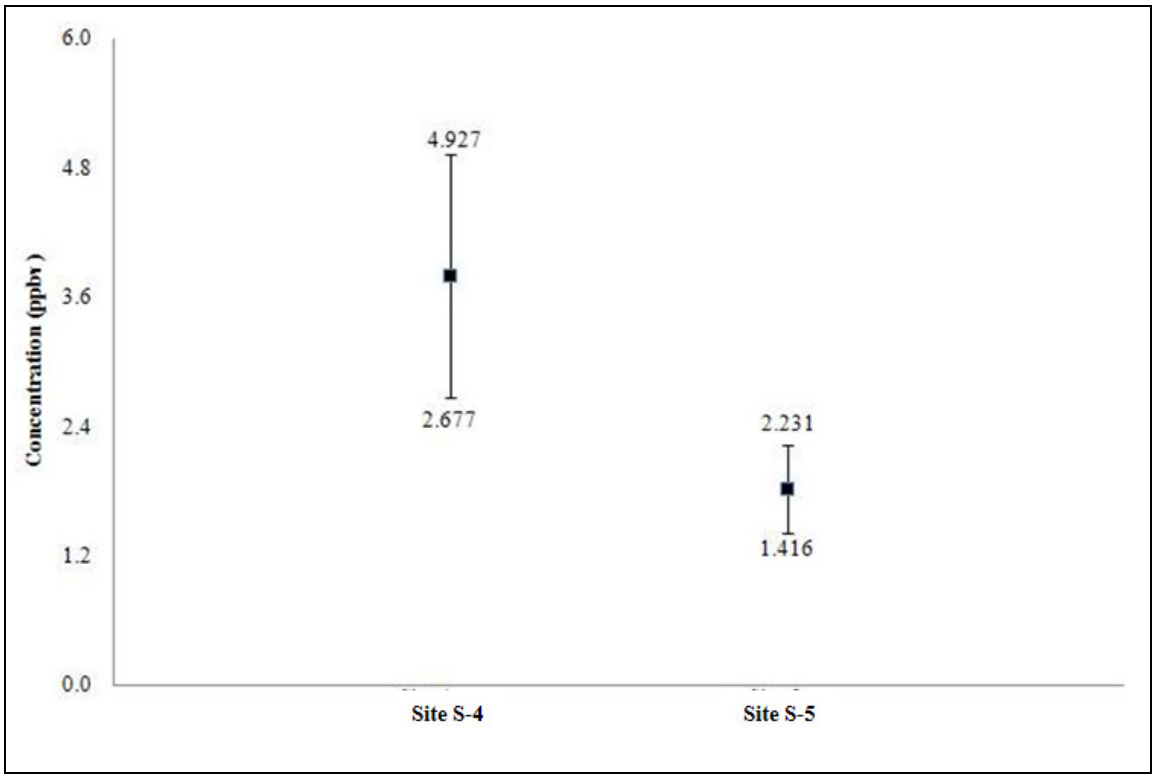


Figure 2.5-1. Acetaldehyde Average Concentrations by Site

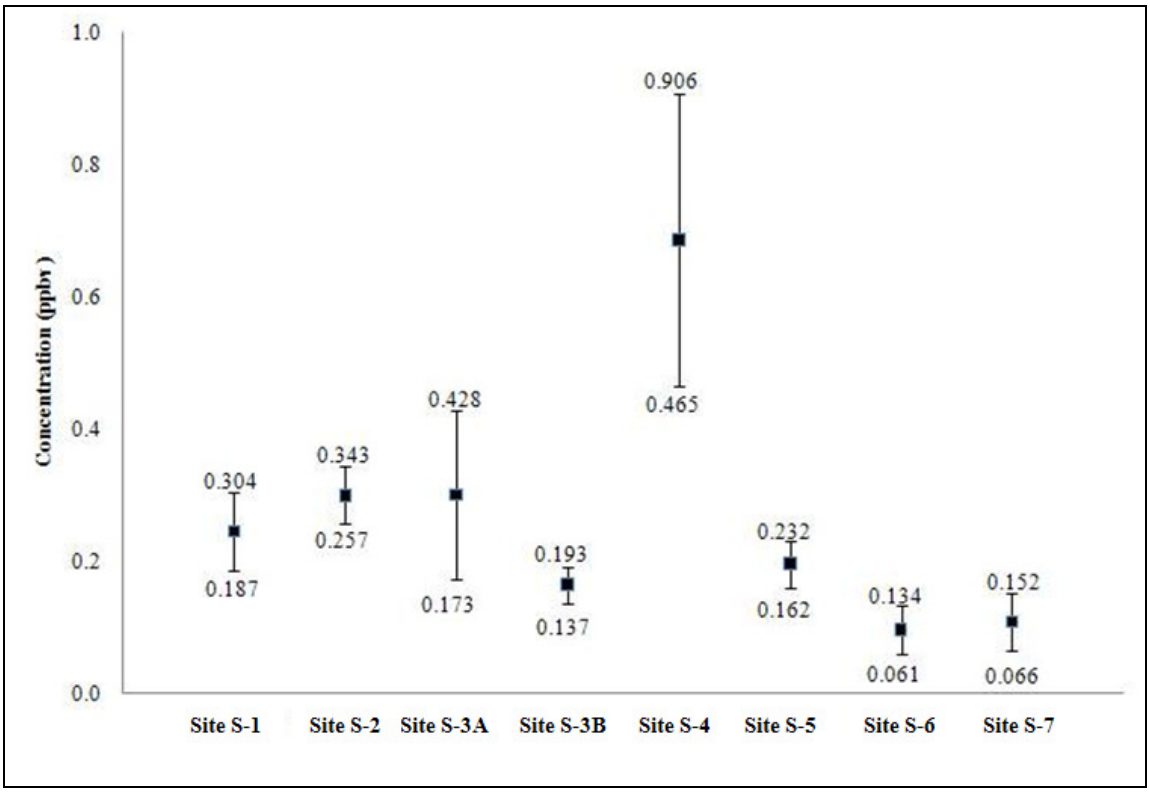


Figure 2.5-2. Benzene Average Concentrations by Site

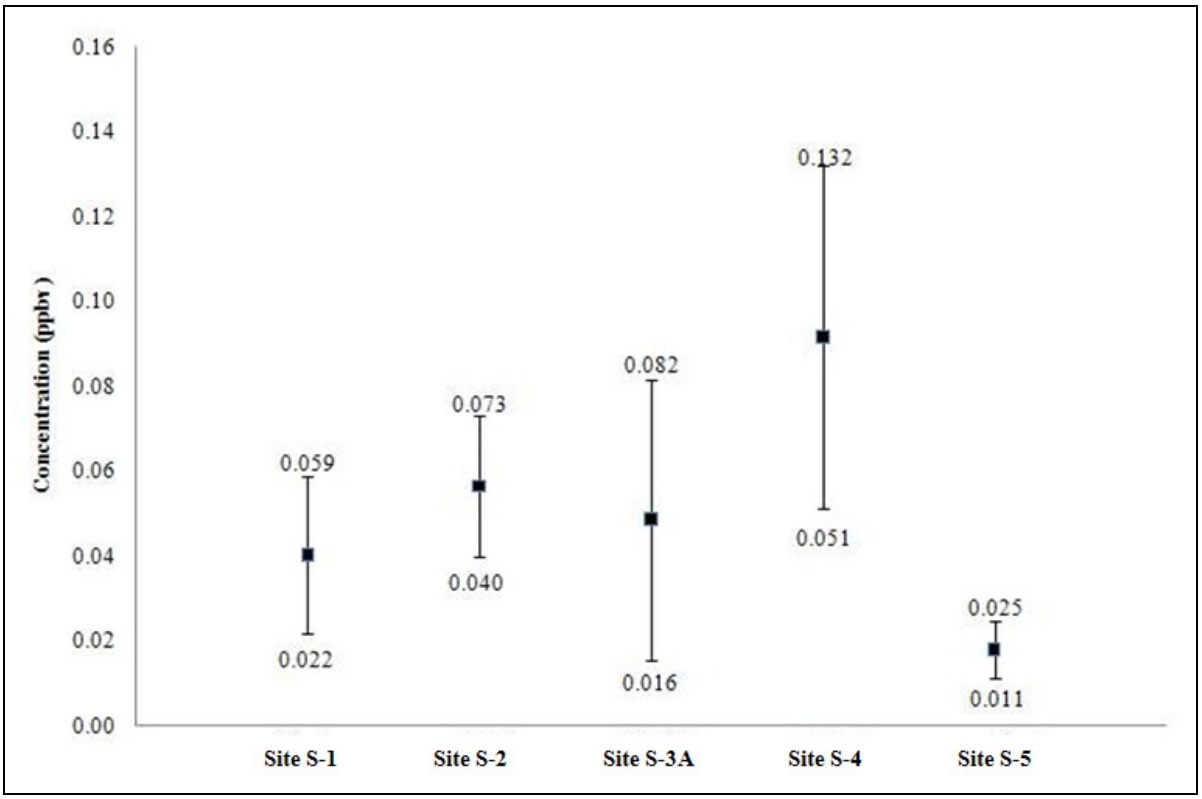


Figure 2.5-3. 1,3-Butadiene Average Concentrations by Site

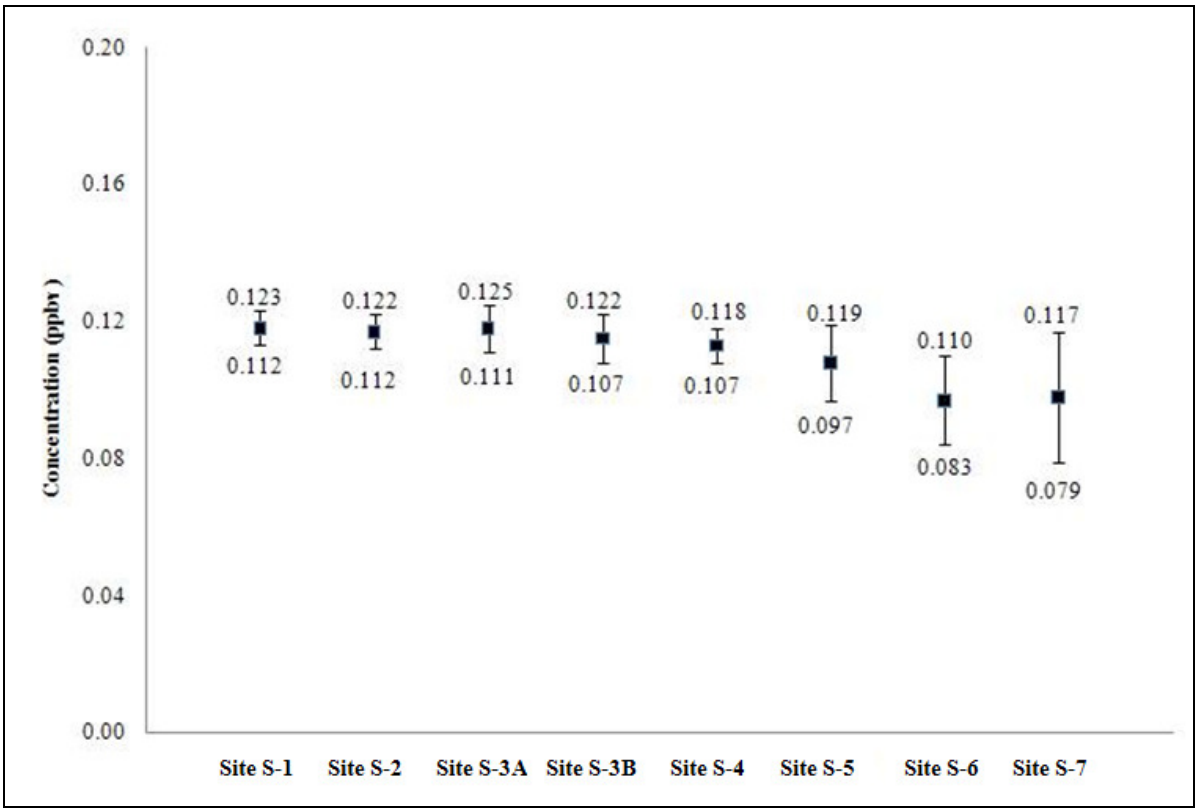


Figure 2.5-4. Carbon Tetrachloride Average Concentrations by Site

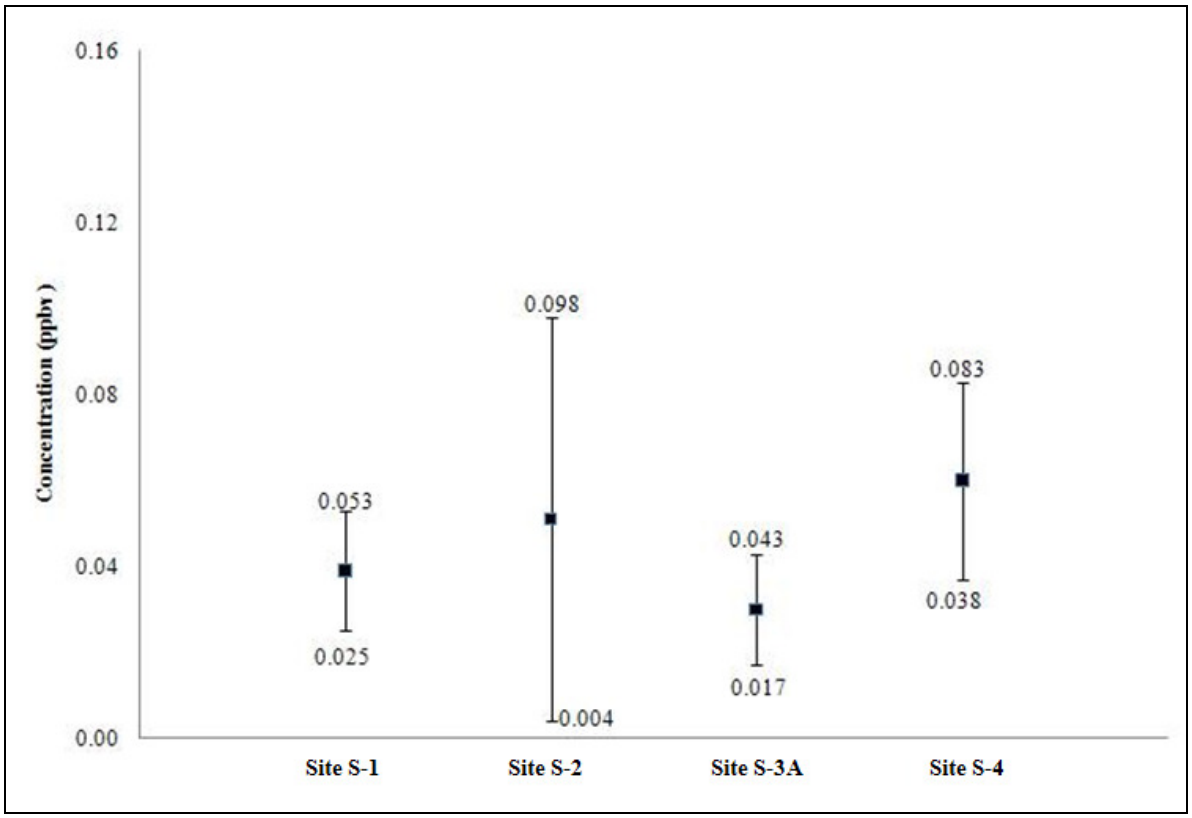


Figure 2.5-5. *p*-Dichlorobenzene Average Concentrations by Site

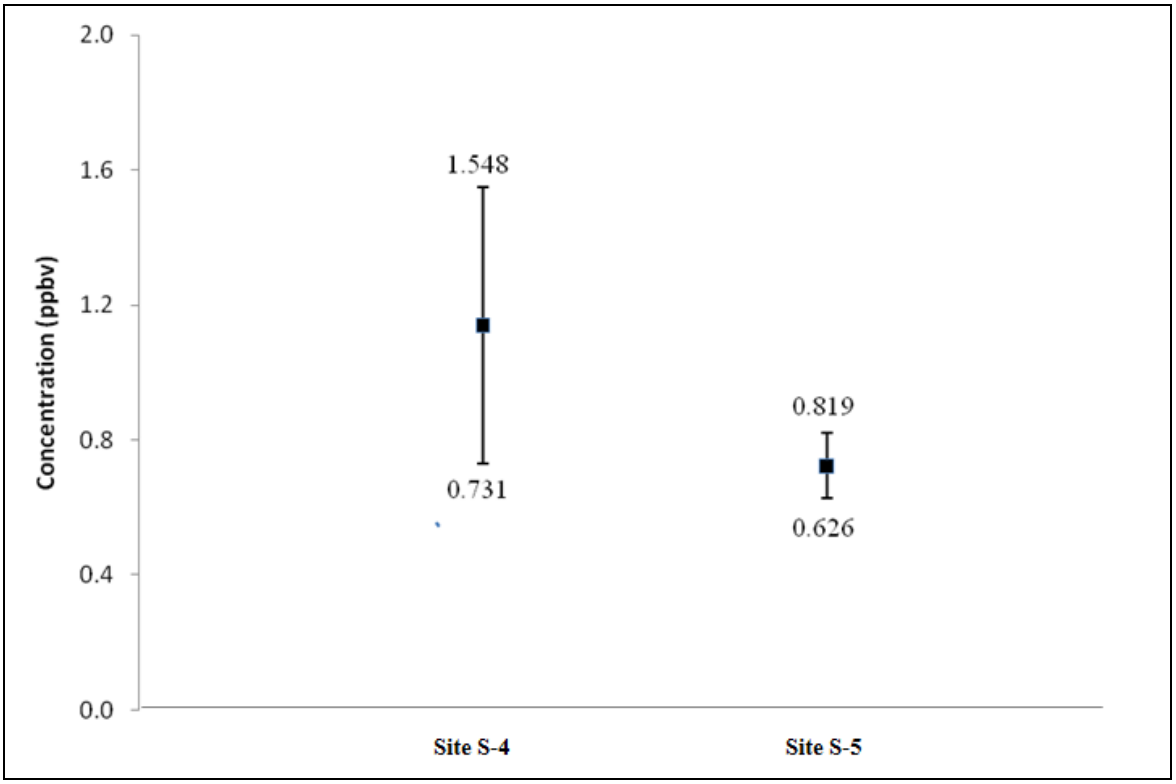


Figure 2.5-6. Formaldehyde Average Concentrations by Site

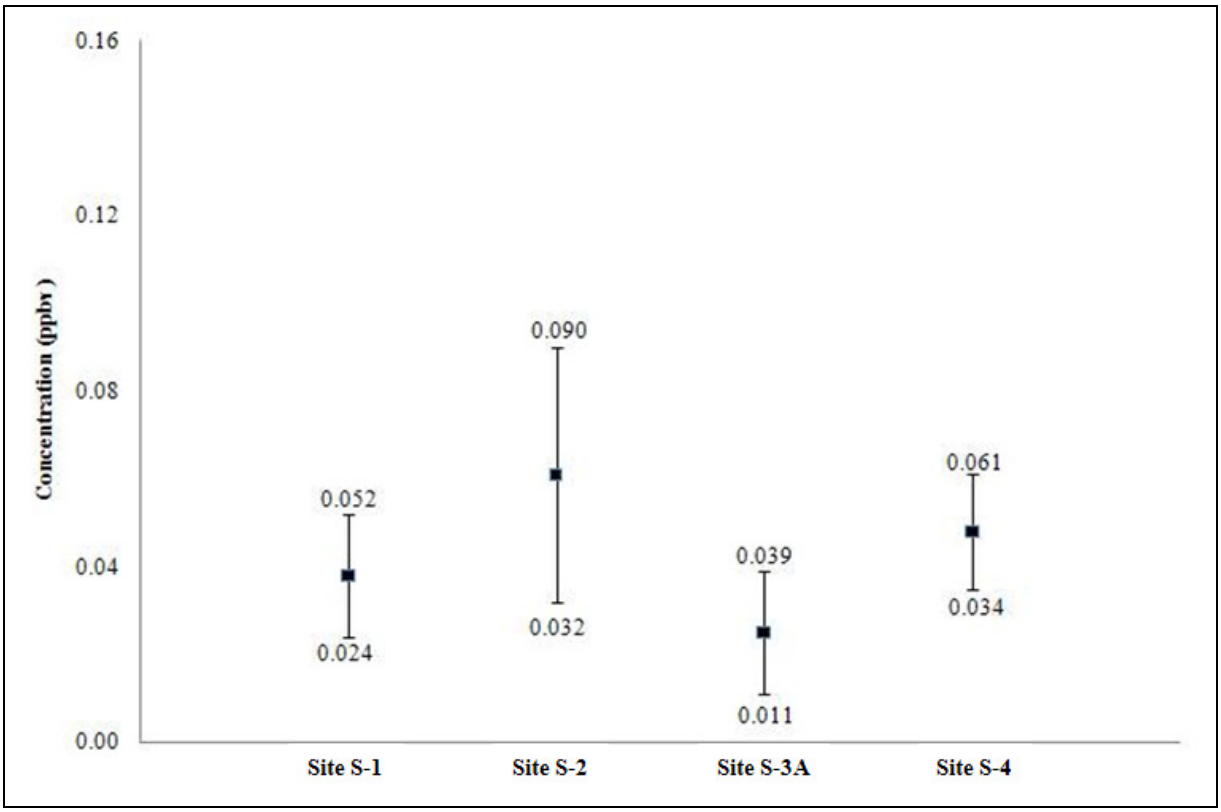


Figure 2.5-7. Tetrachloroethylene Average Concentrations by Site

Table 2.5-20. Meteorological Stations Used in This Study

Site	Closest Meteorological Station	Distance/ Orientation from Site	Type	Alternate Meteorological Station	Distance/ Orientation from Site	Type
