

Air Quality Sampling Near Hollingsworth and Vose in Corvallis, Oregon

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Laboratory and Environmental Assessment Program

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DEQ is a leader in restoring, maintaining and enhancing the quality of Oregon's air, land and water.



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Executive Summary

In July of 2017, due to concerns over air quality of the surrounding community, the Oregon DEQ started collecting air samples near Hollingsworth and Vose (H&V). H&V is a facility in Corvallis, OR that emits glass fibers as a byproduct of their specialty purpose fiber manufacturing process.

DEQ collected air samples approximately every three days over a 12 hour period. Four sampling locations were chosen and monitored for one month. Data from a wind sensor located on the H&V property was used to evaluate wind conditions during the sampling period.

No health-based guideline exists for the specific type of glass fibers that are produced by H&V. However, the Agency for Toxic Substances and Disease Registry (ATSDR) has established a minimal risk level (MRL) of 0.03 fibers/cc for chronic exposure to refractory ceramic fibers (RCF) which are considered to be the most toxic of all types of synthetic vitreous fibers (ATSDR 2004). Though H&V does not emit RCFs, the MRL for RCFs may be used as a cautious point of reference with which to compare the concentration of glass fibers from samples collected around H&V. Monitoring results were also compared to the NIOSH recommended exposure level of 3 fibers/cc, which applies to occupational exposure of all types of respirable glass fibers.

A total of 38 primary air samples were taken along with five duplicate samples. All samples were analyzed using phase contrast microscopy (PCM) which is the standard method for the determination of airborne fibrous particles in the workplace (NIOSH Method 7400). The PCM results showed the concentration of airborne fibers in all samples was less than or equal to 0.002 fibers/cc. Nine samples were further analyzed by transmission electron microscopy (TEM) to identify the specific types of fibers present in the samples (NIOSH Method 7402). TEM results showed that 99.2% of the fibers in the nine samples were classified as man-made vitreous fibers, which is the general class of fiber emitted by the H&V facility.

All laboratory results from PCM analysis show that airborne fiber concentrations are below the MRL for RCFs and significantly below the NIOSH recommended exposure level. These data suggest that the fiber concentrations detected are unlikely to pose respiratory health risks.

Key Findings:

- There is no specific health-based standard for the types of fibers emitted by H&V. However, as a health-protective approach, DEQ compared air monitoring results to health-based comparison values for refractory ceramic fiber and NIOSH workplace exposure limit for all types of respirable glass fiber.
- All PCM results were below the NIOSH recommended exposure level of 3.0 fibers/cc for workplace exposure and below the minimal risk level of 0.03 fibers/cc for chronic exposure to refractory ceramic fibers.
- Only one sample (out of 43 total) showed airborne fiber concentrations above the highest PCM method detection limit of 0.001 fibers/cc (Crystal Lake Dr. on 7/3/17, 0.002 fibers/cc).
- TEM analysis showed that 99.2% of airborne fibers were classified as man-made vitreous fibers (MMVF), which is the same type of fiber emitted by H&V as part of their manufacturing process. One sample analyzed by TEM showed a concentration of MMVFs (0.0989 fibers/cc) above the MRL for chronic exposure to RCFs (0.03 fibers/cc) and significantly below the NIOSH recommended exposure level for airborne fibers in the workplace (3 fibers/cc).
- A diurnal wind pattern was observed. Wind directions were generally from the east during the morning to afternoon period, and switched to generally from the west-northwest during the afternoon to evening period.

1. Introduction and Background

Hollingsworth and Vose (H&V) is a specialty glass fiber manufacturing company which has a facility located in the southeast corner of Corvallis, Oregon. They produce raw materials for filtration, battery, and industrial applications. H&V currently has the potential to emit over 100 tons per year of carbon monoxide and is therefore considered a “major source” of air pollutants by the U.S. Environmental Protection Agency (EPA). Title V of the Clean Air Act requires all major sources to obtain and operate in compliance with a permit which is administered by Oregon DEQ.

As part of its manufacturing process, H&V emits particulate matter as glass fibers from its facility. Concern has been raised from within the nearby community that airborne fibers may be negatively impacting human health. DEQ conducted air monitoring near the H&V facility in order to assess the concentrations of airborne fibers in the area. The purpose of this report is to present the results of this sampling effort.

