



Limited Hazardous Material Sampling Assessment

Pierce Hall- First Floor South Hallway  
University of California - Riverside  
Riverside, California

Omega Project #2019-3488UCR  
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## 1. INTRODUCTION

On September 20th, 2019, Tanya Seneviratne, Industrial Hygienist with Omega Environmental Services, Inc. (Omega) conducted a limited hazardous material sampling assessment at Pierce Hall, University of California – Riverside (UCR) located in Riverside, California. Ms. Rebecca Lally, Certified Industrial Hygienist with Environmental Health and Safety, UCR (the Client) provided background information and arranged for site access for the assessment.

## 2. EXECUTIVE SUMMARY

The Client retained Omega to conduct a bioaerosol study of the south hallway in Pierce Hall. Ceiling substrate was recently removed in the subject hallway. Visible stain impacted Heating Ventilation and Air Conditioning (HVAC) fiberglass duct insulation (insulation) was noted in the sub-ceiling spaces. The study focused on suspect mold growth on the stained insulation material and its potential impact on the occupants using the subject hallway.

2.1 Omega's scope of work was limited to the following:

- Collect indoor air, surface, and bulk samples for viable and non-viable fungi; collect outdoor air samples for viable and non-viable fungi; and collect direct read measurements for aerosol particulate matter with diameters 3  $\mu\text{m}$  (micrometers), 5  $\mu\text{m}$ , and 10  $\mu\text{m}$  (PM<sub>3</sub>, PM<sub>5</sub>, and PM<sub>10</sub>) at indoor and outdoor locations using a factory calibrated laser particle counter (LPC); and
- Develop a written report discussing the findings, conclusions and recommendations.

2.2 Visual Findings:

The findings included sporadic staining and accumulated dust on the insulation in the sub-ceiling spaces along the south hallway. Infrared thermal images indicated temperature differentials suggesting retained moisture on a section of stained insulation located at the east end of the hallway near Room #1134. Moisture meter measurements collected confirmed the presence of retained moisture in the insulation.

2.3 Laboratory analytical results:

- Non-viable fungi (air): Indoor bioaerosol concentrations were comparable to those concentrations found in the outdoors at the time of sampling.
- Non-viable other particulates (air): Indoor other particulate concentrations were comparable to those concentrations found in the outdoors at the time of sampling. However, epithelial (skin) cell concentrations found indoors were elevated when compared to the outdoor concentrations.

- Non-viable particulates (surface tape): Fungal spores were not detected in the two indoor samples collected. Other particulates including cellulosic fibers (fabric/paper), synthetic fibers, fiberglass, soil minerals, carbonates (gypsum like), and fire residue (soot and char) were identified in both surface samples.
- Viable fungi (air): Colony forming units (CFUs) found indoors (4 samples) were unremarkable and comparable to those CFUs found outdoors (1 sample) at the time of sampling.
- Viable fungi (bulk): Omega collected 2 fibrous duct insulation material samples during the assessment. Sample Number 1 was collected at the east hallway near Room #1134 (wet area) and indicated the presence of seventeen (17) non-sporulating fungal CFUs. Fungi were not detected on duct insulation sample Number 2, which was collected at the west end of the hallway near Room #1104 (dry area).
- Direct read LPC measurements (air): Data was collected both at the beginning [approximately (~) 9.15 am] and at the end (~ 12.30 pm) of the assessment. The measurements indicated that the average indoor PM<sub>3</sub>, PM<sub>5</sub> and PM<sub>10</sub> concentrations were less than the outdoor concentrations.

The building HVAC system design includes the return-air via an open plenum in the subject hallway where the stain impacted duct insulation is located. The laboratory dust analytical results indicated the presence of inorganic and mineral constituents which may have contributed to the discoloration of the insulation material. The findings showed the presence of particulates generally composed of amorphous sands (quartz-like, clays, and soil minerals) and fire residue (soot and char). These findings are considered typical for older buildings located in semi-arid climates with exposure to high winds and historical wildfires.

The laboratory analytical findings confirm that there is no evidence of significant viable and non-viable fungal growth on the stain impacted insulation along the south hallway.

Based on these findings, it is Omega's professional opinion that the stain impacted insulation has no adverse health effects from mold growth on the building occupants utilizing the hallway.

The elevated epithelial cell concentrations noted are considered acceptable in a well-trafficked hallway located within an occupied building.

Moisture intrusion issues impacting the insulation material were noted at the east hallway area near Room #1134. Omega recommends that the moisture-impacted insulation material be removed and discarded, and that the source of moisture intrusion be identified and repaired as soon as possible. Additional recommendations are not warranted at this time.

The Appendices present Omega field notes, field map indicating the sample locations, laboratory analytical results with Chain of Custodies, laser particle counter TSI 9306-04 Aerotrak Instrument Calibration Reports, and Omega research paper on health effects of exposure to total particulates.

### **3. SAMPLING METHODOLOGY**

Prior to collection of samples, a visual and moisture assessment was conducted along the sub-ceiling spaces in the south hallway of Pierce Hall. The assessment conducted was to determine: (a) stain impacted areas with retained moisture and (b) stain impacted areas without retained moisture.

#### **3.1 Visual Inspection**

Visual inspection focuses on observing existing conditions. This inspection consists of a surface screening for the following:

- Visible excess moisture
- Staining/suspect mold growth
- Discoloration
- Texture changes
- Material dimensional changes
- Decay
- Structural dislocations

Note: The absence of visible deficiencies does not exclude the presence of excess moisture within the envelope or on a surface.

#### **3.2 Moisture Assessment**

- An IR camera (FLIR E6 with Serial Number 63916555) was utilized to observe temperature differentials on the building substrate. Temperature distribution on a surface causes the underlying geometry of the substructures to stand out. In addition, the sensitivity of the camera causes water-saturated or questionable materials to stand out (i.e. missing insulation, thermal bridges, and air leakage). The camera provides a non-destructive method for identifying probable leakage areas and focuses investigations on the building envelope and latent water leaks that could lead to microbial growth. The IR camera also permits the option of obtaining colorized images in printable formats.



- A Delmhorst moisture meter (Model BD-2100 with Serial Number 53089) was used in conjunction with the IR thermography to determine if the observed temperature differentials were in fact caused by moisture intrusion. Table 1 below presents the Delmhorst BD-2100 manufacturer recommended testing criteria:

Table 1 - *Moisture Testing Criteria*<sup>(a)</sup>

Measurement Scale #/ Substrate material	Moisture content % Considered dry	Moisture content % Considered borderline	Moisture content % Considered elevated (wet)
#3/Drywall	< 0.5	≥ 0.5 < 1.0	≥ 0.9
#3/Fiberglass Insulation <sup>(b)</sup>	0.1 - 0.4	Not determined	Not determined
#1/Wood or particle board	< 5.0	≥ 15.0 < 17.0	≥ 17.0

<sup>(a)</sup>Moisture testing criteria is based on the Delmhorst Instrument Co. user manual for moisture meter Model BD-2100; < - Less than; ≥ - Greater than or equal.

<sup>(b)</sup>Omega utilized the #3/Drywall scale setting of the moisture meter to collect moisture measurements in the fiberglass duct insulation. Initially, baseline measurements were collected from fiberglass insulation material found on ducting located near the east entrance door to the Pierce Hall south lobby area (control area). Measurements collected in the control area were between 0.1% and 0.4% and were considered as the baseline measurements for comparison purposes.

### 3.3 Sample Types

During the subject assessment, Omega collected five types of samples:

- Airborne samples to evaluate non-viable airborne fungi and other background particulates,
- Surface tape-lift samples from sub-ceiling duct insulation to quantitatively and qualitatively examine the presence of fungi and total dust,
- Culturable airborne samples for the presence of viable fungi,
- Culturable surface bulk samples of sub-ceiling duct insulation material for the presence of viable fungi, and
- Real time indoor and outdoor aerosol particulates (PM<sub>3</sub>, PM<sub>5</sub>, and PM<sub>10</sub>).

#### 3.3.1 Non-viable aerosol sampling

Sampling methods and the laboratory analytical results evaluation criteria was based on acceptable industry standards and reference to “Recognition, Evaluation, and Control of Indoor Mold”, American Industrial Hygiene Association 2008, edited by Prezant, Weeks, and Miller.

Comparison of types and concentrations of bioaerosols found indoors to those found outdoors is a key aspect of an environmental assessment for molds. The total counts for each spore type and the overall totals for the indoor samples should be less when compared to the outdoor samples. The rank order (biodiversity) for each spore type in each indoor sample should be comparable to the rank order for the corresponding types in the outdoor samples.

Non-viable aerosol particulate samples were collected using laboratory supplied single use spore trap samplers (Zefon Air-O-Cell cassettes) and a pump (Zefon Bio-Pump). At each indoor location along the south hall, two (2) samples were collected - one at a ceiling height with a distance of ~ one-foot (1') from the sub-ceiling impacted duct insulation, and one at adult breathing zone at ~ 5' from the finished floor level, also at the same location. The exterior sample was taken at a 5' height from the floor.

Prior to sampling, the pump was calibrated to sample at a flow rate of 15 LPM and programmed to run for five minutes, yielding a total volume of 75 liters per sample. An unused sampling cassette was included into the non-viable airborne sample mixture to represent the media batch and for Quality Assurance and Quality Control (QAQC) purposes. Samples were issued unique identifications to represent the sampling locations, documented on a laboratory provided chain of custody (COC) and submitted to Eurofins EMLab P&K Laboratory<sup>1</sup> (EML), for Direct Microscopy Examination (DME) analysis.

### 3.3.2 Surface Tape-lift sampling

At each indoor location along the south hall, four (4) tape lift samples were collected from the surface of the sub-ceiling stain impacted duct insulation. Two (2) tape-lift samples were collected next to each other at each sample location using laboratory issued test slides (Zefon Bio Tape). An unused sample media was included into the tape-lift sample mixture to represent the media batch and for Quality Assurance and Quality Control (QAQC) purposes. Samples were issued unique identifications to represent the sampling locations, documented on a COC and submitted to Environmental Analysis Associates, Inc<sup>2</sup>, (EAA) for DME analysis

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<sup>1</sup> Eurofins EMLab P&K Laboratory is an American Industrial Hygiene Association (AIHA) accredited microbiology laboratory located at 17461 Derian Avenue, Suite 100 in Irvine, California.

<sup>2</sup> Environmental Analysis Associates, Inc., AIHA accredited microbiology laboratory located at 306 5<sup>th</sup> Street, Suite 2A in Bay City, MI 48708.

### 3.3.3 Culturable airborne sampling

Culturable bioaerosol samples were collected using laboratory supplied Biocassete<sup>®</sup> sampling devices (Eurofins EMLab P&K) and a high-volume pump. Each disposable Biocassete<sup>®</sup> comes pre-filled with malt extract agar (MEA) which is designed to capture bioactive airborne fungi. At each indoor sample location along the south hall, two (2) samples were collected; (a) one sample at a ceiling height at a distance of ~ 1' from the sub-ceiling impacted duct insulation, and (b) one sample at adult breathing zone at ~ 5' from the floor level, also at the same location. The exterior sample was collected at the adult breathing zone.

Prior to sampling, a high-volume Air-Gast pump was calibrated to 28.3 liters per minute (LPM) using a factory calibrated DryCal DC-Lite Primary Flow Meter connected to a Biocassete<sup>®</sup> media. A Biocassete<sup>®</sup> was used to collect each sample for two minutes (volume of 56.6 liters). An unused Biocassete<sup>®</sup> media was included into the sample mixture to represent the media batch and for QA/QC purposes. Samples were issued unique identifications to represent the sampling locations, documented on a laboratory provided COC and submitted to EML, for culturable air fungi analysis.

### 3.3.4 Bulk sampling

At each indoor location along the south hall, one (1) bulk sample was collected from the sub-ceiling stain impacted duct insulation material. A ~ 1 square inch piece of insulation was cut using cleaned and sterile hand tools and was placed in a plastic baggie for laboratory analysis. Samples were issued unique identifications to represent the sampling locations, documented on a laboratory provided COC and submitted to EML, for 1-media surface fungi culture analysis.

### 3.3.5 Aerosol dust particulate sampling

To further characterize the real time concentrations of aerosol particulates in the subject areas, direct read particulate spot measurements were collected for PM<sub>3</sub>, PM<sub>5</sub>, and PM<sub>10</sub> using a factory calibrated handheld TSI Aerotrak (Serial Number 93061629015) with laser particle counter (LPC). The LPC was programmed to collect a two (2) minute sample at each location. The samples were collected with the LPC held at arms-length at a height of ~ 5' from floor level to mimic the adult breathing zone.