S-1	Dallas–Ft. Worth International (03927)	5.29 miles/ north	National Weather Service	Oakwood Terrace Elementary School	2.75 miles/ west	Weatherbug
S-2	Nolan High School (NOLAN)	2.22 miles/ west	Weatherbug	Arlington Municipal Airport	10.30 miles/ southeast	National Weather Service
S-3A	Nolan High School (NOLAN)	0.50 miles/ southeast	Weatherbug	Arlington Municipal Airport	12.15 miles/ southeast	National Weather Service
S-3B	Ft. Worth Naval Air Station/Carswell Field (13911)	3.11 miles/ east	National Weather Service	Ft. Worth Northwest (48-439-1002)	8.23 miles/ east-northeast	TCEQ
S-4	Ft. Worth Meacham Airport (13961)	2.98 miles/ northwest	National Weather Service	Ft. Worth Northwest (48-439-1002)	2.21 miles/ northwest	TCEQ
S-5	Ft. Worth Alliance Airport (53909)	3.88 miles/ east	National Weather Service	Eagle Mountain Lake (48-439-0075)	5.40 miles/ west	TCEQ
S-6	Spinks Airport (03985)	0.69 miles/ north-northeast	National Weather Service	Wm. Stribling Elementary School	2.75 miles/ southeast	Weatherbug
S-7	Spinks Airport (03985)	0.40 miles/ southeast	National Weather Service	Wm. Stribling Elementary School	3.50 miles/ southeast	Weatherbug

Figure 2.5-8 presents an overview of the monitoring sites and their nearest meteorological stations.

Windrose Analysis

In this set of analyses, ERG compared wind patterns on sample days to patterns for the whole sampling period, as well as comparing the sampling period's wind patterns to historical wind patterns. The purpose of these analyses was to confirm that sampling occurred under typical conditions. Finally, the historical two-month patterns were compared to the long-term annual patterns that were generated at onset of this study.

> ***Key Point: Windrose Analysis***
> Based on the windrose profiles associated with each monitoring site during the sampling period, the locations of the monitoring sites were accurately sited relative to wind direction.