1.1 Glass Fiber Hazards and Standards

1.1.1 Glass Fiber Hazards

In their manufacturing process, H&V emits glass fibers that are classified as a type of ‘special purpose fiber’. For the purposes of evaluating toxicity, the fibers fall into the broad category of ‘synthetic vitreous fibers’, also referred to as ‘man-made vitreous fibers’ (MMVF). There are three general categories of synthetic vitreous fibers: fiberglass (glass wool and glass filament), mineral wool (rock wool and slag wool), and refractory ceramic fibers (RCF). These categories cover a range of fiber types that vary in toxicity. Toxicity of some of the more widely used MMVFs is well-studied. Toxicity of other less well-studied fibers may be predicted based on similarity to fibers that are better characterized. Based on physical and chemical characteristics, RCFs are considered to be the most toxic of the synthetic vitreous fibers because they are the most durable and biopersistent. When these fibers become airborne, they can cause irritation to the eyes, nose, throat and lungs. These non-cancer effects are typically reversible and often disappear shortly after exposure ceases. Research in animals suggests that chronic exposure to some synthetic vitreous fibers in air may cause inflammation and fibrosis in the lung.

The U.S. EPA has classified RCFs as a *probable human carcinogen* (IRIS 2017) but has not quantitatively assessed the potential carcinogenicity of any glass fibers (ATSDR 2004). U.S. EPA Hazard Summary for Fine Mineral Fibers reports that “most studies in humans have not shown an increase in cancer from exposure to glasswool, glass filaments, rockwool, and slagwool” (EPA 2016). Because no agency has defined a relationship between exposure to glass fibers and cancer risk, it is not possible to make clear conclusions about any cancer risk that may be associated with exposure to specific forms of glass fibers. Generally, fibers that are inhalable and that remain in the lungs for long periods are thought to have the highest potential cancer risk. The National Toxicology Program has concluded that certain (inhalable and biopersistent) glass wool fibers that are inhalable and biopersistent are “reasonably anticipated to be carcinogenic”. The World Health Organization (WHO) International Agency for Research on Cancer concluded that glass filaments were *not classifiable as to carcinogenicity to humans* due to the “inadequate evidence of carcinogenicity in humans and the low biopersistence of these materials”.

1.1.2 Glass Fiber Standards

Both the National Institute of Occupational Health and Safety (NIOSH) and the Occupational Safety and Health Administration (OSHA) have standards relating to glass fiber dust, a broad category that would include the glass fiber emissions from H&V. The NIOSH has a recommended exposure limit (REL) of 3.0 fibers/cc for glass dust (fibers $\leq 3.5 \mu\text{m}$ in diameter & $\geq 10 \mu\text{m}$ in length). This is a time-weighted average concentration for up to a 10-hour workday during a 40-hour workweek. The Occupational Safety and Health Administration (OSHA) has a permissible exposure limit (PEL) of 5 mg/m³ for glass fibers (fibers $\leq 3.5 \mu\text{m}$ in diameter & $\geq 10 \mu\text{m}$ in length). This level must not be exceeded during any 8-hour work shift of a 40-hour workweek.

While workplace standards provide some context for air monitoring results, it is important to understand that they are often developed based on what is practical to achieve in addition to what is protective of human health. Workplace standards are not designed to be protective of sensitive populations like children or people with chronic disease. For that reason, they are not always appropriate for evaluation of potential public health risks for the general population.

There are no public health-based standards for the specific type of glass fibers emitted by H&V. In the absence of health-based standards for the specific fibers of interest at H&V, we can instead compare monitoring results to standards developed for other, more toxic fibers. If monitored concentrations are below health-based standards for more toxic fibers, we can have reasonable confidence that the concentrations detected near H&V are not high enough to harm health. The Agency for Toxic Substances and Disease Registry (ATSDR) established a minimal risk level (MRL) of 0.03 fibers/cc for chronic-duration inhalation exposure to RCFs (ATSDR 2004). MRLs are health-based guidelines designed to protect the health of the general population. The H&V facility does not emit RCF fibers, however, RCFs are considered to be the most toxic type of synthetic vitreous fiber. Therefore the MRL for RCF fibers may serve as a health-protective point of reference for concentrations of glass fibers detected in air near the facility.

1.2 H&V Facility and Operations

The H&V facility operates continuously (24 hours per day and 7 days per week). Correspondingly, the emission rate of glass fibers is relatively constant and continuous.

2. Air Quality Sampling

2.1 Partnerships

DEQ partnered with Oregon State University (OSU) to staff the air monitoring effort. DEQ air quality monitoring specialists established the monitoring locations and completed the initial setup of monitoring equipment. A graduate student from OSU was trained by DEQ staff on procedures used to setup samples in the field, retrieve completed samples and data from the instruments, as well as on documentation procedures which accompany completed samples.

The DEQ laboratory is not currently certified to implement the National Institute for Occupational Safety and Health (NIOSH) 7400 analytical method that was used to analyze the air quality samples, therefore all completed samples were sent to LabCor Inc. in Portland for laboratory analysis.