Particulate spot measurements were collected twice; (a) at the beginning and (b) at the end of the assessment. Direct read measurements were collected at three (3) indoor locations (south hallway near room 1134, room 1104, and the south lobby area) and two (2) outdoor locations (west entrance and east courtyard). Omega also measured the temperature and relative humidity at the five sample locations. Measurements were scribed onto a field sample data sheet.

#### 4. SAMPLE LOCATIONS AND RESULTS

Visible sporadic black/brown staining was noted on insulation material located throughout the south hallway sub ceiling space. Two indoor sample locations were determined based on the presence of retained moisture and dry conditions on stain impacted insulation material.

Infrared (IR) thermal differentials were noted on insulation material located at the east end of the hallway at Room 1134. Moisture measurements collected at this location confirmed retained moisture (2.9% - 5.1%) in the insulation. The second sample location was at the west end of the hallway at Room 1104. IR thermal differentials were not noted at the second location. Moisture meter measurements were considered dry (0.3%-0.4%).

During the assessment, Omega collected samples at two indoor locations and one outdoor location for laboratory analysis. Direct read spot measurements were collected in three indoor locations and two outdoor locations. Sample locations are presented in Table 2:

Table 2- *Sample Location and Types*

Location ID	Location	(Number) Sample Types Collected	Sample ID
1	Indoor: East S. Hall at Room 1134	(2) Biocassete® (2) Spore Traps (1) Tape-lifts (1) Bulk Direct read aerosol particulates	BC-2, BC-3 ST-2, ST-3 1, 1A B-1 Interior @ Rm 1134
2	Indoor: West S. Hall at Room 1104	(2) Biocassete® (2) Spore Traps (1) Tape-lifts (1) Bulk Direct read aerosol particulates	BC-4, BC-5 ST-4, ST-5 2, 2A B-2 Interior @ Rm 1104
3	Outdoor: West Lobby Entrance	(1) Biocassete® (1) Spore Trap Direct read aerosol particulates	BC-1 ST-1 Outdoor West
4	Indoor: Pierce Hall South Lobby	Direct read aerosol particulates	Indoor – South Lobby
5	Outdoor - East Courtyard	Direct read aerosol particulates	Outdoor - East

Appendix 1 presents a field map with corresponding Location and Sample IDs.

BC2, ST2, BC4, and ST4 samples were collected at a distance of ~ 1’ below the impacted insulation material. BC3, ST3, BC5, and ST5 samples were collected at an adult breathing zone. Direct read aerosol particulate measurements were also collected at an adult breathing zone.

Laboratory analytical results for non-viable bioaerosols are presented in Table 3:

Table 3 - Summary Bioaerosols via Spore Trap Analysis – Non-viable methodology (September 20, 2019)

Sample ID: Location	Total spores/m <sup>3</sup>	Spore Type	Raw count	Calc. count	% of total
ST-1: Exterior- Outside South Main Entrance	2,300	Cladosporium	16	850	37
		Penicillium/Aspergillus types	11	590	25
		Basidiospores	7	370	16
		Smuts, Periconia, Myxomycetes	16	210	9
		Ulocladium	4	53	2
		Ascospores	1	53	2
		Other brown	2	27	1
		Oidium	2	27	1
		Alternaria	2	27	1
		Torula	1	13	1
		Tetraploa	1	13	1
		Stachybotrys	1	13	1
		Nigrospora	1	13	1
		Ganoderma	1	13	1
		Chaetomium	1	13	1
Bipolaris/Drechslera group	1	13	1		
ST-2: Interior- East S. Hallway at Room 1134 near Ceiling	110	Penicillium/Aspergillus types	1	53	50
		Cladosporium	1	53	50
ST-3: Interior- East S. Hallway at 1134 at Breathing Zone	110	Penicillium/Aspergillus types	1	53	50
		Smuts, Periconia, Myxomycetes	2	27	25
		Other brown	1	13	13
		Alternaria	1	13	13
ST-4: Interior- West S. Hallway at Room 1104 near Ceiling	440	Cladosporium	5	270	61
		Penicillium/Aspergillus types	1	53	12
		Basidiospores	1	53	12
		Smuts, Periconia, Myxomycetes	2	27	6
		Other brown	1	13	3
		Ganoderma	1	13	3
Alternaria	1	13	3		

Continuation of Table 3:

Sample ID: Location	Total spores/m <sup>3</sup>	Spore Type	Raw count	Calc. count	% of total
ST-5: Interior- West S. Hallway at Room 1104 at Breathing Zone	450	Cladosporium	4	210	47
		Basidiospores	2	110	24
		Penicillium/Aspergillus types	1	53	12
		Stachybotrys	1	13	3
		Pithomyces	1	13	3
		Other colorless	1	13	3
		Chaetomium	1	13	3
		Bipolaris/Drechslera group	1	13	3
		Alternaria	1	13	3
ST-6: QAQC	-	None detected	-	-	-

The laboratory analytical results indicated that at the time of the sample collection, the indoor biodiversity and the bioaerosol concentrations found at both indoor sample locations were comparable to those found in the outdoors.

Laboratory analytical results for non-viable Other Biological Particulates are presented in Table 4:

Table 4 - Summary Other Biological Particles via Spore Trap Analysis  
 (September 20, 2019) Non-Viable Methodology

Sample Locations --->	ST-1: Exterior- Outside South Main Entrance		ST-2: Interior- Hallway East at Ceiling @ Rm 1134		ST-3: Interior- Hallway East at Breathing Zone @ Rm 1134		ST-4: Interior- Hallway West at Ceiling @ Rm 1104		ST-5: Interior- Hallway West at Breathing Zone @ Rm 1104		ST-6: QAQC	
	Raw Count	Particles /m <sup>3</sup>	Raw ct.	Particles /m <sup>3</sup>	Raw ct.	Particles /m <sup>3</sup>	Raw ct.	Particles /m <sup>3</sup>	Raw ct.	Particles /m <sup>3</sup>	Raw ct.	Particles /m <sup>3</sup>
Lab ID-Version :	10738678-1		10738680-1		10738682-1		10738684-1		10738686-1		10738688-1	
Grass (Poaceae)	20	270			1	13	1	13	10	130		
Other	3	40			1	13						
Palm (Arecaceae)	3	40							1	13		
Poplar, cottonwood (Populus)	1	13							5	67		
Epithelial (skin) cells	1	53	21	1,100	48	2,600	22	1,200	60	3,200		
Hyphal fragments	4	53	4	53	2	27	3	40	3	40		
NON-BIOLOGICAL												
Cellulose fibers			1	13					1	13		
Glass fiber	1	13					1	13				
Starch particles					1	13	1	13				
Synthetic fibers	2	27	5	67	2	27	1	13	3	40		
Background debris (1-4+)†	2+		2+		2+		2+		2+		ND	-
Sample volume (liters)	75		75		75		75		75		-	

Other biological particles detected were unremarkable. The elevated epithelial cell concentrations noted are considered acceptable in a hallway located within an occupied building.

Surface tape-lift laboratory analytical results are presented in Table 5:

Table 5: Summary Tape-lift Surface Dust Analysis via Optical Microscopy

	Sample ID: Location	1: East S. Hallway at Room 1134	1A: East S. Hallway at Room 1134	2: West S. Hallway at Room 1104	2A: West S. Hallway at Room 1104	3: QAQC
<i>Inorganic/Mineral Constituents</i>		<i>Numerical Ratio %</i>				
<b>Fibrous Constituents</b>	Cellulosic fabrics/paper		4.1	2.2	0.9	
	Synthetic fibers (nylon, rayon, etc.)		0.5	0.4	0.2	
	Clear fiberglass					
	Colored fiberglass	20.0	5.1	3.7	2.5	
<b>Non-fibrous Constituents</b>	Quartz-like, clays, soil minerals	38.6	25.3	10.4	11.5	33.3
	Gypsum-like, carbonates		0.5	0.2	0.6	
	Other/amorphous particles			0.4	0.2	
	Unidentified opaque/corrosion/paint	8.6	24.0	16.1	16.0	33.3
	Fire indicators- Soot, char	31.4	33.6	62.6	62.6	
<i>Biological Constituents</i>		<i>Numerical Ratio %</i>				
<b>Predominant mold spores</b>	Other					
<b>Other fungal structures</b>	Mycelia, phialides, perithecia, etc.					
<b>Pollen</b>	Pinus/other					
<b>Plant fragments</b>	Flower parts, trichomes, etc.		6.0			
<b>Animal fragments</b>	Dander/skin cells	1.4		3.3	4.7	33.3
<b>Miscellaneous</b>	Insect parts		0.5	0.4	0.2	
<b>Brown/black biogenic debris</b>	Decayed biogenic debris		0.5	0.4	0.6	

Omega collected two side-by-side surface tape-lift samples from insulation material at each indoor location. One sample was analyzed for inorganic mineral constituents and the other for biological constituents. Fungal structures were not detected at either sample location.

During the assessment Omega collected indoor and outdoor viable bioaerosol samples. Two samples were collected at each indoor location (east and west hallway). The outdoor viable bioaerosol sample was collected outside the west entrance to the south lobby area. Laboratory results of culturable bioaerosols are presented in Table 6.

Table 6 - Summary Viable Bioaerosols via Culturable Air Fungi Analysis  
 (September 20, 2019)

**CULTURABLE AIR FUNGI REPORT**

Location:	BC-1: Exterior-Outside South Entry				BC-2: Hallway East at Ceiling 1134				BC-3: Hallway East at Breathing Zone 1134			
Comments (see below)	None				A				None			
Lab ID-Version#:	10738099-1				10738100-1				10738101-1			
Sample volume (liters)	56.66				56.66				56.66			
Positive Hole	342				342				342			
Medium:	MEA				MEA				MEA			
	CFU*	CFU*/m3	DL/m3	%	CFU*	CFU*/m3	DL/m3	%	CFU*	CFU*/m3	DL/m3	%
§ TOTAL CFU*	17	300	18	100	< 18	18	100	100	1	18	18	100
Aspergillus												
Aspergillus niger	1	18	18	6								
Aspergillus versicolor												
Aureobasidium												
Basidiomycetes												
Bipolaris/Drechslera group												
Botrytis												
Chaetomium												
Cladosporium	14	250	18	82								
Curvularia												
Epicoccum												
Fusarium												
Non-sporulating fungi												
Paecilomyces												
Penicillium												
Phoma												
Phoma/coelomycetes	2	35	18	12								
Rhizopus												
Stachybotrys chartarum												
Ulocladium												
Yeasts									1	18	18	100

\* cfu = colony forming units Positive hole correction chart used for all calculations  
 Comments: A) No fungal colonies detected.

**CULTURABLE AIR FUNGI REPORT**

Location:	BC-4: Hallway West at Ceiling 1104				BC-5: Hallway West at Breathing Zone 1104				BC-6: QAQC			
Comments (see below)	None				None				None			
Lab ID-Version#:	10738102-1				10738103-1				10738104-1			
Sample volume (liters)	56.66				56.66				0			
Positive Hole	342				342				0			
Medium:	MEA				MEA				MEA			
	CFU*	CFU*/m3	DL/m3	%	CFU*	CFU*/m3	DL/m3	%	CFU*	CFU*/m3	DL/m3	%
§ TOTAL CFU*	2	35	18	100	3	53	18	100		N/A	N/A	100
Aspergillus	1	18	18	50								
Aspergillus niger												
Aspergillus versicolor												
Aureobasidium												
Basidiomycetes												
Bipolaris/Drechslera group												
Botrytis												
Chaetomium												
Cladosporium	1	18	18	50	2	35	18	67				
Curvularia												
Epicoccum												
Fusarium												
Non-sporulating fungi												
Paecilomyces												
Penicillium					1	18	18	33				
Phoma												
Phoma/coelomycetes												
Rhizopus												
Stachybotrys chartarum												
Ulocladium												
Yeasts												

\* cfu = colony forming units Positive hole correction chart used for all calculations  
 Comments:

Laboratory analytical results of viable bioaerosols indicate that samples collected near duct insulation outside Room 1134 where moisture was present had very low viable fungal counts present.