Windroses were created for several time periods (historical, annual for 2009, sample days, and sample period) for each sampling site. The data for the windroses came from the NWS stations, EPA's Air Quality System (AQS), and the Fort Worth Weatherbug Network; the windroses were created using Lakes Environmental's WRPlot® View (version 6.5.1) software.

The following observations are made for each site:

- *Site S-1:* As presented in Table 2.5-20, the closest meteorological station is located at Dallas–Fort Worth International Airport, approximately 5 miles north of Site S-1. As shown in Figure 2.5-9, all five time-period windroses appear similar, with winds predominantly from the south-southeast and south.
- *Site S-2:* As presented in Table 2.5-20, the closest meteorological station is located at Nolan High School, which is approximately 2 miles west of Site S-2. For historical comparisons, ERG used the meteorological data from Arlington Municipal Airport, a station approximately 10 miles to the southeast. As shown in Figure 2.5-10, the sample day and sample period windroses at Nolan High School are from the south, south-southeast, and southeast, while the windroses at Arlington Municipal Airport are predominantly southerly.
- *Site S-3A:* Similar to Site S-2, the closest meteorological station is located at Nolan High School, which is approximately one-half mile southwest of Site S-3A. For historical comparisons, ERG used the meteorological data from Arlington Municipal Airport, a station approximately 12 miles to the southeast. As shown in Figure 2.5-11, the sample day and sample period windroses at Nolan High School are from the south, south-southeast, and southeast, while the windroses at Arlington Municipal Airport are predominantly southerly.
- *Site S-3B:* As presented in Table 2.5-20, the closest meteorological station is located at Fort Worth Naval Air Station/Carswell Field, approximately 3 miles east of Site S-3B. As shown in Figure 2.5-12, all five time-period windroses appear similar, with winds predominantly from the south-southeast and south.
- *Site S-4:* As presented in Table 2.5-20, the closest meteorological station is located at Fort Worth Meacham Airport, approximately 3 miles northeast of Site S-4. As shown

in Figure 2.5-13, all five time-period windroses appear similar, with winds predominantly from the south-southeast and south.

- *Site S-5:* As presented in Table 2.5-20, the closest meteorological station is located at Fort Worth Alliance Airport, approximately 4 miles east of Site S-5. As shown in Figure 2.5-14, all five time-period windroses appear similar, with winds predominantly from the south-southeast and south.
- *Site S-6:* As presented in Table 2.5-20, the closest meteorological station is located at Spinks Airport, less than 0.75 miles north-northeast of Site S-6. As shown in Figure 2.5-15, all five time-period windroses appear similar, with winds predominantly from the south-southeast and south.
- *Site S-7:* Similar to Site S-6, the closest meteorological station is located at Spinks Airport, less than half a mile southeast of Site S-7. As shown in Figure 2.5-16, all five time-period windroses appear similar, with winds predominantly from the south-southeast and south.

As described in the Ambient Air Monitoring Plan, the monitoring network was designed in part after understanding typical wind patterns in and around the City of Fort Worth through the use of historical windroses. Monitoring sites were placed to capture ambient air downwind of the target areas of interest. The general conclusion from the above windrose comparisons at each monitoring site during the study period is that wind patterns on sample days were generally typical of year-round and long-term historical wind patterns, indicating that the monitoring sites were able to collect samples from the target direction.