Wind data was collected by instruments owned by H&V. The operation and maintenance of the wind sensor followed a plan that was reviewed and approved by DEQ.

The Oregon Health Authority was consulted in order to evaluate any human health risks associated with the levels of fibers found in this sampling effort.

2.2 Sampling Locations

Three air quality samplers were setup adjacent to the H&V facility to measure nearfield airborne fiber concentrations. A fourth sampler was set up approximately 0.6 miles to the southwest of the H&V facility for the purposes of measuring fiber concentrations away from the facility. The meteorological (“met”) station is located adjacent to the H&V facility and was used to assess wind conditions during the sampling period (Figure 1).

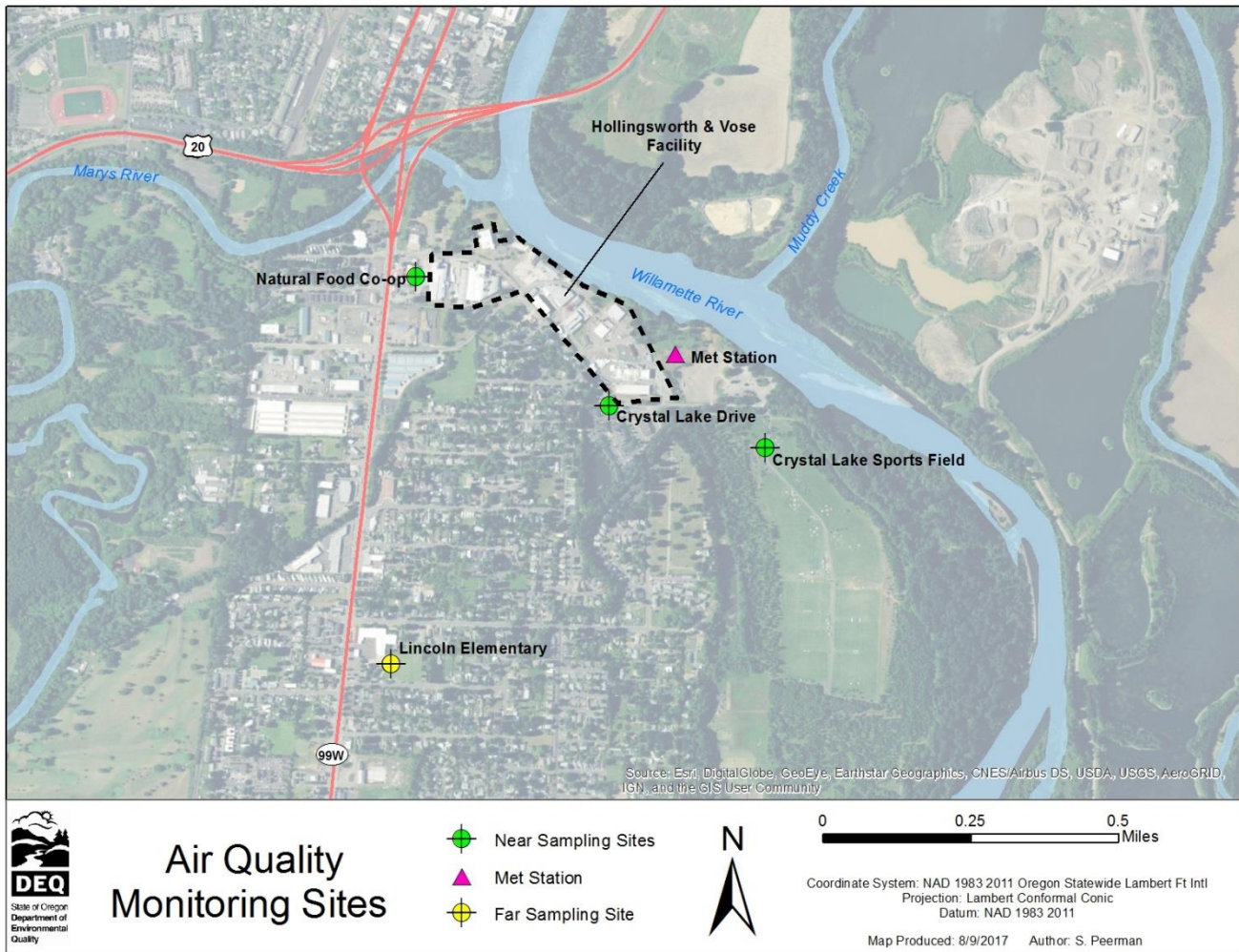


Figure 1. Air quality monitoring sites located near Hollingsworth & Vose.