Sample BC-2, which was taken ~ 1’ from the duct insulation near room 1134, had below the laboratory detection limit of 18 colony forming units per cubic meter of air (CFU/m<sup>3</sup>) when cultured. Sample BC-3, taken at the adult breathing zone near room 1134, had 1 raw count (18 CFU/m<sup>3</sup>) of a type of yeast when cultured, which is the laboratory detection limit.

Samples collected near duct insulation outside Room 1104 where no moisture was present also had low counts of viable fungal spores. Sample BC-4, which was taken ~ 1’ below the impacted duct insulation near room 1104, had a total of 35 CFU/m<sup>3</sup>, while sample BC-5 at the adult breathing zone had a total of 53 CFU/m<sup>3</sup>. In comparison, the sample collected at the exterior location outside the south entry to the main lobby had a total of 300 CFU/m<sup>3</sup>.

Omega collected two bulk samples from the stain impacted insulation material at; (a) East hallway near Room 1134 and (b) West hallway near Room 1104. Laboratory analytical results are presented in Table 7:

Table 7 - Summary Viable Bulk/Surface via 1-Media Fungi Culture Analysis  
 (September 20, 2019)

Sample ID/ Location	Sample Size/ Report Unit	Medium	Dilution Factor	Fungal ID	Colony Counts	Colony Forming Units/Unit	%
B1/E Hall @ Room 1134 (Insulation)	Size:1 Swab/ Unit:1 Swab	MEA	10	Non-Sporulating Fungi	17	170	100
B2/W Hall @ Room 1104 (Insulation)	Size:1 Swab/ Unit:1 Swab	MEA	10	None Detected	-	< 10	100

MEA - Malt extract agar; < Less than; % - Percent

The findings include 17 non-sporulating fungal colonies in Sample B1, which was collected from the stain impacted insulation material impacted with moisture. Fungi was not detected on Sample B2 which was considered dry.

Direct Read Aerosol Particulate Measurements were collected using an LPC. Air samples were collected before and after the subject assessment was completed. Direct read measurements were collected in three indoor locations and two outdoor locations. Tables 8 and 9 present the respective outdoor and indoor measurements:



Table 8- *Direct Read- Outdoor Aerosol Particulate Measurements*

Location	Sample Time	PM3 (p/m <sup>3</sup> )	PM5 (p/m <sup>3</sup> )	PM10 (p/m <sup>3</sup> )	Temp °F	RH %	Comments
Exterior - West Entrance	9:20 AM	333,392	84,806	10,424	68	61	Minor activity noted, area shaded
Exterior - West Entrance	12:34 PM	406,506	134,918	19,624	76	47	No activity noted, area shaded
Average - Exterior West Entrance:		369,949	109,862	15,024	72	54	
<b>Total Sum Particulates- Exterior West Entrance:</b>		<b>494,835</b>					
Exterior - East Courtyard	9:17 AM	385,336	98,410	12,898	71	61	Minor activity noted, area shaded
Exterior - East Courtyard	12:31 PM	374,259	130,622	22,279	74	51	No activity noted, area shaded
Average - Exterior East Courtyard:		379,798	114,516	17,589	72	56	
<b>Total Sum Particulates- Exterior East Courtyard:</b>		<b>511,902</b>					
Average - Exterior:		374,873	112,189	16,306	72	55	
<b>Average- Total Sum Particulates West &amp; East :</b>		<b>503,369</b>					

PM - particulate matter; p/m<sup>3</sup> - particles per cubic meter; °F - degrees Fahrenheit; RH - relative humidity as a percent

Table 9- *Direct Read- Indoor Aerosol Particulate Measurements*

Direct Read - Indoor Aerosol Particulate Measurements							
Location	Sample Time	PM3 (p/m <sup>3</sup> )	PM5 (p/m <sup>3</sup> )	PM10 (p/m <sup>3</sup> )	Temp °F	RH %	Comments
East S. Hall @ Room 1134	9:06 AM	316,445	173,766	39,968	67	66	No foot traffic noted
East S. Hall @ Room 1134	12:22 PM	118,984	59,766	13,891	67	66	No foot traffic noted
Average - Exterior West Entrance:		217,715	116,766	26,930	67	66	
<b>Total Sum Particulates- East S. Hall @ Room 1134:</b>		<b>361,410</b>					
West S. Hall @ Room 1104	9:10 AM	53,722	19,764	4,312	69	61	No foot traffic noted
West S. Hall @ Room 1104	12:25 PM	104,570	41,864	8,085	69	63	No foot traffic noted
Average - Exterior East Courtyard:		79,146	30,814	6,199	69	62	
<b>Total Sum Particulates- East S. Hall @ Room 1104:</b>		<b>116,159</b>					
Pierce Hall Lobby	9:14 AM	143,559	62,347	14,194	70	60	No foot traffic noted
Pierce Hall Lobby	12:28 PM	213,517	78,796	16,861	72	54	No foot traffic noted
Average - Exterior East Courtyard:		178,538	70,572	15,528	71	57	
<b>Total Sum Particulates- Pierce Hall Lobby:</b>		<b>264,637</b>					
Average - Interior:		158,466	72,717	16,219	69	62	
<b>Average- Total Sum Particulates Interior Locationst :</b>		<b>247,402</b>					

PM - particulate matter; p/m<sup>3</sup> - particles per cubic meter; °F - degrees Fahrenheit; RH - relative humidity as a percent



For total respirable particles (diameter <10 micrometers), it was found that the ambient air outside Pierce Hall had an average of 503,369 respirable particles per cubic meter (m<sup>3</sup>). The indoor air on the first floor of Pierce Hall along the south hallway and lobby had an average of 247,402 particles per m<sup>3</sup>. The overall respirable particle concentrations inside the building were found to be significantly lower than those found outside the building.

## **5. CONCLUSIONS AND RECOMMENDATIONS**

The findings confirm that there is no evidence of significant viable and non-viable fungal growth on the stain impacted insulation along the south hallway.

Therefore, it is Omega’s professional opinion that the stain impacted insulation has no adverse effects on the building occupants utilizing the hallway.

Moisture intrusion issues impacting the insulation material were noted at the east hallway area near Room #1134. Omega recommends that the moisture-impacted insulation material be removed and discarded, and that the source of moisture intrusion be identified and repaired as soon as possible. Additional recommendations are not warranted at this time.

## **6. LIMITATIONS**

This report and opinions are based on evidence provided by the University of California – Riverside, Environmental Health and Safety officials and the results of the samples collected by Omega Environmental Inc., and Ambient Environmental Inc. If additional information or findings are made available, we reserve the right to change our opinions.

Our services consist of professional opinions, conclusions, and recommendations that are made in accordance with generally accepted consulting standards, principles, and practices. Reasonable attempts have been made to provide a report that is complete and accurate with respect to Omega's authorized scope of investigation. Omega assumes no liability for damages, which might result from errors contained in the report or conditions, which the report fails to disclose.





## Appendix 1

# **Omega Field Notes & Field Map with Sample Locations**



# Field Logs

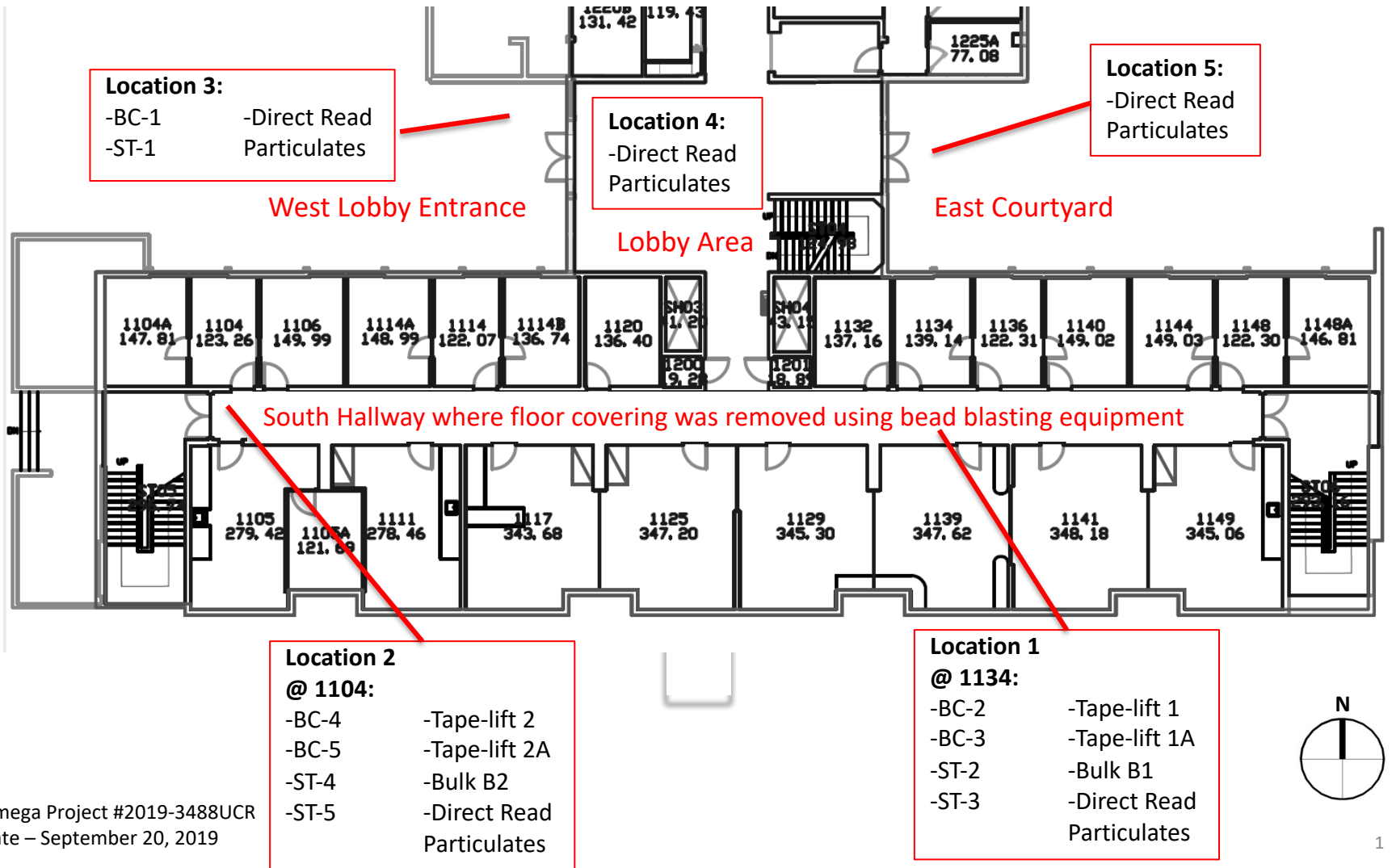
PAGE 1 OF 1

PROJECT NAME	VCR Pierce Hall South Hall <sup>Sampling</sup>	DATE	09/20/19
SITE ADDRESS	1600 Campus Dr	Omega PROJECT #	2019-3488 VCR
SITE CONTACT	Kyle Soliz Ubl-406-2849	IH NAME	TS

0800: omega onsite. meet Kyle Soliz of VCR @ Dean's office Rm 1148. set up equipment & calibrate High Vol pump.
0830: use IR cam to confirm E & W sampling locations:
① East South Hall: <sup>outside</sup> Room 1134 - visible staining, MM=2.9-5.1 (moisture)
② West South Hall: <sup>outside</sup> Rm 1104 - visible staining, MM=0.3-0.4 (dry)
0900: take particulate measurements
1) 1134 2) 1104 3) lobby 4) w. exterior 5) e. courtyard ext.
0930: calibrate biopump. take exterior (w) ST sample
take exterior west biocassette sample
10:30: take interior biocassette samples
west Hall @ 1104: 1' from insulation & breathing area (2)
east Hall @ 1134: ceiling & breathing (2)
Fill out COC, package 5 samples + 1 blank on ice.
11:00: take indoor sporetrap samples
w Hall @ 1104: ceiling & breathing (2)
E Hall @ 1134: ceiling & breathing (2)
Fill out COC, package 5 samples + 1 blank
12:00: take 2 tapelifts & 1 bulk sample from fiberglass duct insulation @ E Hall @ 1134 & @ W Hall @ 1104
12:30: take final particulate <sup>late</sup> IA, B-1 2, 2A, B-2 measurements (3 in, 2 out).