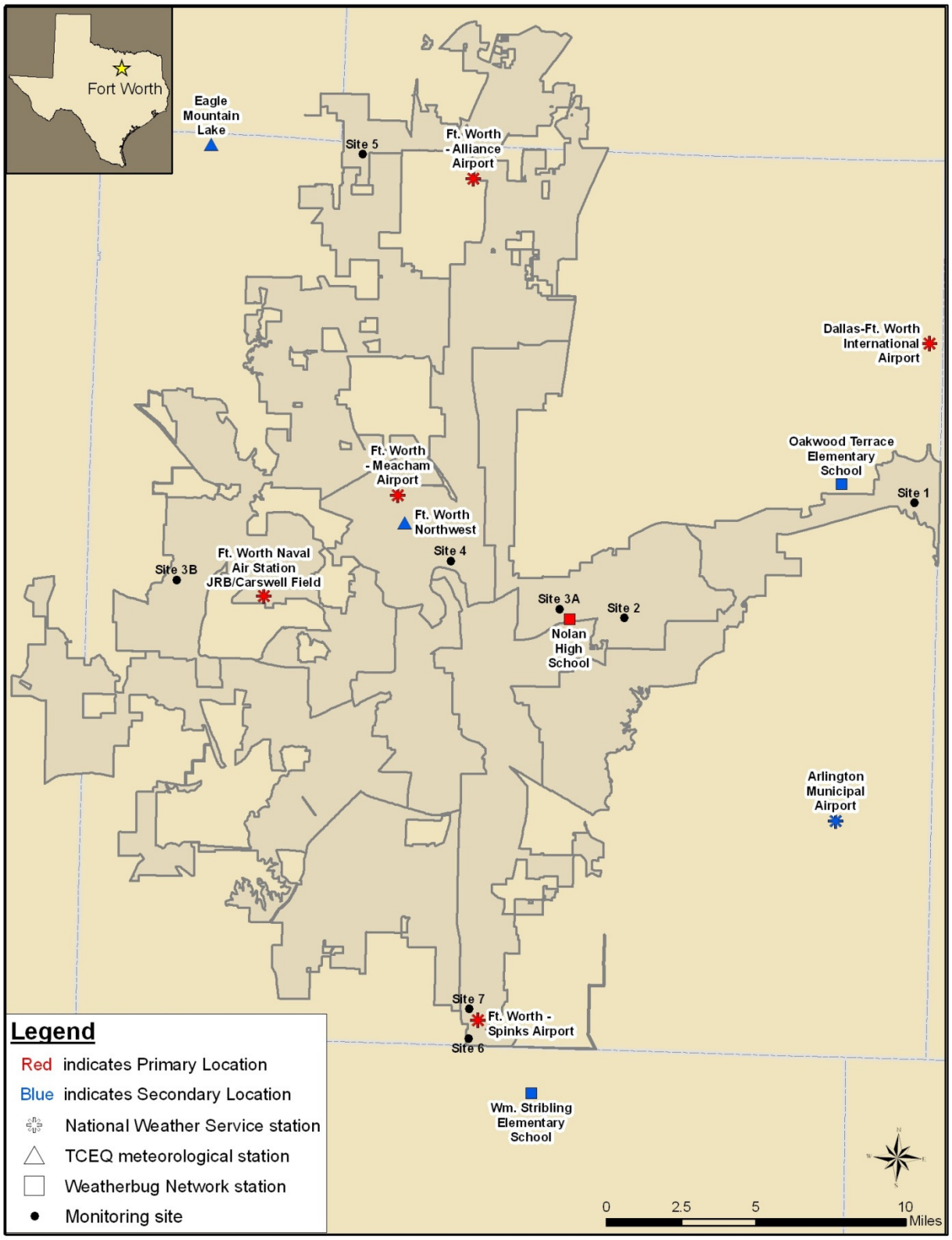


Figure 2.5-8. Meteorological Stations and Monitoring Site Locations

NWS WBAN 03927

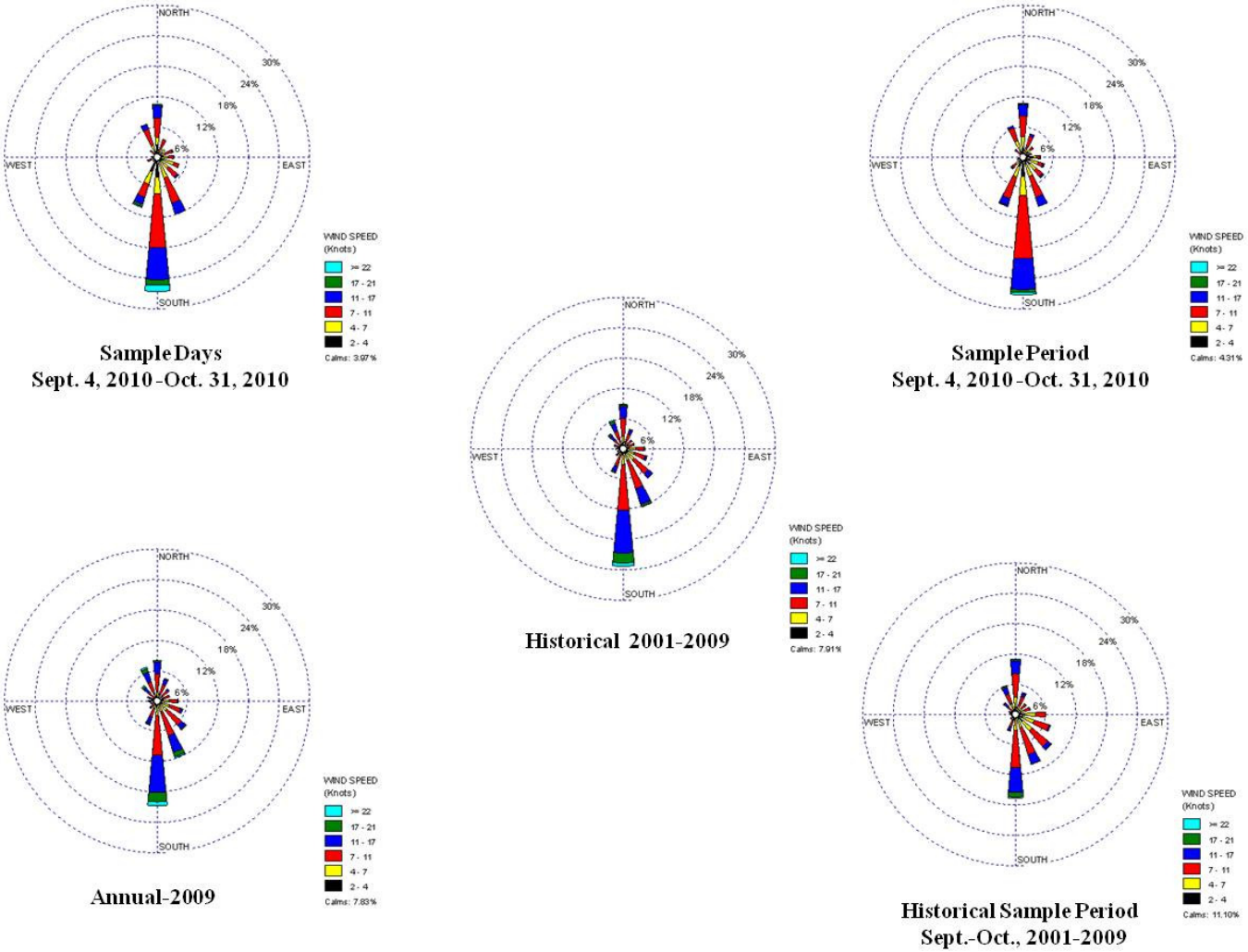


Figure 2.5-9. Site S-1 Windrose Comparisons

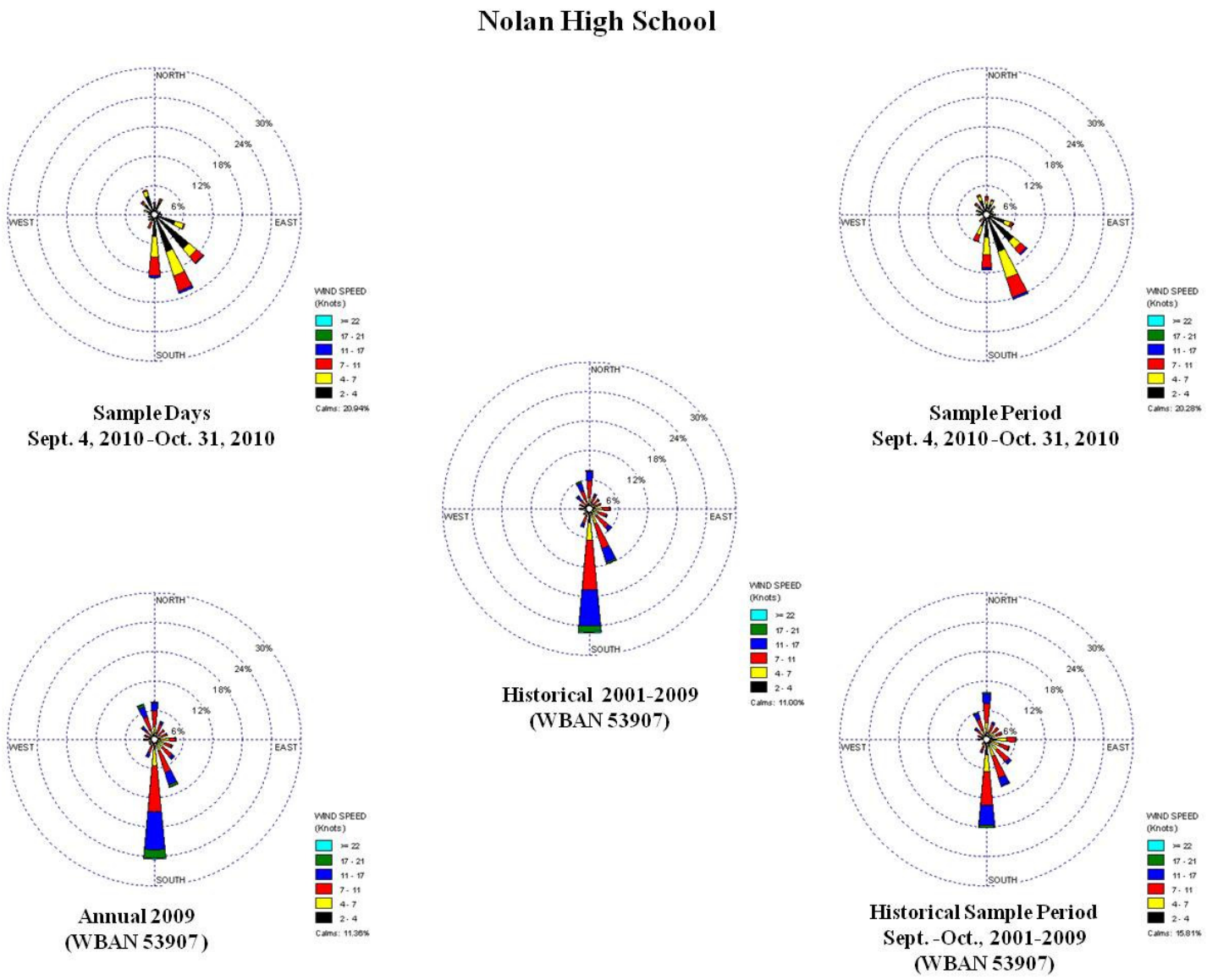


Figure 2.5-10. Site S-2 Windrose Comparisons

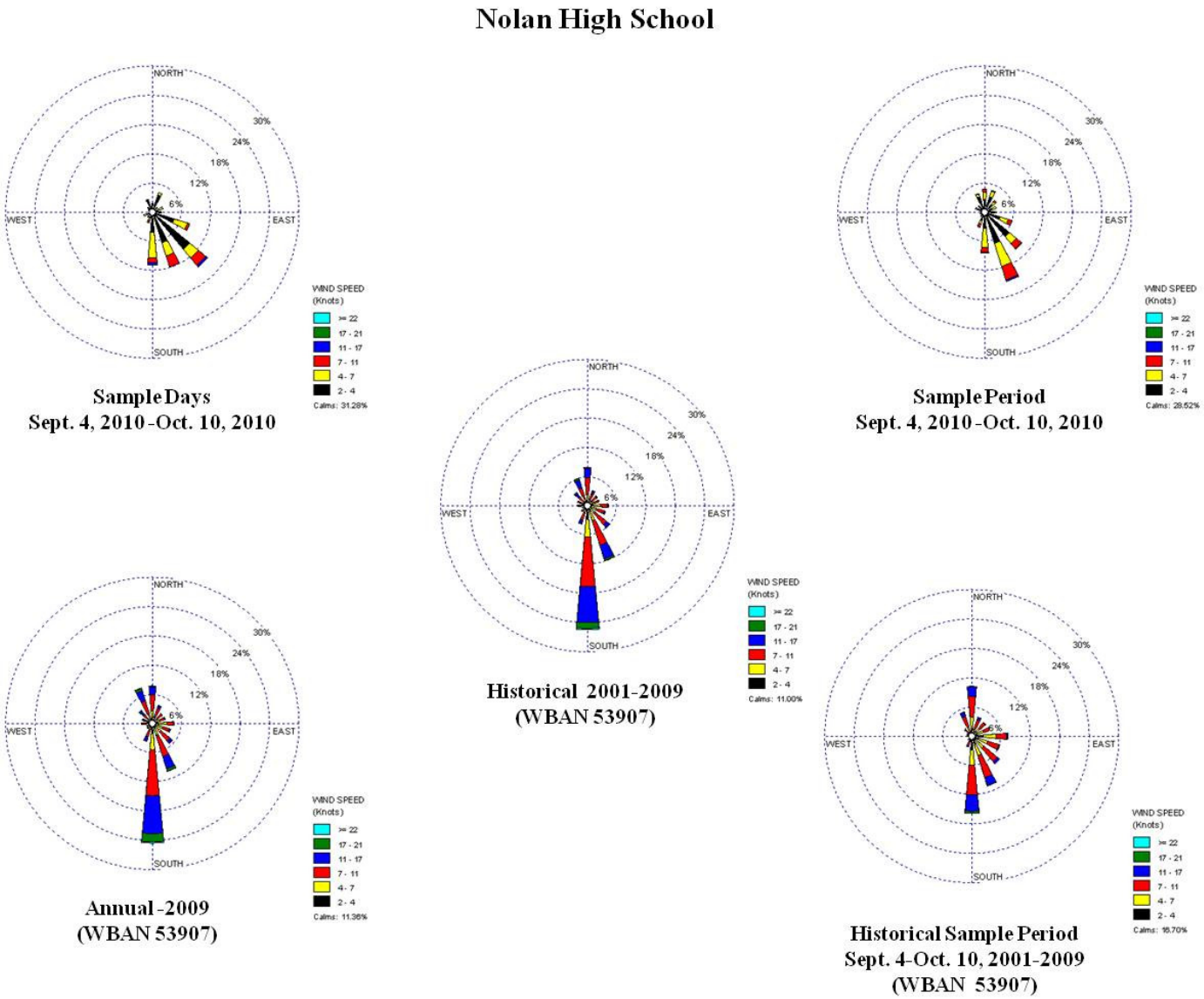


Figure 2.5-11. Site S-3A Windrose Comparisons

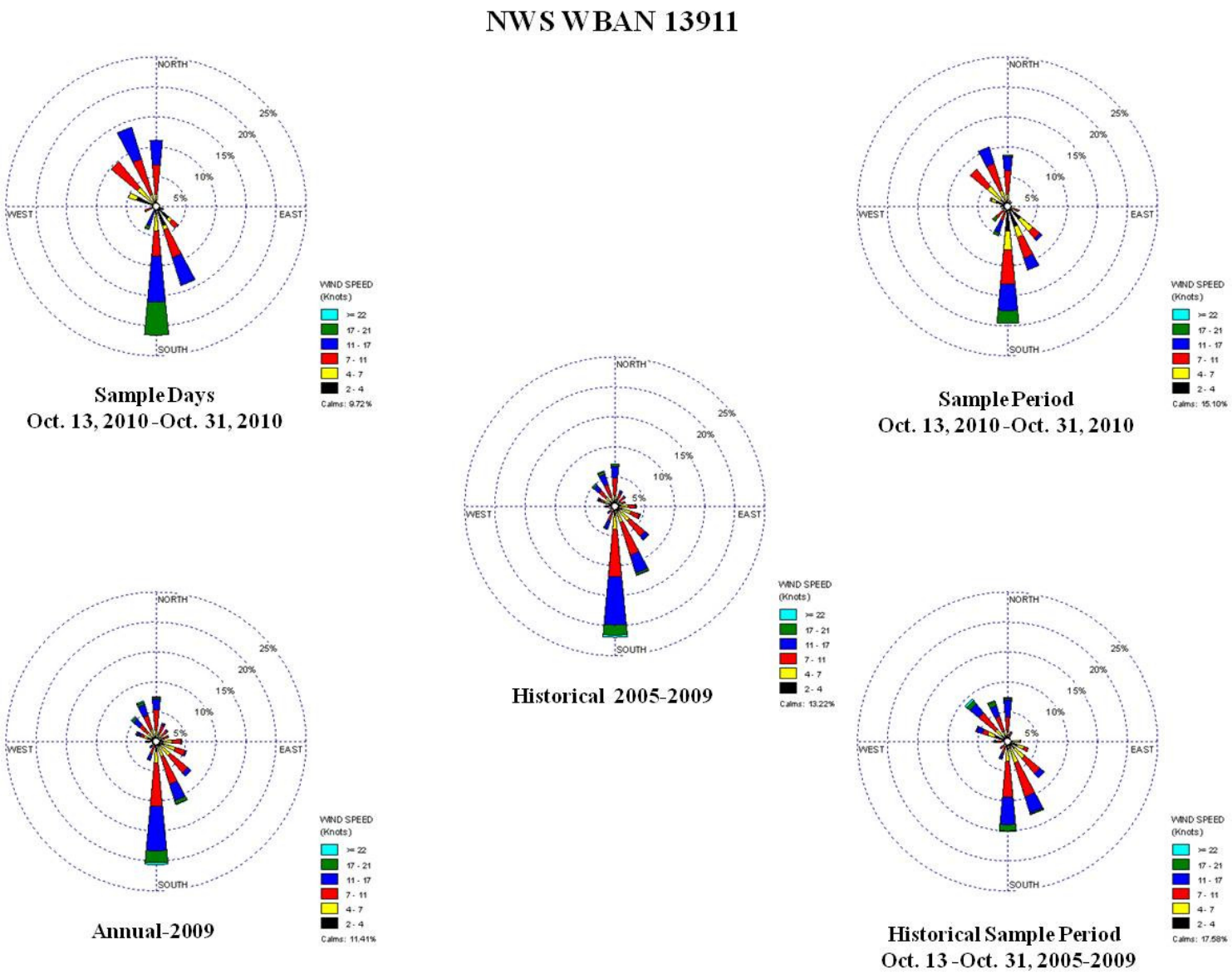


Figure 2.5-12. Site S-3B Windrose Comparisons

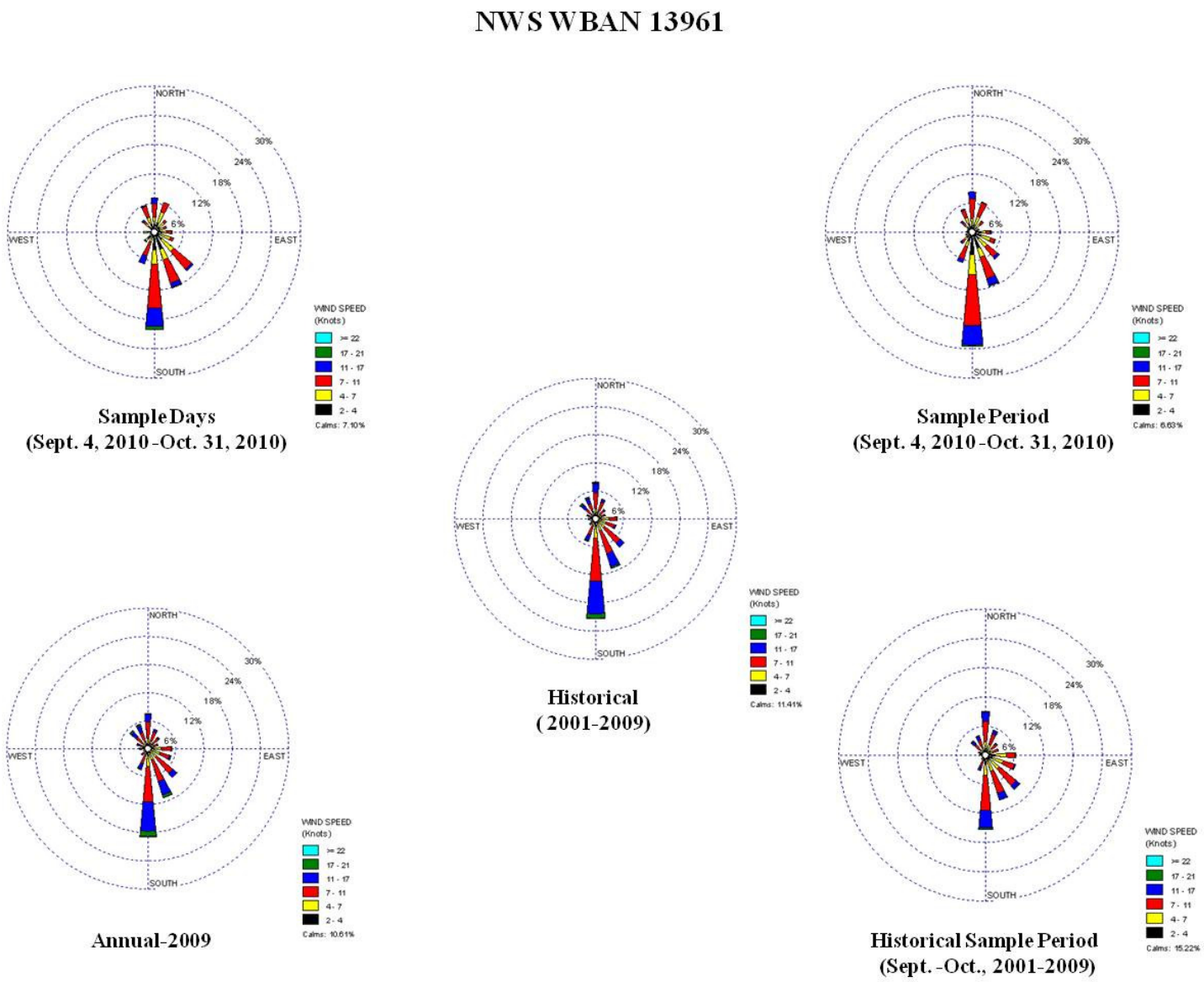


Figure 2.5-13. Site S-4 Windrose Comparisons

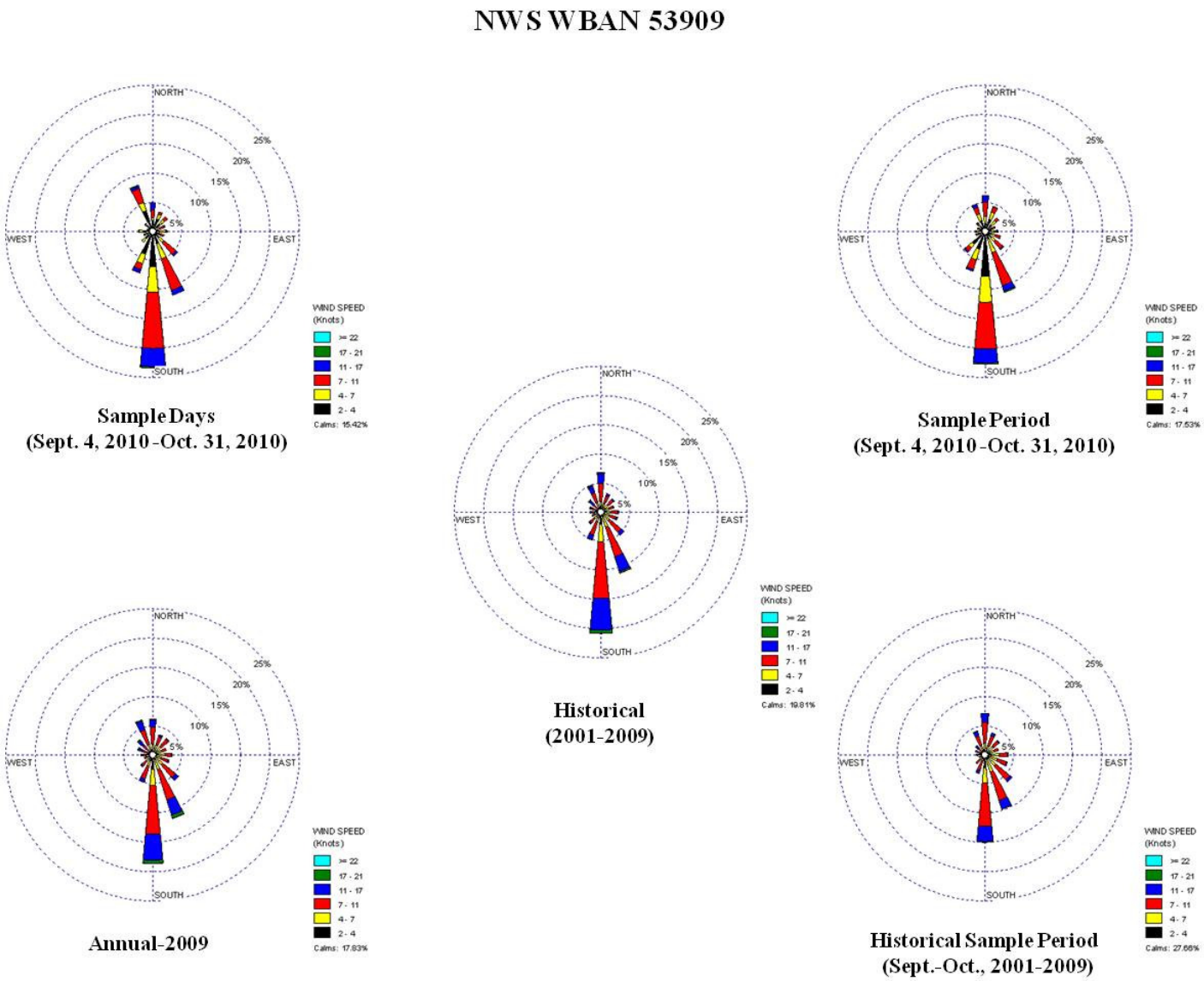


Figure 2.5-14. Site S-5 Windrose Comparisons

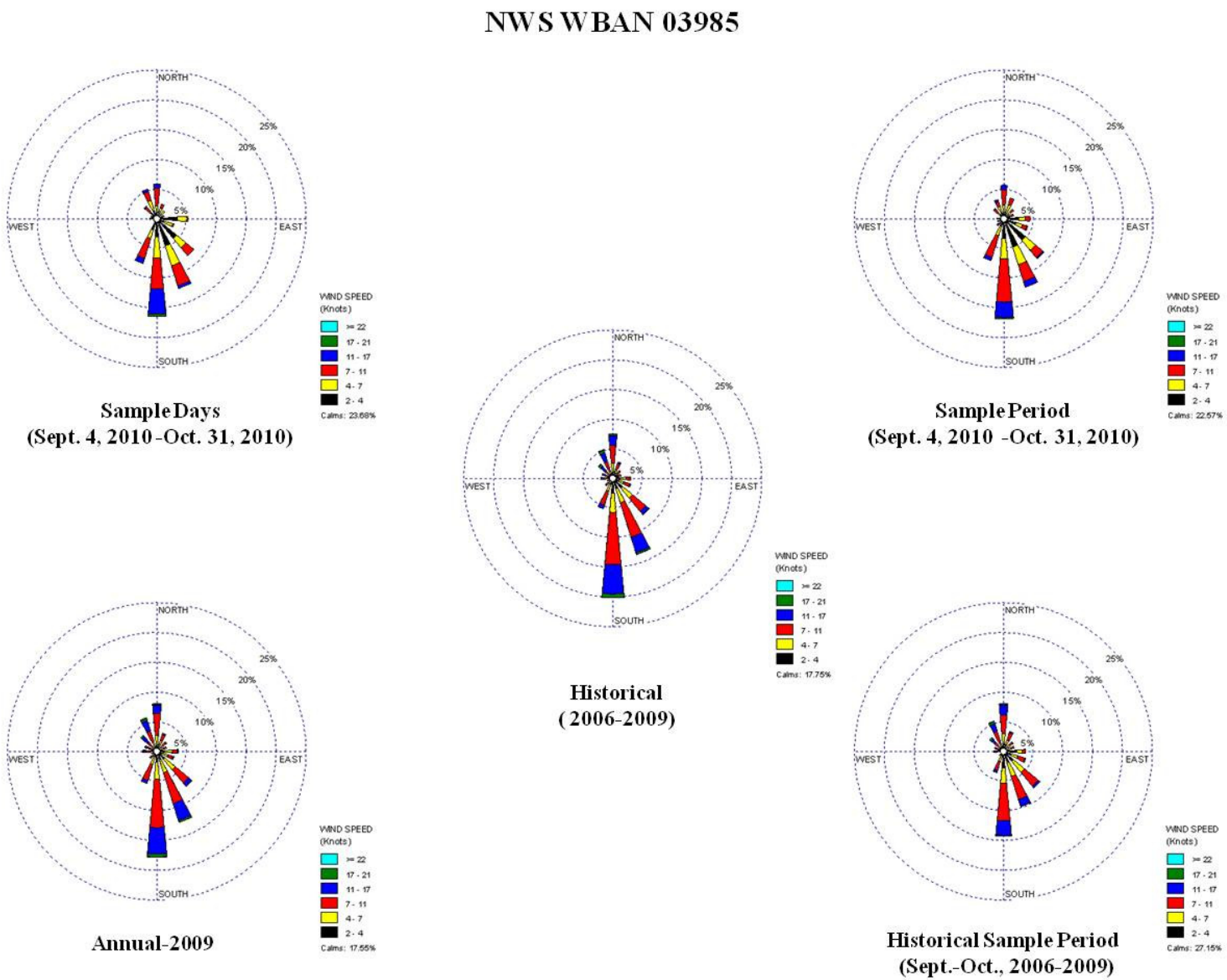


Figure 2.5-15. Site S-6 Windrose Comparisons

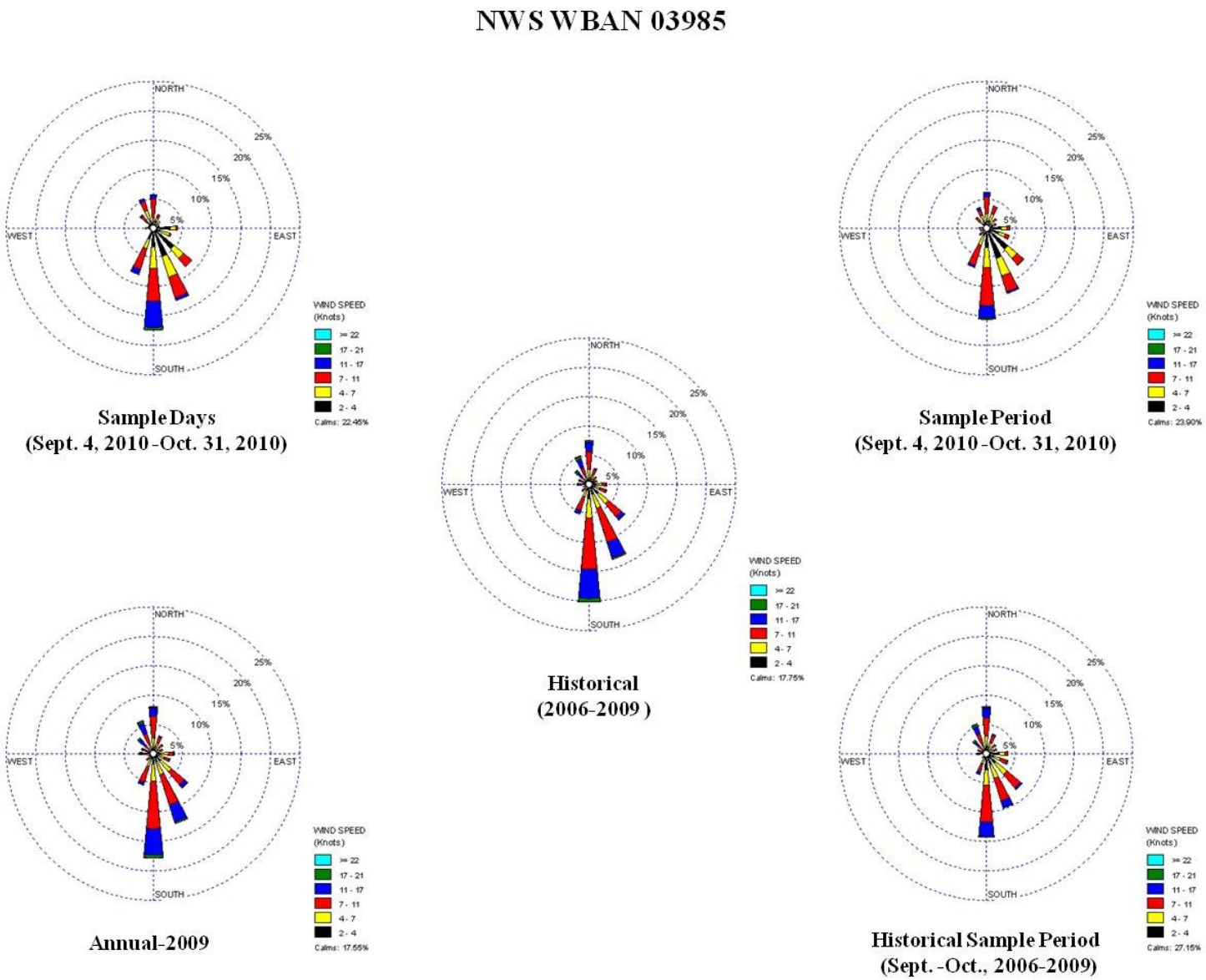


Figure 2.5-16. Site S-7 Windrose Comparisons

2.6 Ambient Air Monitoring Conclusions