2.3 Sampling Method

A total of 38 primary air samples were taken along with five field duplicate air samples for quality assurance purposes. Samples were collected approximately every 3 days starting on July 3rd and ending on August 3rd. Individual samples were collected by drawing ambient air through a cellulose filter at a constant flow rate of 8.5 liters per minute (LPM) for a duration of 12 hours. The cellulose filters trap airborne fibers of any composition, including glass fibers.

A total of 15 air samples were taken during the daytime (8 a.m. – 8 p.m. PST) while 23 air samples were taken during nighttime (8 p.m. – 8 a.m. PST).

2.4 Laboratory Analysis

2.4.1 PCM Analysis

Completed air samples were analyzed by LabCor Inc. in Portland using NIOSH Method 7400. This method uses phase contrast microscopy (PCM) to determine the concentration and density of fibers collected on the filters and is the current standard for the determination of airborne fibrous particles in the workplace (ATSDR 2004). All fibers which met the analytical method criteria specified in NIOSH Method 7400 Appendix C, regardless of fiber

type, were counted during PCM analysis. This analytical method does not distinguish between glass fibers and fibers of other types.

2.4.1 TEM Analysis

In order to determine the types of fibers present in the air samples, nine samples were further analyzed using transmission electron microscopy (TEM). The sample with the highest fiber density from each of the four sites, as indicated by PCM results, was chosen for further TEM analysis along with a mix of other samples. LabCor Inc. performed the TEM analysis following NIOSH Method 7402. Fibers were classified as man-made vitreous fibers (MMVF), Libby-other amphibole, asbestos, or non-asbestos.

3. Results

3.1 PCM Results

PCM results showed the concentration of airborne fibers was less than or equal to 0.002 fibers/cc in all samples. The highest detection limit of the analytical method for the concentration of airborne fibers was 0.001 fibers/cc. The detection limit of the method is the minimum amount of a substance that the analytical process can reliably detect. The only sample that was above this detection limit was the duplicate sample taken at the Crystal Lake Dr. site on July 3rd, 2017 (result = 0.002 f/cc). The fiber concentration and fiber density results for primary samples analyzed by PCM are presented below in Table 1. Results for duplicate samples analyzed by PCM are presented in Table 2.

Air Quality Sampling Near Hollingsworth and Vose in Corvallis, Oregon

Table 1. Phase Contrast Microscopy (PCM) results for primary air quality samples collected near Corvallis, Oregon. Filter samples were analyzed by Phase Contrast Microscopy (PCM) which counts fibers of any type (ex. glass, wool, non-natural) that meet the analytical method criteria. Samples were analyzed by LabCor Inc. in Portland.

Sample Date	Sample Start Time (PST)	Sample Duration	Sample Type	Fiber Concentration (fibers / cc)	Fiber Density (fibers / mm ²)
Site: Lincoln Elementary					
7/3/17	8:00	12 hours	Primary	< 0.0004	< 7.0000
7/6/17	8:00	12 hours	Primary	< 0.0004	< 7.0000
7/9/17	8:00	12 hours	Primary	< 0.0004	< 7.0000
7/12/17	8:00	12 hours	Primary	< 0.0004	< 7.0000
7/18/17	20:00	12 hours	Primary	0.001	8.5454
7/21/17	20:00	12 hours	Primary	< 0.0004	< 7.0000
7/24/17	20:00	12 hours	Primary	< 0.0004	< 7.0000
7/27/17	20:00	12 hours	Primary	< 0.0004	< 7.0000
7/30/17	20:00	12 hours	Primary	< 0.0004	< 7.0000
Site: Natural Foods Co-op					
7/3/17	8:00	12 hours	Primary	< 0.0004	< 7.0000
7/6/17	8:00	12 hours	Primary	< 0.0004	< 7.0000
7/9/17	8:00	12 hours	Primary	< 0.0004	< 7.0000
7/12/17	8:00	12 hours	Primary	< 0.0004	< 7.0000
7/18/17	20:00	12 hours	Primary	< 0.0004	< 7.0000
7/21/17	20:00	12 hours	Primary	< 0.0004	< 7.0000
7/24/17	20:00	12 hours	Primary	< 0.0004	< 7.0000
7/26/17	20:00	12 hours	Primary	0.001	10.496
7/27/17	20:00	12 hours	Primary	< 0.0004	< 7.0000
7/30/17	20:00	12 hours	Primary	< 0.0005	< 7.0000
Site: Crystal Lake Drive					
7/3/17	8:00	12 hours	Primary	0.001	23.5659
7/6/17	8:00	12 hours	Primary	< 0.0004	< 7.0000
7/9/17	8:00	12 hours	Primary	0.001	13.3758
7/12/17	8:00	12 hours	Primary	0.001	12.1019
7/15/17	20:00	12 hours	Primary	0.001	14.0127
7/18/17	20:00	12 hours	Primary	0.001	10.496
7/21/17	20:00	12 hours	Primary	< 0.001	7.8952
7/24/17	20:00	12 hours	Primary	< 0.0004	< 7.0000
7/27/17	20:00	12 hours	Primary	< 0.0004	< 7.0000
7/30/17	20:00	12 hours	Primary	0.001	8.5454
Site: Crystal Lake Sports Field					
7/3/17	8:00	12 hours	Primary	< 0.0004	< 7.0000
7/7/17	8:00	12 hours	Primary	< 0.0004	< 7.0000
7/9/17	8:00	12 hours	Primary	0.001	< 7.0000
7/15/17	20:00	12 hours	Primary	0.001	8.9172
7/18/17	20:00	12 hours	Primary	0.001	11.7964
7/24/17	20:00	12 hours	Primary	0.001	8.5454
7/25/17	20:00	12 hours	Primary	< 0.0004	< 7.0000
7/27/17	20:00	12 hours	Primary	0.001	9.1956
8/3/17	20:00	12 hours	Primary	< 0.0004	< 7.0000