Omega IH Signature: Tzenette

**Field Map- 1<sup>st</sup> Floor Pierce Hall South Hallway**  
**Sample IDs and Locations**  
 (Sketch is not to scale)





## Appendix 2

# **Laboratory Analytical Results & Chain of Custodies**

Report for:

**Ms. Irene Benavides, Mr. Kumar Gunaratna, Mr. Navid Salari**  
**Omega Environmental Services, Inc.: CA**  
4570 Campus Drive, Ste. 30  
Newport Beach, CA 92660

---

Regarding: Project: 2019-3488UCR; Pierce Hall-1st Floor South Hallway  
EML ID: 2258181

Approved by:



Technical Manager  
Danny Li

Dates of Analysis:

Spore trap analysis: 09-23-2019

Service SOPs: Spore trap analysis (EM-MY-S-1038)  
AIHA-LAP, LLC accredited service, Lab ID #178697

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All samples were received in acceptable condition unless noted in the Report Comments portion in the body of the report. Due to the nature of the analyses performed, field blank correction of results is not applied. The results relate only to the samples as received. Sample air volume is supplied by the client.

Eurofins EMLab P&K ("the Company") shall have no liability to the client or the client's customer with respect to decisions or recommendations made, actions taken or courses of conduct implemented by either the client or the client's customer as a result of or based upon the Test Results. In no event shall the Company be liable to the client with respect to the Test Results except for the Company's own willful misconduct or gross negligence nor shall the Company be liable for incidental or consequential damages or lost profits or revenues to the fullest extent such liability may be disclaimed by law, even if the Company has been advised of the possibility of such damages, lost profits or lost revenues. In no event shall the Company's liability with respect to the Test Results exceed the amount paid to the Company by the client therefor.

Eurofins EMLab P&K's LabServe® reporting system includes automated fail-safes to ensure that all AIHA-LAP, LLC quality requirements are met and notifications are added to reports when any quality steps remain pending.

Client: Omega Environmental Services, Inc.: CA Date of Sampling: 09-20-2019  
 C/O: Ms. Irene Benavides, Mr. Kumar Gunaratna, Mr. Navid Salari Date of Receipt: 09-20-2019  
 Re: 2019-3488UCR; Pierce Hall-1st Floor South Hallway Date of Report: 09-23-2019

**SPORE TRAP REPORT: NON-VIABLE METHODOLOGY**

Location:	ST-1: Exterior-Outside South Main Entrance			ST-2: Interior-Hallway East at Ceiling 1134		
Comments (see below)	None			None		
Lab ID-Version‡:	10738677-1			10738679-1		
Analysis Date:	09/23/2019			09/23/2019		
	raw ct.	% read	spores/m3	raw ct.	% read	spores/m3
Alternaria	2	100	27			
Ascospores	1	25	53			
Basidiospores	7	25	370			
Bipolaris/Drechslera group	1	100	13			
Chaetomium	1	100	13			
Cladosporium	16	25	850	1	25	53
Ganoderma	1	100	13			
Nigrospora	1	100	13			
Oidium	2	100	27			
Other brown	2	100	27			
Other colorless						
Penicillium/Aspergillus types†	11	25	590	1	25	53
Smuts, Periconia, Myxomycetes	16	100	210			
Stachybotrys	1	100	13			
Tetraploa	1	100	13			
Torula	1	100	13			
Ulocladium	4	100	53			
Background debris (1-4+)††	2+			2+		
Hyphal fragments/m3	53			53		
Pollen/m3	360			< 13		
Skin cells (1-4+)	< 1+			1+		
Sample volume (liters)	75			75		
<b>§ TOTAL SPORES/m3</b>			<b>2.300</b>			<b>110</b>

**Comments:**

Spore types listed without a count or data entry were not detected during the course of the analysis for the respective sample, indicating a raw count of <1 spore.

† The spores of *Aspergillus* and *Penicillium* (and others such as *Acremonium*, *Paecilomyces*) are small and round with very few distinguishing characteristics. They cannot be differentiated by non-viable sampling methods. Also, some species with very small spores are easily missed, and may be undercounted.

†† Background debris indicates the amount of non-biological particulate matter present on the trace (dust in the air) and the resulting visibility for the analyst. It is rated from 1+ (low) to 4+ (high). Counts from areas with 4+ background debris should be regarded as minimal counts and may be higher than reported. It is important to account for samples volumes when evaluating dust levels.

The analytical sensitivity is the spores/m<sup>3</sup> divided by the raw count, expressed in spores/m<sup>3</sup>. The limit of detection is the analytical sensitivity (in spores/m<sup>3</sup>) multiplied by the sample volume (in liters) divided by 1000 liters.

For more information regarding analytical sensitivity, please contact QA by calling the laboratory.

‡ A "Version" indicated by "-x" after the Lab ID# with a value greater than 1 indicates a sample with amended data. The revision number is reflected by the value of "x".

§ Total Spores/m<sup>3</sup> has been rounded to two significant figures to reflect analytical precision.

Client: Omega Environmental Services, Inc.: CA Date of Sampling: 09-20-2019  
 C/O: Ms. Irene Benavides, Mr. Kumar Gunaratna, Mr. Navid Salari Date of Receipt: 09-20-2019  
 Re: 2019-3488UCR; Pierce Hall-1st Floor South Hallway Date of Report: 09-23-2019

**SPORE TRAP REPORT: NON-VIABLE METHODOLOGY**

Location:	ST-3: Interior-Hallway East at Breathing Zone 1134			ST-4: Interior-Hallway West at Ceiling 1104		
Comments (see below)	None			None		
Lab ID-Version‡:	10738681-1			10738683-1		
Analysis Date:	09/23/2019			09/23/2019		
	raw ct.	% read	spores/m3	raw ct.	% read	spores/m3
Alternaria	1	100	13	1	100	13
Ascospores						
Basidiospores				1	25	53
Bipolaris/Drechslera group						
Chaetomium						
Cladosporium				5	25	270
Ganoderma				1	100	13
Nigrospora						
Oidium						
Other brown	1	100	13	1	100	13
Other colorless						
Penicillium/Aspergillus types†	1	25	53	1	25	53
Pithomyces						
Smuts, Periconia, Myxomycetes	2	100	27	2	100	27
Stachybotrys						
Tetraploa						
Background debris (1-4+)††	2+			2+		
Hyphal fragments/m3	53			40		
Pollen/m3	27			13		
Skin cells (1-4+)	1+			1+		
Sample volume (liters)	75			75		
<b>§ TOTAL SPORES/m3</b>			<b>110</b>			<b>440</b>

**Comments:**

Spore types listed without a count or data entry were not detected during the course of the analysis for the respective sample, indicating a raw count of <1 spore.

† The spores of *Aspergillus* and *Penicillium* (and others such as *Acremonium*, *Paecilomyces*) are small and round with very few distinguishing characteristics. They cannot be differentiated by non-viable sampling methods. Also, some species with very small spores are easily missed, and may be undercounted.

†† Background debris indicates the amount of non-biological particulate matter present on the trace (dust in the air) and the resulting visibility for the analyst. It is rated from 1+ (low) to 4+ (high). Counts from areas with 4+ background debris should be regarded as minimal counts and may be higher than reported. It is important to account for samples volumes when evaluating dust levels.

The analytical sensitivity is the spores/m<sup>3</sup> divided by the raw count, expressed in spores/m<sup>3</sup>. The limit of detection is the analytical sensitivity (in spores/m<sup>3</sup>) multiplied by the sample volume (in liters) divided by 1000 liters.

For more information regarding analytical sensitivity, please contact QA by calling the laboratory.

‡ A "Version" indicated by -"x" after the Lab ID# with a value greater than 1 indicates a sample with amended data. The revision number is reflected by the value of "x".

§ Total Spores/m<sup>3</sup> has been rounded to two significant figures to reflect analytical precision.



Client: Omega Environmental Services, Inc.: CA Date of Sampling: 09-20-2019  
 C/O: Ms. Irene Benavides, Mr. Kumar Gunaratna, Mr. Navid Salari Date of Receipt: 09-20-2019  
 Re: 2019-3488UCR; Pierce Hall-1st Floor South Hallway Date of Report: 09-23-2019

**SPORE TRAP REPORT: NON-VIABLE METHODOLOGY**

Location:	ST-5: Interior-Hallway West at Breathing Zone 1104			ST-6: QAQC		
Comments (see below)	None			A		
Lab ID-Version‡:	10738685-1			10738687-1		
Analysis Date:	09/23/2019			09/23/2019		
	raw ct.	% read	spores/m3	raw ct.	% read	spores/m3
Alternaria	1	100	13			
Ascospores						
Basidiospores	2	25	110			
Bipolaris/Drechslera group	1	100	13			
Chaetomium	1	100	13			
Cladosporium	4	25	210			
Ganoderma						
Nigrospora						
Oidium						
Other brown						
Other colorless	1	100	13			
Penicillium/Aspergillus types†	1	25	53			
Pithomyces	1	100	13			
Smuts, Periconia, Myxomycetes						
Stachybotrys	1	100	13			
Tetraploa						
Background debris (1-4+)††	2+			None		
Hyphal fragments/m3	40			N/A		
Pollen/m3	210			N/A		
Skin cells (1-4+)	1+			None		
Sample volume (liters)	75			0		
<b>§ TOTAL SPORES/m3</b>			450			N/A

Comments: A) No trace present.

Spore types listed without a count or data entry were not detected during the course of the analysis for the respective sample, indicating a raw count of <1 spore.

† The spores of *Aspergillus* and *Penicillium* (and others such as *Acremonium*, *Paecilomyces*) are small and round with very few distinguishing characteristics. They cannot be differentiated by non-viable sampling methods. Also, some species with very small spores are easily missed, and may be undercounted.

†† Background debris indicates the amount of non-biological particulate matter present on the trace (dust in the air) and the resulting visibility for the analyst. It is rated from 1+ (low) to 4+ (high). Counts from areas with 4+ background debris should be regarded as minimal counts and may be higher than reported. It is important to account for samples volumes when evaluating dust levels.

The analytical sensitivity is the spores/m<sup>3</sup> divided by the raw count, expressed in spores/m<sup>3</sup>. The limit of detection is the analytical sensitivity (in spores/m<sup>3</sup>) multiplied by the sample volume (in liters) divided by 1000 liters.

For more information regarding analytical sensitivity, please contact QA by calling the laboratory.

‡ A "Version" indicated by -"x" after the Lab ID# with a value greater than 1 indicates a sample with amended data. The revision number is reflected by the value of "x".

§ Total Spores/m<sup>3</sup> has been rounded to two significant figures to reflect analytical precision.



Report for:

**Ms. Irene Benavides, Mr. Kumar Gunaratna, Mr. Navid Salari**  
**Omega Environmental Services, Inc.: CA**  
4570 Campus Drive, Ste. 30  
Newport Beach, CA 92660

---

Regarding: Project: 2019-3488UCR; Pierce Hall-1st Floor South Hallway  
EML ID: 2258181

Approved by:



Technical Manager  
Danny Li

Dates of Analysis:

Spore trap analysis other particles-Supplement: 09-23-2019

Service SOPs: Spore trap analysis other particles-Supplement (EM-MY-S-1038)  
AIHA-LAP, LLC accredited service, Lab ID #178697

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Eurofins EMLab P&K ("the Company") shall have no liability to the client or the client's customer with respect to decisions or recommendations made, actions taken or courses of conduct implemented by either the client or the client's customer as a result of or based upon the Test Results. In no event shall the Company be liable to the client with respect to the Test Results except for the Company's own willful misconduct or gross negligence nor shall the Company be liable for incidental or consequential damages or lost profits or revenues to the fullest extent such liability may be disclaimed by law, even if the Company has been advised of the possibility of such damages, lost profits or lost revenues. In no event shall the Company's liability with respect to the Test Results exceed the amount paid to the Company by the client therefor.

Eurofins EMLab P&K's LabServe® reporting system includes automated fail-safes to ensure that all AIHA-LAP, LLC quality requirements are met and notifications are added to reports when any quality steps remain pending.