Ambient air monitoring sampling at eight monitoring sites for nearly 140 pollutants yielded over 15,000 data points for this study. The ambient monitoring data presented in this report is based on air samples collected during a two-month timeframe at eight locations. The data should not be used to make inferences about air quality during times when, and locations where, samples were not collected. Insights from the dispersion modeling analysis have been used to help address this inherent limitation of the ambient air monitoring program, and a full discussion of the health implications of this study are presented in Section 5 of this report.

Key findings from the ambient monitoring study are as follows:

- 169 ambient air samples from 8 locations in Fort Worth were collected and analyzed, resulting in over 15,000 ambient air data points generated for this study.
- ERG found little variability across the sampling network for certain pollutants, such as carbon tetrachloride, chloroform, chloromethane, crotonaldehyde, dichlorodifluoromethane, dichlorotetrafluoroethane, ethylene, 1-hexene, isoprene, propylene, trichlorotrifluoromethane, and trichlorotrifluoroethane. The low variability across the entire network suggests that these pollutants are not affected by localized, anthropogenic sources, but rather exist as background pollutants.
- Benzene and carbon tetrachloride were identified as key VOCs at each site.
- Acetaldehyde and formaldehyde were identified as key carbonyls at Sites S-4 and S-5.
- No SNMOCs were identified as key pollutants.
- Concentrations measured at Site S-4 (located in a high-level activity area near compressor stations, well pads, and mobile sources) were generally higher than at other sites. For some of the key pollutants (acetaldehyde and benzene), concentrations at this site were considerably higher.
- Pollutant concentrations at Sites S-6 and S-7 (located in a medium-level activity area) were surprisingly low relative to other sites, especially given their close proximity to active well pad locations.
- Concentrations at Site S-1 ("background" site with no nearby natural gas well pads upwind) were generally similar to Site S-2 ("mobile sources" site). Concentrations at these two sites were slightly higher than Sites S-6 and S-7.
- Concentrations at the two "preproduction" sites did not display higher pollutant concentrations than the two monitoring stations designated as "background" and "mobile source" sites.
- Wind patterns observed during the sampling period were consistent with historical wind patterns, indicating proper placement of the ambient air monitors.