Table 2. Phase Contrast Microscopy (PCM) results for duplicate air quality samples collected near Corvallis, Oregon. Filter samples were analyzed by Phase Contrast Microscopy (PCM) which counts fibers of any type (ex. glass, wool, non-natural) that meet the analytical method criteria. Samples were analyzed by LabCor Inc. in Portland.

Site	Sample Date	Sample Start Time (PST)	Sample Duration	Sample Type	Fiber Concentration (fibers / cc)	Fiber Density (fibers / mm ²)
Crystal Lake Drive	7/3/17	8:00	12 hours	Duplicate	0.002	37.5796
Crystal Lake Drive	7/9/2017	8:00	12 hours	Duplicate	0.001	15.2866
Crystal Lake Drive	7/15/2017	20:00	12 hours	Duplicate	0.001	12.1019
Crystal Lake Drive	7/21/2017	20:00	12 hours	Duplicate	< 0.0004	< 7.0000
Crystal Lake Drive	7/27/2017	20:00	12 hours	Duplicate	< 0.0004	< 7.0000

3.2 TEM Results

No asbestos fibers were detected in any of the nine samples analyzed by TEM. Five fibers were identified as non-asbestos, while all other fibers (637 fibers total) were classified as man-made vitreous fibers (MMVF). Results for samples analyzed by TEM are presented in Appendix A: TEM Results.

In addition to characterizing the types of fibers detected, TEM analysis also provided additional data on fiber concentrations. TEM provides very high resolution imaging that is more sensitive than the standard PCM detection method. The MMVF fiber concentrations detected by TEM are also shown in Appendix A. One sample showed a concentration (0.0989 fibers/cc) of MMVFs above the MRL for chronic exposure to RCFs (0.03 fibers/cc) and significantly below the NIOSH recommended exposure level for airborne fibers in the workplace (3 fibers/cc).

3.3 Meteorological Conditions

A diurnal wind pattern was observed during the sampling period. Wind directions were generally from the east during the morning to afternoon period, and switched to generally from the west-northwest during the afternoon to evening period. Various wind rose plots are presented in Appendix B: Meteorological Data.

4. Summary

PCM analysis of 43 total air samples showed only one 12-hr sample that was above the highest method detection limit of 0.001 f/cc. One 12-hr air sample taken from 8 a.m. – 8 p.m. on July 3rd at the Crystal Lake Drive site showed an airborne concentration of 0.002 f/cc. All results are below the general NIOSH recommended exposure level of 3 f/cc for all types of glass fiber dust in the workplace. All PCM results were also below the minimal risk level for refractory ceramic fibers, a separate type of MMVF that is considered to be more toxic than glass fibers. TEM analysis showed that almost all fibers were identified as MMVF fibers (as opposed to asbestos or plant fibers), which are the same type of fiber that is emitted by the H&V facility.

In order to evaluate potential health risks that may result from the concentrations observed during this sampling effort, DEQ consulted with Oregon Health Authority for guidance. As described above in section 1.1.1, there is not sufficient evidence in the scientific literature to support definitive conclusions about cancer risks from exposure to glass fibers. To evaluate non-cancer risks we compared these air monitoring results with available health-based comparison values for the most toxic type of MMVF fibers. These comparisons indicate that it is unlikely for chronic exposure to fiber concentrations detected near the facility to result in non-cancer health effects.