Client: Omega Environmental Services, Inc.: CA Date of Sampling: 09-20-2019  
 C/O: Ms. Irene Benavides, Mr. Kumar Gunaratna, Mr. Navid Salari Date of Receipt: 09-20-2019  
 Re: 2019-3488UCR; Pierce Hall-1st Floor South Hallway Date of Report: 09-23-2019

**OTHER BIOLOGICAL PARTICLES REPORT: NON-VIABLE METHODOLOGY**

Location:	ST-1: Exterior-Outside South Main Entrance		ST-2: Interior-Hallway East at Ceiling 1134		ST-3: Interior-Hallway East at Breathing Zone 1134	
Comments (see below)	None		None		None	
Lab ID-Version‡:	10738678-1		10738680-1		10738682-1	
	raw ct.	particles/m3	raw ct.	particles/m3	raw ct.	particles/m3
<b>POLLEN</b>						
Grass (Poaceae)	20	270			1	13
Other	3	40			1	13
Palm (Arecaceae)	3	40				
Poplar, cottonwood (Populus)	1	13				
Sycamore (Platanus)						
<b>OTHER PLANT</b>						
Algae						
Diatoms						
Fern, moss, etc. spores						
Other (wood, trichomes, etc.)						
<b>OTHER PARTICLES:</b>						
<b>ANIMAL</b>						
Epithelial (skin) cells	1	53	21	1,100	48	2,600
Hair						
Insect parts						
Mites						
<b>FUNGI</b>						
Hyphal fragments	4	53	4	53	2	27
<b>NON-BIOLOGICAL</b>						
Cellulose fibers			1	13		
Glass fiber	1	13				
Starch particles					1	13
Synthetic fibers	2	27	5	67	2	27
Background debris (1-4+)†	2+		2+		2+	
Sample volume (liters)	75		75		75	

**Comments:**

The analytical sensitivity is the spores/m3 divided by the raw count. The limit of detection is the analytical sensitivity multiplied by the sample volume divided by 1000.

Carbonaceous particles include soot and other combustion products. In most instances a detailed analysis of soot can be accomplished using scanning electron microscopy.

Note: Interpretation is left to the company and/or persons who conducted the field work.

† Background debris is an indication of the amounts of non-biological particulate matter present on the slide (dust in the air) and is graded from 1+ to 4+ with 4+ indicating the largest amounts. To evaluate dust levels it is important to account for differences in sample volume.

‡ A "Version" indicated by "-x" after the Lab ID# with a value greater than 1 indicates a sample with amended data. The revision number is reflected by the value of "x".  
 EMLab P&K, LLC

Client: Omega Environmental Services, Inc.: CA  
 C/O: Ms. Irene Benavides, Mr. Kumar Gunaratna, Mr. Navid Salari  
 Re: 2019-3488UCR; Pierce Hall-1st Floor South  
 Hallway

Date of Sampling: 09-20-2019  
 Date of Receipt: 09-20-2019  
 Date of Report: 09-23-2019

**OTHER BIOLOGICAL PARTICLES REPORT: NON-VIABLE METHODOLOGY**

Location:	ST-4: Interior-Hallway West at Ceiling 1104		ST-5: Interior-Hallway West at Breathing Zone 1104		ST-6: QAQC	
Comments (see below)	None		None		None	
Lab ID-Version†:	10738684-1		10738686-1		10738688-1	
	raw ct.	particles/m3	raw ct.	particles/m3	raw ct.	particles/m3
<b>POLLEN</b>						
Grass (Poaceae)	1	13	10	130		
Other						
Palm (Arecaceae)			1	13		
Poplar, cottonwood (Populus)			5	67		
Sycamore (Platanus)						
<b>OTHER PLANT</b>						
Algae						
Diatoms						
Fern, moss, etc. spores						
Other (wood, trichomes, etc.)						
<b>OTHER PARTICLES:</b>						
<b>ANIMAL</b>						
Epithelial (skin) cells	22	1,200	60	3,200		
Hair						
Insect parts						
Mites						
<b>FUNGI</b>						
Hyphal fragments	3	40	3	40		
<b>NON-BIOLOGICAL</b>						
Cellulose fibers			1	13		
Glass fiber	1	13				
Starch particles	1	13				
Synthetic fibers	1	13	3	40		
Background debris (1-4+)†	2+		2+		None	
Sample volume (liters)	75		75		0	

**Comments:**

The analytical sensitivity is the spores/m3 divided by the raw count. The limit of detection is the analytical sensitivity multiplied by the sample volume divided by 1000.

Carbonaceous particles include soot and other combustion products. In most instances a detailed analysis of soot can be accomplished using scanning electron microscopy.

Note: Interpretation is left to the company and/or persons who conducted the field work.

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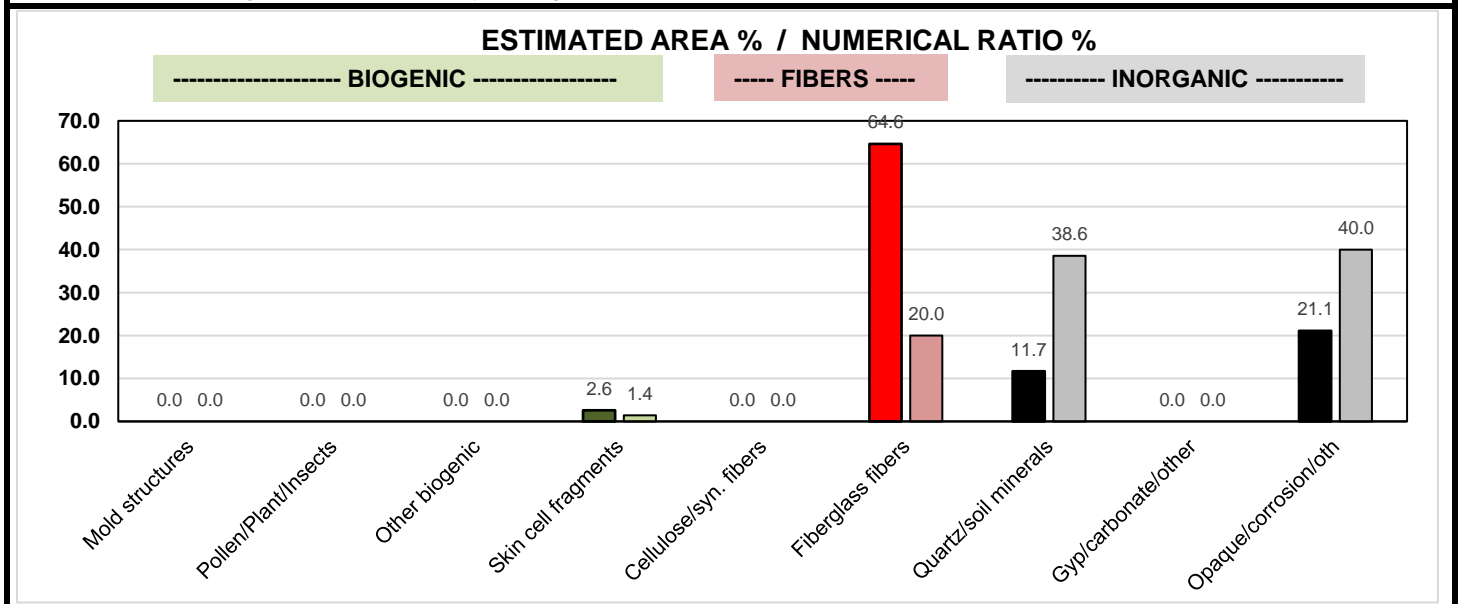


**SURFACE DUST ANALYSIS - Optical Microscopy**

**Method: DUST-D02**

Client Name : Omega Environmental Services, Inc.	Page 1 of 5
Client Project # : 2019-3488UCR	Sample collected : 9/20/19
Requested by : Dr. Wade	Sample received : 9/23/19
Project Description : 2019-3488UCR	Magnification : 500x
Client Sample # : 1-1134	Fields counted : 5
Client sample description: Stain impacted duct insulation - So corridor (east end location)	Field area counted (mm <sup>2</sup> ) : 0.69
EAA Project # : 19-1218	Total particles counted : 70
EAA Sample # : 1	Detection Limit (num. %) : 1.43
Sample media: Tape	
Summary Conclusions : No mold detected	

INORGANIC / MINERAL CONSTITUENTS		* Particles / mm <sup>2</sup>	Numerical Ratio %	Estimated Area %
<b>Fibrous Constituents :</b>	Cellulosic fabrics / paper	--		
	Synthetic fibers (nylon, rayon, etc.)	--		
	Clear fiberglass	--		
	Colored fiberglass	--	20.0	64.6
<b>Non-fibrous Constituents :</b>	Quartz-like, clays, soil minerals	--	38.6	11.7
	Gypsum-like, carbonates	--		
	Other / amorphous particles	--		
	Unidentified opaque / corrosion / paint	--	8.6	8.7
	Fire indicators - Soot, char	--	31.4	12.4
BIOLOGICAL CONSTITUENTS				
<b>Predominant mold spores :</b>	Other	--		
<b>Other fungal structures :</b>	Mycelia, phialides, perithecia, etc.	--		
<b>Pollen :</b>	Pinus / other	--		
<b>Plant fragments :</b>	Flower parts, trichomes, etc.	--		
<b>Animal fragments :</b>	Dander / skin cells	--	1.4	2.6
<b>Miscellaneous :</b>	Insect parts	--		
<b>Brown/black biogenic debris :</b>	Decayed biogenic debris	--		



Authorized / data reviewed by : Jackie L. Sova

Date : 9/26/19

Analyst : jrh

\* Indicates particle surface density (particles / mm<sup>2</sup>) cannot be calculated from the type of submitted sample

doc.rev.2019-7 4/2/19

Note: Sample results are only applicable to the items or locations tested

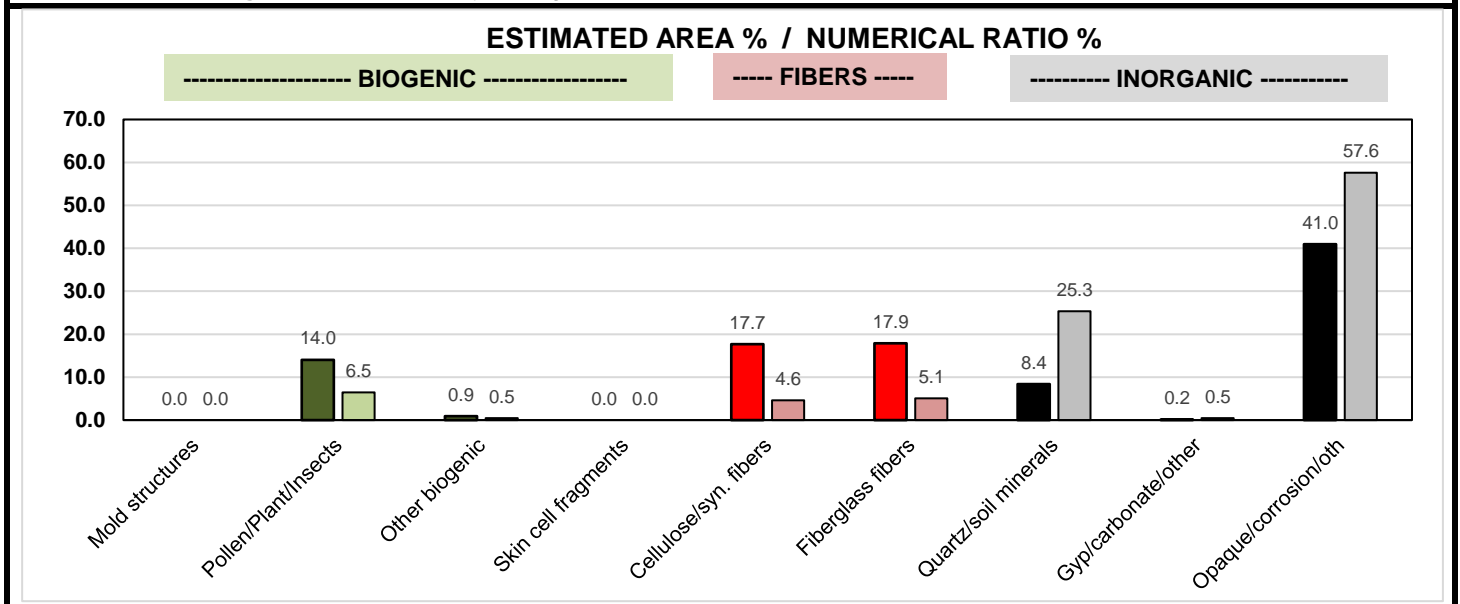


**SURFACE DUST ANALYSIS - Optical Microscopy**

**Method: DUST-D02**

Client Name : Omega Environmental Services, Inc. Page 2 of 5  
 Client Project # : 2019-3488UCR  
 Requested by : Dr. Wade Sample collected : 9/20/19  
 Project Description : 2019-3488UCR Sample received : 9/23/19  
 Client Sample # : 1A-1134 Magnification : 500x  
 Client sample description: Stain impacted duct insulation - So corridor (east end location) Fields counted : 5  
 EAA Project # : 19-1218 Field area counted (mm<sup>2</sup>) : 0.69  
 EAA Sample # : 2 Total particles counted : 217  
 Sample media: Tape Detection Limit (num. %) : 0.46  
 Summary Conclusions : No mold detected