5. References

Agency for Toxic Substances and Disease Registry (ATSDR). 2004. Toxicological profile for Synthetic Vitreous Fibers. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Integrated Risk Information System (IRIS). Chemical Assessment Summary for Refractory Ceramic Fibers. National Center for Environmental Assessment. Accessed: October 2017.

NIOSH 7400. Manual of Analytical Methods. 4th Edition. 1994. Asbestos and Other Fibers by PCM. Method 7400, Issue 2. Appendix C.

NIOSH 7402. Manual of Analytical Methods. 4th Edition. 1994. Asbestos and by TEM. Method 7402, Issue 2.

U.S. EPA. Hazard Summary for Fine Mineral Fibers. Summary updated September 2016.
<https://www.epa.gov/sites/production/files/2016-10/documents/fine-mineral-fibers.pdf>

Appendix A: TEM Results

Nine samples were analyzed using transmission electron microscopy (TEM) for the purposes of classifying the types of fibers present in the air samples. In contrast, the results from phase contrast microscopy (PCM) analysis are used for comparison to health-based concentrations.

Table A-1. Summary of Transmission Electron Microscopy (TEM) results for selected air quality samples collected near Corvallis, Oregon. A total of nine filters were analyzed by TEM to characterize the types of fibers present in the air samples. TEM categorizes fibers into four categories: asbestos, non-asbestos, man-made vitreous fibers (MMVF), or Libby or other amphibole. Samples were analyzed by LabCor Inc.

Site: Crystal Lake Drive
Sample Start Date & Time (PST): 7/3/2017 8:00
Sample Duration: 12 hours
Sample Type: Duplicate

<i>Structure Type</i>	<i>Fiber Count</i>	<i>(fibers/cc) Concentration</i>
NIOSH Asbestos	0	< 0.0002
NIOSH Non-Asbestos	0	< 0.0002
NIOSH Libby-Other Amphibole	0	< 0.0002
NIOSH MMVF Fibers	104	0.0182
NIOSH Total Fibers	104	0.0182

Site: Crystal Lake Drive
Sample Start Date & Time (PST): 7/12/2017 8:00
Sample Duration: 12 hours
Sample Type: Primary

<i>Structure Type</i>	<i>Fiber Count</i>	<i>(fibers/cc) Concentration</i>
NIOSH Asbestos	0	< 0.0002
NIOSH Non-Asbestos	0	< 0.0002
NIOSH Libby-Other Amphibole	0	< 0.0002
NIOSH MMVF Fibers	101	0.0224
NIOSH Total Fibers	101	0.0224

Site: Lincoln Elementary
Sample Start Date & Time (PST): 7/15/2017 20:00
Sample Duration: 12 hours
Sample Type: Primary

<i>Structure Type</i>	<i>Fiber Count</i>	<i>(fibers/cc) Concentration</i>
NIOSH Asbestos	0	< 0.0003
NIOSH Non-Asbestos	3	0.0009
NIOSH Libby-Other Amphibole	0	< 0.0003
NIOSH MMVF Fibers	98	0.0283
NIOSH Total Fibers	101	0.0291

Air Quality Sampling Near Hollingsworth and Vose in Corvallis, Oregon

Site: Crystal Lake Drive
Sample Start Date & Time (PST): 7/9/2017 8:00
Sample Duration: 12 hours
Sample Type: Primary

<i>Structure Type</i>	<i>Fiber Count</i>	<i>(fibers/cc) Concentration</i>
NIOSH Asbestos	0	< 0.0008
NIOSH Non-Asbestos	0	< 0.0008
NIOSH Libby-Other Amphibole	0	< 0.0008
NIOSH MMVF Fibers	120	0.0989
NIOSH Total Fibers	120	0.0989

Site: Crystal Lake Sports Field
Sample Start Date & Time (PST): 7/18/2017 20:00
Sample Duration: 12 hours
Sample Type: Primary

<i>Structure Type</i>	<i>Fiber Count</i>	<i>(fibers/cc) Concentration</i>
NIOSH Asbestos	0	< 0.0001
NIOSH Non-Asbestos	0	< 0.0001
NIOSH Libby-Other Amphibole	0	< 0.0001
NIOSH MMVF Fibers	20	0.0029
NIOSH Total Fibers	20	0.0029

Site: Crystal Lake Drive
Sample Start Date & Time (PST): 7/18/2017 20:00
Sample Duration: 12 hours
Sample Type: Primary

<i>Structure Type</i>	<i>Fiber Count</i>	<i>(fibers/cc) Concentration</i>
NIOSH Asbestos	0	< 0.0001
NIOSH Non-Asbestos	1	0.0001
NIOSH Libby-Other Amphibole	0	< 0.0001
NIOSH MMVF Fibers	1	0.0001
NIOSH Total Fibers	2	0.0003