INORGANIC / MINERAL CONSTITUENTS		* Particles / mm <sup>2</sup>	Numerical Ratio %	Estimated Area %
<b>Fibrous Constituents :</b>	Cellulosic fabrics / paper	--	4.1	14.6
	Synthetic fibers (nylon, rayon, etc.)	--	0.5	3.0
	Clear fiberglass	--		
	Colored fiberglass	--	5.1	17.9
<b>Non-fibrous Constituents :</b>	Quartz-like, clays, soil minerals	--	25.3	8.4
	Gypsum-like, carbonates	--	0.5	0.2
	Other / amorphous particles	--		
	Unidentified opaque / corrosion / paint	--	24.0	26.4
	Fire indicators - Soot, char	--	33.6	14.5
BIOLOGICAL CONSTITUENTS				
<b>Predominant mold spores :</b>	Other	--		
<b>Other fungal structures :</b>	Mycelia, phialides, perithecia, etc.	--		
<b>Pollen :</b>	Pinus / other	--		
<b>Plant fragments :</b>	Flower parts, trichomes, etc.	--	6.0	13.2
<b>Animal fragments :</b>	Dander / skin cells	--		
<b>Miscellaneous :</b>	Insect parts	--	0.5	0.8
<b>Brown/black biogenic debris :</b>	Decayed biogenic debris	--	0.5	0.9



Authorized / data reviewed by : Jackie L. Sova

Date : 9/26/19

Analyst : jrh

\* Indicates particle surface density (particles / mm<sup>2</sup>) cannot be calculated from the type of submitted sample

Note: Sample results are only applicable to the items or locations tested

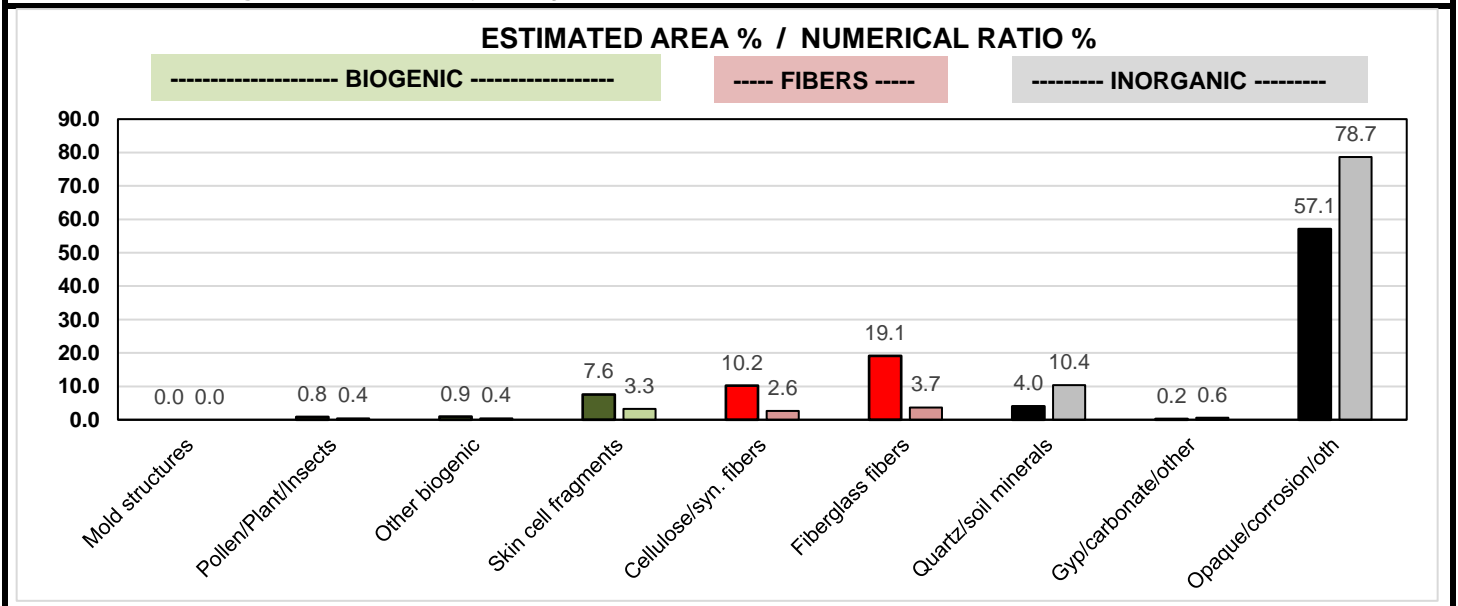


**SURFACE DUST ANALYSIS - Optical Microscopy**

**Method: DUST-D02**

Client Name : Omega Environmental Services, Inc. Page 3 of 5  
 Client Project # : 2019-3488UCR  
 Requested by : Dr. Wade Sample collected : 9/20/19  
 Project Description : 2019-3488UCR Sample received : 9/23/19  
 Client Sample # : 2-1104 Magnification : 500x  
 Client sample description: Stain impacted duct insulation - So corridor (west end location) Fields counted : 5  
 EAA Project # : 19-1218 Field area counted (mm<sup>2</sup>) : 0.69  
 EAA Sample # : 3 Total particles counted : 492  
 Sample media: Tape Detection Limit (num. %) : 0.20  
 Summary Conclusions : No mold detected

INORGANIC / MINERAL CONSTITUENTS		* Particles / mm <sup>2</sup>	Numerical Ratio %	Estimated Area %
<b>Fibrous Constituents :</b>	Cellulosic fabrics / paper	--	2.2	7.1
	Synthetic fibers (nylon, rayon, etc.)	--	0.4	3.1
	Clear fiberglass	--		
	Colored fiberglass	--	3.7	19.1
<b>Non-fibrous Constituents :</b>	Quartz-like, clays, soil minerals	--	10.4	4.0
	Gypsum-like, carbonates	--	0.2	0.1
	Other / amorphous particles	--	0.4	0.2
	Unidentified opaque / corrosion / paint	--	16.1	20.7
	Fire indicators - Soot, char	--	62.6	36.4
BIOLOGICAL CONSTITUENTS				
<b>Predominant mold spores :</b>	Other	--		
<b>Other fungal structures :</b>	Mycelia, phialides, perithecia, etc.	--		
<b>Pollen :</b>	Pinus / other	--		
<b>Plant fragments :</b>	Flower parts, trichomes, etc.	--		
<b>Animal fragments :</b>	Dander / skin cells	--	3.3	7.6
<b>Miscellaneous :</b>	Insect parts	--	0.4	0.8
<b>Brown/black biogenic debris :</b>	Decayed biogenic debris	--	0.4	0.9



Authorized / data reviewed by : Jackie L. Sova

Date : 9/26/19

Analyst : jrh

\* Indicates particle surface density (particles / mm<sup>2</sup>) cannot be calculated from the type of submitted sample

Note: Sample results are only applicable to the items or locations tested



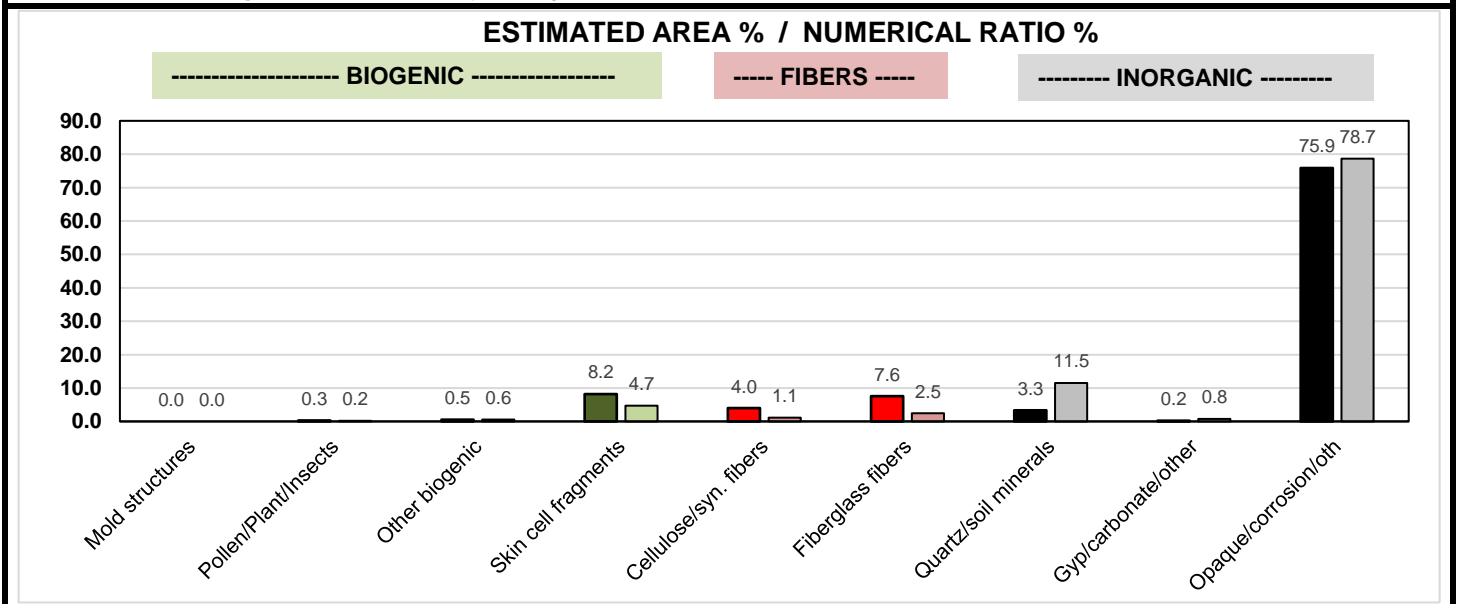


**SURFACE DUST ANALYSIS - Optical Microscopy**

**Method: DUST-D02**

Client Name : Omega Environmental Services, Inc. Page 4 of 5  
 Client Project # : 2019-3488UCR  
 Requested by : Dr. Wade Sample collected : 9/20/19  
 Project Description : 2019-3488UCR Sample received : 9/23/19  
 Client Sample # : 2A-1104 Magnification : 500x  
 Client sample description: Stain impacted duct insulation - So corridor (west end location) Fields counted : 5  
 EAA Project # : 19-1218 Field area counted (mm<sup>2</sup>) : 0.69  
 EAA Sample # : 4 Total particles counted : 530  
 Sample media: Tape Detection Limit (num. %) : 0.19  
 Summary Conclusions : No mold detected

INORGANIC / MINERAL CONSTITUENTS		* Particles / mm <sup>2</sup>	Numerical Ratio %	Estimated Area %
<b>Fibrous Constituents :</b>	Cellulosic fabrics / paper	--	0.9	2.9
	Synthetic fibers (nylon, rayon, etc.)	--	0.2	1.1
	Clear fiberglass	--		
	Colored fiberglass	--	2.5	7.6
<b>Non-fibrous Constituents :</b>	Quartz-like, clays, soil minerals	--	11.5	3.3
	Gypsum-like, carbonates	--	0.6	0.2
	Other / amorphous particles	--	0.2	0.1
	Unidentified opaque / corrosion / paint	--	16.0	15.5
	Fire indicators - Soot, char	--	62.6	60.4
BIOLOGICAL CONSTITUENTS				
<b>Predominant mold spores :</b>	Other	--		
<b>Other fungal structures :</b>	Mycelia, phialides, perithecia, etc.	--		
<b>Pollen :</b>	Pinus / other	--		
<b>Plant fragments :</b>	Flower parts, trichomes, etc.	--		
<b>Animal fragments :</b>	Dander / skin cells	--	4.7	8.2
<b>Miscellaneous :</b>	Insect parts	--	0.2	0.3
<b>Brown/black biogenic debris :</b>	Decayed biogenic debris	--	0.6	0.5



Authorized / data reviewed by : Jackie L. Sova

Date : 9/26/19

Analyst : jrh

\* Indicates particle surface density (particles / mm<sup>2</sup>) cannot be calculated from the type of submitted sample

doc.rev.2019-7 4/2/19

Note: Sample results are only applicable to the items or locations tested





**SURFACE DUST ANALYSIS - Optical Microscopy**

**Method: DUST-D02**

**Client Name : Omega Environmental Services, Inc.**

Page 5 of 5

Client Project # : 2019-3488UCR

(end of data report)

Requested by : Dr. Wade

Sample collected : 9/20/19

Project Description : 2019-3488UCR

Sample received : 9/23/19

Client Sample # : 3-Blank

Magnification : 200x

Client sample description: QAQC

Fields counted : 10

EAA Project # : 19-1218

Field area counted (mm<sup>2</sup>) : 8.67

EAA Sample # : 5

Total particles counted : 3

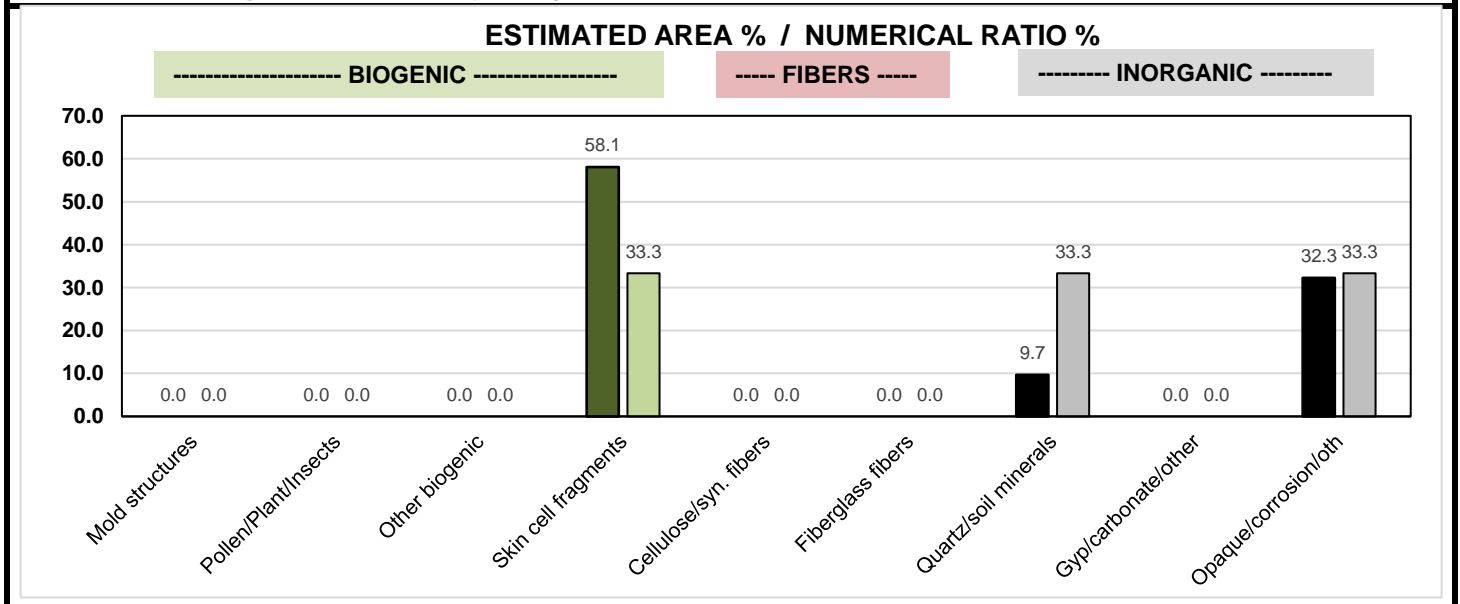
Sample media: Tape

Detection Limit (num. %) : 33.33

Summary Conclusions : No mold detected

3 total particles detected

	<b>INORGANIC / MINERAL CONSTITUENTS</b>	<b>* Particles / mm<sup>2</sup></b>	<b>Numerical Ratio %</b>	<b>Estimated Area %</b>
<b>Fibrous Constituents :</b>	Cellulosic fabrics / paper	--		
	Synthetic fibers (nylon, rayon, etc.)	--		
	Clear fiberglass	--		
	Colored fiberglass	--		
<b>Non-fibrous Constituents :</b>	Quartz-like, clays, soil minerals	--	33.3	9.7
	Gypsum-like, carbonates	--		
	Other / amorphous particles	--		
	Unidentified opaque / corrosion / paint	--	33.3	32.3
	Fire indicators - Soot, char	--		
<b>BIOLOGICAL CONSTITUENTS</b>				
<b>Predominant mold spores :</b>	Other	--		
<b>Other fungal structures :</b>	Mycelia, phialides, perithecia, etc.	--		
<b>Pollen :</b>	Pinus / other	--		
<b>Plant fragments :</b>	Flower parts, trichomes, etc.	--		
<b>Animal fragments :</b>	Dander / skin cells	--	33.3	58.1
<b>Miscellaneous :</b>	Insect parts	--		
<b>Brown/black biogenic debris :</b>	Decayed biogenic debris	--		



Authorized / data reviewed by : Jackie L. Sova

Date : 9/26/19

Analyst : jrh

\* Indicates particle surface density (particles / mm<sup>2</sup>) cannot be calculated from the type of submitted sample

doc.rev.2019-7 4/2/19

Note: Sample results are only applicable to the items or locations tested

**BULK DUST CONSTITUENT ANALYSIS SUMMARY - Optical Microscopy**

doc.rev.2

1

Client Name : Omega Environmental Services, Inc. Lab : m  
 Client project # : 2019-3488UCR Page : 1  
 Project description : 2019-3488UCR # of total pages / sples : 5  
 Client Sample # : 1-1134 Sample collected : 9/20/19  
 Client sample description : Stain impacted duct insulation - So corridor (sample received : 9/23/19  
 EAA Project # : 19-1218 Requested by : Dr. Wade  
 EAA Sample # : 1 Analyst initials : jrh  
 Sample media : Tape  
 Field diameter mm : 0.420 Field area mm<sup>2</sup> : 0.139 Cted a  
 Analysis magnification : 500  
 Fields counted : 5  
 Report comments ? : 1 (comment / conclusions in report, enter t  
 Density (cts/mm<sup>2</sup>) (Y/N)? : n

FIBROUS CONSTITUENTS		1	2	3	4	5	Sub-total
Fibrous -1 :	Cellulosic fabrics / paper						
Fibrous -2 :	Synthetic fibers (nylon, rayon, etc.)						
Fibrous -3 :	Clear fiberglass						
Fibrous -4 :	Colored fiberglass	14					14

NON-FIBROUS CONSTITUENTS		1	2	3	4	5	Sub-total
Non-fibrous-1 :	Quartz-like, clays, soil minerals	27					27
Non-fibrous-2 :	Gypsum-like, carbonates						
Non-fibrous-3 :	Other / amorphous particles						
3	Non-fibrous-4 :	Unidentified opaque / corrosion / paint	6				6
1	Non fibrous-5 :	Fire indicators - Soot, char	22				22

BIOAEROSOLS		1	2	3	4	5	Sub-total
Predominant mold spores :	Other						
Other fungal structures :	Mycelia, phialides, perithecia, etc.						
Pollen :	Pinus / other						
Plant fragments :	Flower parts, trichomes, etc.						
Animal fragments :	Dander / skin cells	1					1
Miscellaneous :	Insect parts						

ORGANIC / OTHER CONSTITUENTS		1	2	3	4	5	Sub-total
Brown/black biogenic debris :	Decayed biogenic debris						

Totals

Conclusions : No mold detected

**BULK DUST CONSTITUENT ANALYSIS SUMMARY - Optical Microscopy**

2

Client Name : Omega Environmental Services, Inc.

Client project # : 2019-3488UCR

Project description : 2019-3488UCR

Client Sample # : 1A-1134

Client sample description : Stain impacted duct insulation - So corridor (east end location)

EAA Project # : 19-1218

EAA Sample # : 2

Sample media : Tape

Field diameter mm : 0.420

Field area (mm<sup>2</sup>) : 0.139 Cted a

Analysis magnification : 500x

Fields counted : 5

Report comments ? : 1 (comment / conclusions in report, enter t

Density (cts/mm<sup>2</sup>) (Y/N)? : n

FIBROUS CONSTITUENTS		1	2	3	4	5	Sub-total
Fibrous -1 :	Cellulosic fabrics / paper	9					9
Fibrous -2 :	Synthetic fibers (nylon, rayon, etc.)	1					1
Fibrous -3 :	Clear fiberglass						
Fibrous -4 :	Colored fiberglass	11					11

NON-FIBROUS CONSTITUENTS		1	2	3	4	5	Sub-total
Non-fibrous-1 :	Quartz-like, clays, soil minerals	55					55
Non-fibrous-2 :	Gypsum-like, carbonates	1					1
Non-fibrous-3 :	Other / amorphous particles						
3	Non-fibrous-4 :	Unidentified opaque / corrosion / paint	52				52
1	Non fibrous-5 :	Fire indicators - Soot, char	73				73

BIOAEROSOLS		1	2	3	4	5	Sub-total
Predominant mold spores :	Other						
Other fungal structures :	Mycelia, phialides, perithecia, etc.						
Pollen :	Pinus / other						
Plant fragments :	Flower parts, trichomes, etc.	13					13
Animal fragments :	Dander / skin cells						
Miscellaneous :	Insect parts	1					1

ORGANIC / OTHER CONSTITUENTS		1	2	3	4	5	Sub-total
Brown/black biogenic debris :	Decayed biogenic debris	1					1

Conclusions : No mold detected


**BULK DUST CONSTITUENT ANALYSIS SUMMARY - Optical Microscopy**

3

Client Name : Omega Environmental Services, Inc.

Client project # : 2019-3488UCR

Project description : 2019-3488UCR

Client Sample # : 2-1104

Client sample description : Stain impacted duct insulation - So corridor (west end location)

EAA Project # : 19-1218

EAA Sample # : 3

Sample media : Tape

Field diameter mm : 0.420

Field area (mm<sup>2</sup>) : 0.139

Cted a

Analysis magnification : 500x

Fields counted : 5

Report comments ? : 1 (comment / conclusions in report, enter t

Density (cts/mm<sup>2</sup>) (Y/N)? : N

FIBROUS CONSTITUENTS		1	2	3	4	5	Sub-total
Fibrous -1 :	Cellulosic fabrics / paper	11					11
Fibrous -2 :	Synthetic fibers (nylon, rayon, etc.)	2					2
Fibrous -3 :	Clear fiberglass						
Fibrous -4 :	Colored fiberglass	18					18

NON-FIBROUS CONSTITUENTS		1	2	3	4	5	Sub-total
Non-fibrous-1 :	Quartz-like, clays, soil minerals	51					51
Non-fibrous-2 :	Gypsum-like, carbonates	1					1
Non-fibrous-3 :	Other / amorphous particles	2					2
3	Non-fibrous-4 :	Unidentified opaque / corrosion / paint	79				79
1	Non fibrous-5 :	Fire indicators - Soot, char	308				308

BIOAEROSOLS		1	2	3	4	5	Sub-total
Predominant mold spores :	Other						
Other fungal structures :	Mycelia, phialides, perithecia, etc.						
Pollen :	Pinus / other						
Plant fragments :	Flower parts, trichomes, etc.						
Animal fragments :	Dander / skin cells	16					16
Miscellaneous :	Insect parts	2					2

ORGANIC / OTHER CONSTITUENTS		1	2	3	4	5	Sub-total
Brown/black biogenic debris :	Decayed biogenic debris	2					2

Conclusions : No mold detected

**BULK DUST CONSTITUENT ANALYSIS SUMMARY - Optical Microscopy**

4

Client Name : Omega Environmental Services, Inc.