Air Quality Sampling Near Hollingsworth and Vose in Corvallis, Oregon

Site: Lincoln Elementary

Sample Start Date & Time (PST): 7/18/2017 20:00

Sample Duration: 12 hours

Sample Type: Primary

<i>Structure Type</i>	<i>Fiber Count</i>	<i>(fibers/cc) Concentration</i>
NIOSH Asbestos	0	< 0.0001
NIOSH Non-Asbestos	1	0.0001
NIOSH Libby-Other Amphibole	0	< 0.0001
NIOSH MMVF Fibers	0	< 0.0001
NIOSH Total Fibers	1	0.0001

Site: Natural Food Co-op

Sample Start Date & Time (PST): 7/26/2017 20:00

Sample Duration: 12 hours

Sample Type: Primary

<i>Structure Type</i>	<i>Fiber Count</i>	<i>(fibers/cc) Concentration</i>
NIOSH Asbestos	0	< 0.0001
NIOSH Non-Asbestos	0	< 0.0001
NIOSH Libby-Other Amphibole	0	< 0.0001
NIOSH MMVF Fibers	1	0.0001
NIOSH Total Fibers	1	0.0001

Site: Crystal Lake Sports Field

Sample Start Date & Time (PST): 7/27/2017 20:00

Sample Duration: 12 hours

Sample Type: Primary

<i>Structure Type</i>	<i>Fiber Count</i>	<i>(fibers/cc) Concentration</i>
NIOSH Asbestos	0	< 0.0001
NIOSH Non-Asbestos	0	< 0.0001
NIOSH Libby-Other Amphibole	0	< 0.0001
NIOSH MMVF Fibers	36	0.0052
NIOSH Total Fibers	36	0.0052

Appendix B: Meteorological Data

Site: Hollingsworth & Vose
Date Range: July 1 - August 5, 2017
Sampling Interval: 1 hour

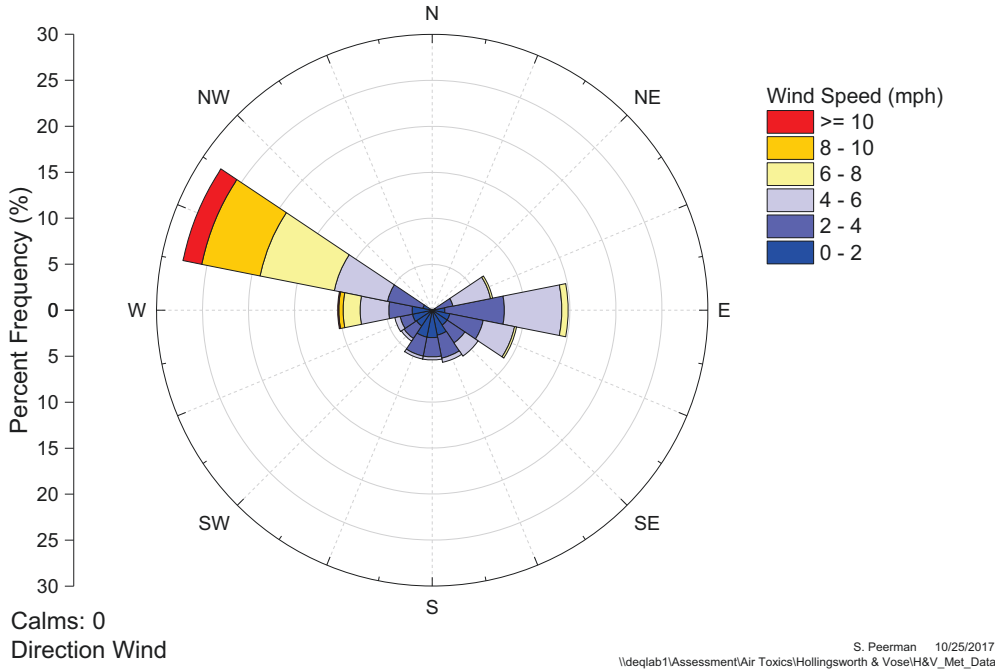


Figure B-1. Meteorological conditions during the sampling period. The meteorological station was located adjacent to the H&V facility.

Site: Hollingsworth & Vose
Date Range: July 1 - August 5, 2017
Sampling Interval: 1 hour

Daytime
 8 a.m. - 8 p.m. PST

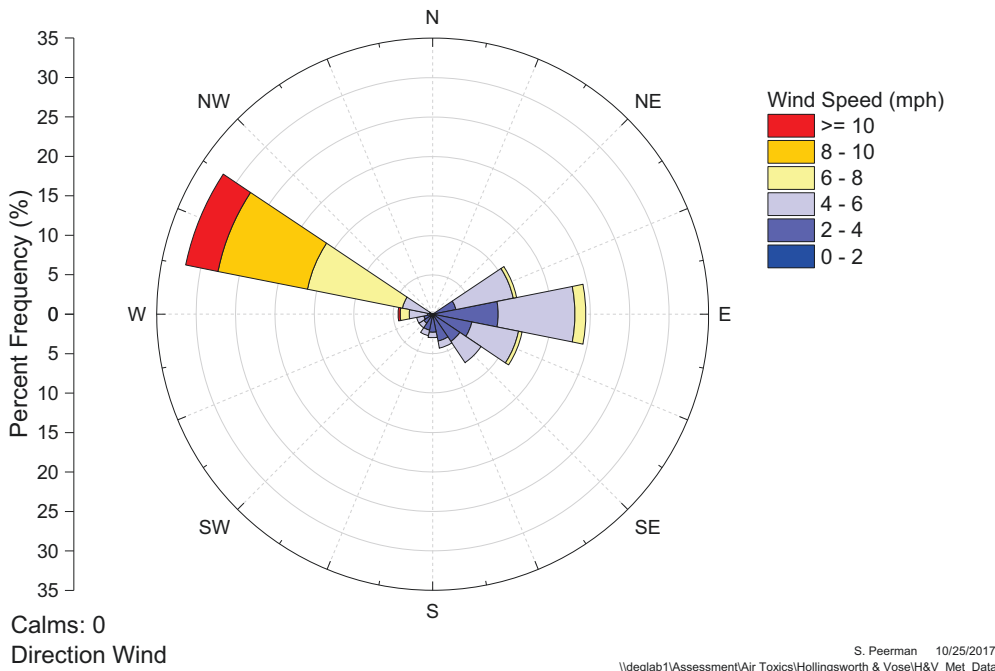


Figure B-2. Meteorological conditions during the daytime throughout the sampling period. The meteorological station was located adjacent to the H&V facility.

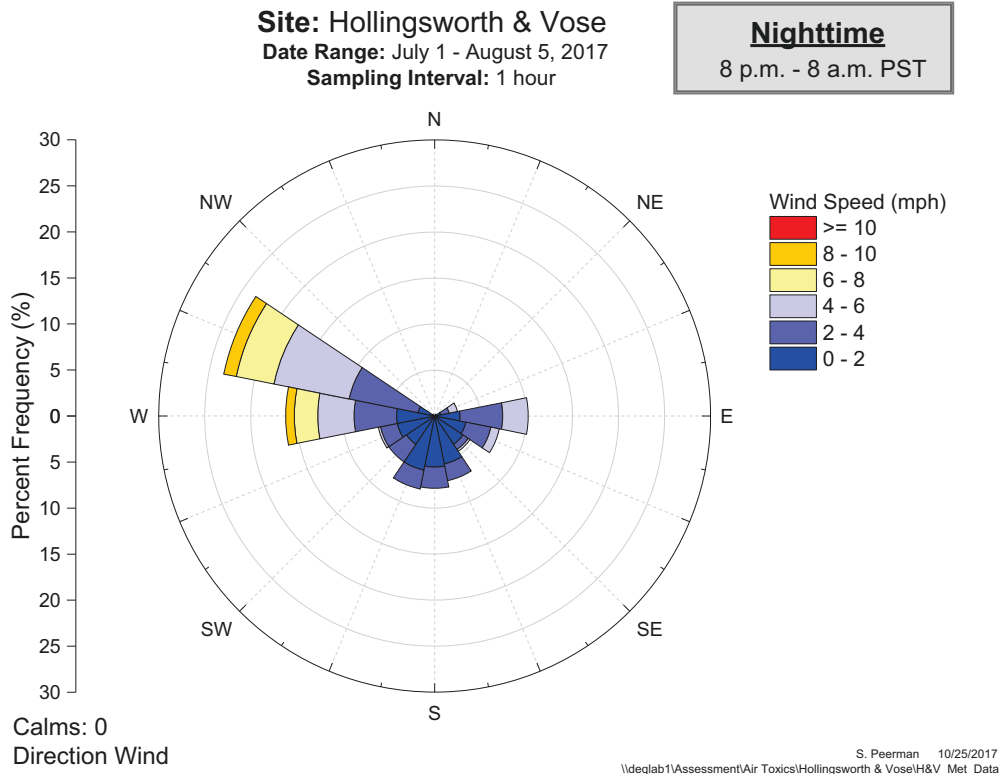


Figure B-3. Meteorological conditions during the nighttime throughout the sampling period. The meteorological station was located adjacent to the H&V facility.