Client project # : 2019-3488UCR

Project description : 2019-3488UCR

Client Sample # : 2A-1104

Client sample description : Stain impacted duct insulation - So corridor (west end location)

EAA Project # : 19-1218

EAA Sample # : 4

Sample media : Tape

Field diameter mm : 0.420

Field area (mm<sup>2</sup>) : 0.139 Cted a

Analysis magnification : 500x

Fields counted : 5

Report comments ? : 1 (comment / conclusions in report, enter t

Density (cts/mm<sup>2</sup>) (Y/N)? : n

FIBROUS CONSTITUENTS		1	2	3	4	5	Sub-total
Fibrous -1 :	Cellulosic fabrics / paper	5					5
Fibrous -2 :	Synthetic fibers (nylon, rayon, etc.)	1					1
Fibrous -3 :	Clear fiberglass						
Fibrous -4 :	Colored fiberglass	13					13

NON-FIBROUS CONSTITUENTS		1	2	3	4	5	Sub-total
Non-fibrous-1 :	Quartz-like, clays, soil minerals	61					61
Non-fibrous-2 :	Gypsum-like, carbonates	3					3
Non-fibrous-3 :	Other / amorphous particles	1					1
3	Non-fibrous-4 :	Unidentified opaque / corrosion / paint	85				85
1	Non fibrous-5 :	Fire indicators - Soot, char	332				332

BIOAEROSOLS		1	2	3	4	5	Sub-total
Predominant mold spores :	Other						
Other fungal structures :	Mycelia, phialides, perithecia, etc.						
Pollen :	Pinus / other						
Plant fragments :	Flower parts, trichomes, etc.						
Animal fragments :	Dander / skin cells	25					25
Miscellaneous :	Insect parts	1					1

ORGANIC / OTHER CONSTITUENTS		1	2	3	4	5	Sub-total
Brown/black biogenic debris :	Decayed biogenic debris	3					3

Conclusions : No mold detected


**BULK DUST CONSTITUENT ANALYSIS SUMMARY - Optical Microscopy**

5

Client Name : **Omega Environmental Services, Inc.**  
 Client project # : **2019-3488UCR**  
 Project description : **2019-3488UCR**  
 Client Sample # : **3-Blank**  
 Client sample description : **QAQC**  
 EAA Project # : **19-1218**  
 EAA Sample # : **5**  
 Sample media : **Tape**  
 Field diameter mm : **1.050** Field area (mm<sup>2</sup>) : **0.867** Cted a  
 Analysis magnification : **200**  
 Fields counted : **10**  
 Report comments ? : **1** (comment / conclusions in report, enter t  
 Density (cts/mm<sup>2</sup>) (Y/N)? : **n**

<b>FIBROUS CONSTITUENTS</b>		1	2	3	4	5	Sub-total
Fibrous -1 :	Cellulosic fabrics / paper						
Fibrous -2 :	Synthetic fibers (nylon, rayon, etc.)						
Fibrous -3 :	Clear fiberglass						
Fibrous -4 :	Colored fiberglass						

<b>NON-FIBROUS CONSTITUENTS</b>		1	2	3	4	5	Sub-total
Non-fibrous-1 :	Quartz-like, clays, soil minerals	1					1
Non-fibrous-2 :	Gypsum-like, carbonates						
Non-fibrous-3 :	Other / amorphous particles						
<b>3</b>	Non-fibrous-4 :	1					1
<b>1</b>	Non fibrous-5 :						

<b>BIOAEROSOLS</b>		1	2	3	4	5	Sub-total
Predominant mold spores :	Other						
Other fungal structures :	Mycelia, phialides, perithecia, etc.						
Pollen :	Pinus / other						
Plant fragments :	Flower parts, trichomes, etc.						
Animal fragments :	Dander / skin cells	1					1
Miscellaneous :	Insect parts						

<b>ORGANIC / OTHER CONSTITUENTS</b>		1	2	3	4	5	Sub-total
Brown/black biogenic debris :	Decayed biogenic debris						

Conclusions : **No mold detected**  
**3 total particles detected**



EAA Project # :  
(Lab use only)

**19 - 1218**

**Environmental Analysis -SAMPLE COLLECTION / CHAIN OF CUSTODY FORM**

Your Contact Information		Your Project Information	
Company name:	Omega Environmental Services, Inc	Client Proj.# :	2019-3488UCR
Address:	4570 Campus Drive, Suite 30	Proj. Descrip. :	Non-viable fungi and total particulate on stain impacted duct insulation
City/State/Zip :	Newport Beach, CA 92660	EAA-Invoice to:	Same <input checked="" type="checkbox"/> Different - Provide below
Phone # :	949-252-2145	Special	
Email address :	kumar@omegaenv.com, labreports@omegaenv.com	Instructions	Email PDF Invoice to Accounts Payable Dept apdept@omegaenv.com
Date collected :	09/20/19		CC. kumar@omegaenv.com
Date Submitted :	09/20/19		
Contact Name :	Kumar Cell #949-230-4440		

Optical Microscopy - Mold & Dust		Electron Microscopy	
Analysis requested <i>Check appropriate boxes, or describe if the analysis is different</i>	<b>Air / Air-O-Cell</b>	<b>Surface / Bulk / Tape</b>	<input type="checkbox"/> Bulk SEM / X-ray analysis only
	<input type="checkbox"/> Airborne mold	<input type="checkbox"/> Mold only - tape (Qualitative)	<input type="checkbox"/> Automated air or dust particle analysis
	<input type="checkbox"/> Airborne mold & dust	<input type="checkbox"/> Mold only - bulk (Qualitative)	<input type="checkbox"/> Automated Fire chemistry analysis
	<input type="checkbox"/> Airborne dust/fire residue	<input type="checkbox"/> Surface mold tape (cts/mm <sup>2</sup> )	<input type="checkbox"/> Quantitative sample analysis (hourly)
	<input type="checkbox"/> Airborne fiberglass only	<input type="checkbox"/> Quantitative dust (cts/mm <sup>2</sup> )	<input type="checkbox"/> Other / describe:
<input checked="" type="checkbox"/> Other	<input type="checkbox"/> Quantitative dust/fire residue (cts/mm <sup>2</sup> )	Dr. Wade's Request:	
Pls refer to discussion we had		(Wildfire- circle one -Structure fire)	Require raw data (only) in % for fungi and other particulate. Pls do not provide the EAA interpretations and comparisons.
	<input type="checkbox"/> pH analysis (wildfire)		
	<input type="checkbox"/> Photo report		
Analysis Turnaround	<input checked="" type="checkbox"/> Standard - 5 Day	<input type="checkbox"/> Rush 24 hr. 50% surcharge*	<input type="checkbox"/> Same day 100% surcharge*

\* Must notify EAA in advance - Limit on number of rush samples that maybe completed in a given day. Turnaround Time (TAT) is measured in full business days; for example, samples arriving today for 24hr TAT are due at the next business day, excludes weekends and holidays.

EAA# lab use only	Sample #	Description / Location	Analysis (if different from above)	Vol. (liters)
1	1- 1134	Stain impacted duct insulation - So corridor (east end location)	Direct microscopy - fungi genus and other particulate	Per bio-tape area
2	1A- 1134	Stain impacted duct insulation - So corridor (east end location)		
3	2- 1104	Stain impacted duct insulation - So corridor (west end location)		
4	2A- 1104	Stain impacted duct insulation - So corridor (west end location)		
5	3- BLANK	QAQC		N/A

**ENVIRONMENTAL ANALYSIS ASSOCIATES, INC. - Shipping Location Information**  
(All samples should be sent to Michigan unless otherwise discussed)

Michigan Lab <input checked="" type="checkbox"/>	Attn: Joseph Heintskill 306 5th Street, Suite 2A (989) 895-4447 Bay City, MI 48708	San Diego - Forensic Research Lab <input type="checkbox"/>	Attn: Daniel Baxter 5290 Soledad Road (858) 272-7747 San Diego, CA 92109
--	--	--	--

Relinquished / received (Signature)	Printed Name	Company	Date	Time
	T Seneviratne	Omega Env	09/20/19	12:15pm
	Daniel Heintskill	EAA	9/23/19	11:30 AM

**CONTRACT TERMS**

By providing signature authorization, the client acknowledges this contract is entered into, and the lab work will be performed in either San Diego, California or Bay City, Michigan. This signature binds the submitting company to provide payment for services according to EAA's fee schedule within 30 days above from receipt of the project invoice. A 1% finance charge per month will be charged on overdue invoices. Sample archive policy: EAA retains and holds samples for a time period of 3 weeks only. If samples need to be retained by the laboratory for a longer period of time, you must make arrangements for retention at the time of sample submission. Additional charges may apply.

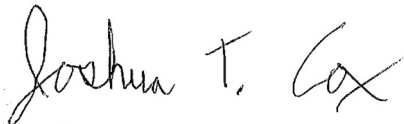
Report for:

**Ms. Irene Benavides, Mr. Kumar Gunaratna, Mr. Navid Salari**  
**Omega Environmental Services, Inc.: CA**  
4570 Campus Drive, Ste. 30  
Newport Beach, CA 92660

---

Regarding: Project: 2019-3488UCR; Pierce Hall-South Corridor  
EML ID: 2258127

Approved by:



Operations Manager  
Joshua Cox

Dates of Analysis:

Culturable air fungi (Incl. Asp spp.): 09-27-2019

Service SOPs: Culturable air fungi (Incl. Asp spp.) (EM-MY-S-1043)  
AIHA-LAP, LLC accredited service, Lab ID #102297

---

All samples were received in acceptable condition unless noted in the Report Comments portion in the body of the report. Due to the nature of the analyses performed, field blank correction of results is not applied. The results relate only to the samples as received. Sample air volume is supplied by the client.

Eurofins EMLab P&K ("the Company") shall have no liability to the client or the client's customer with respect to decisions or recommendations made, actions taken or courses of conduct implemented by either the client or the client's customer as a result of or based upon the Test Results. In no event shall the Company be liable to the client with respect to the Test Results except for the Company's own willful misconduct or gross negligence nor shall the Company be liable for incidental or consequential damages or lost profits or revenues to the fullest extent such liability may be disclaimed by law, even if the Company has been advised of the possibility of such damages, lost profits or lost revenues. In no event shall the Company's liability with respect to the Test Results exceed the amount paid to the Company by the client therefor.

Eurofins EMLab P&K's LabServe® reporting system includes automated fail-safes to ensure that all AIHA-LAP, LLC quality requirements are met and notifications are added to reports when any quality steps remain pending.

---



Client: Omega Environmental Services, Inc.: CA Date of Sampling: 09-20-2019  
 C/O: Ms. Irene Benavides, Mr. Kumar Gunaratna, Mr. Navid Salari Date of Receipt: 09-20-2019  
 Re: 2019-3488UCR; Pierce Hall-South Corridor Date of Report: 09-27-2019

**CULTURABLE AIR FUNGI REPORT**

Location:	BC-1: Exterior-Outside South Entry		BC-2: Hallway East at Ceiling 1134		BC-3: Hallway East at Breathing Zone 1134	
Comments (see below)	None		A		None	
Lab ID-Version‡:	10738099-1		10738100-1		10738101-1	
Analysis Date:	09/27/2019		09/27/2019		09/27/2019	
Medium:	MEA		MEA		MEA	
	raw ct.	cfu*/m3	raw ct.	cfu*/m3	raw ct.	cfu*/m3
Aspergillus						
Aspergillus niger	1	18				
Bipolaris/Drechslera group						
Botrytis						
Chaetomium						
Cladosporium	14	250				
Curvularia						
Epicoccum						
Fusarium						
Non-sporulating fungi						
Paecilomyces						
Penicillium						
Phoma						
Phoma/coelomycetes	2	35				
Rhizopus						
Stachybotrys chartarum						
Ulocladium						
Yeasts					1	18
Positive Hole	342		342		342	
Sample volume (liters)	56.66		56.66		56.66	
<b>§ TOTAL CFU*/M3</b>		<b>300</b>		<b>&lt; 18</b>		<b>18</b>

\* cfu = colony forming units Positive hole correction chart used for all calculations

Comments: A) No fungal colonies detected.

Note: Interpretation is left to the company and/or persons who conducted the field work. Variation is an inherent part of biological sampling.

The presence or absence of a few genera in small numbers should not be considered abnormal.

NORMAL SPORE LEVELS: Indoor spore levels usually average 30 to 80% of the outdoor spore level at the time of sampling, with the same general distribution of spore types. Filtered air, air-conditioned air, or air remote from outside sources may average 5 to 15% of the outside air at the time of sampling. (These percentages are guidelines, only. A major factor is the accessibility of outdoor air. A residence with open doors and windows and heavy foot traffic may average 95% of the outdoor level while high rise office buildings with little air exchange may average 2%. Dusty interiors may exceed 100% of the outdoors to some degree, but will still mirror the outdoor distribution of spore types.)

PROBLEM INTERIORS: A substantial increase of one or two spore types which are inconsistent with and non-reflective of the outside distribution of spore types is usually indicative of an indoor reservoir of mold growth.

The limit of detection is 1 raw count per volume of air sampled. The analytical sensitivity is 1 raw count/volume x the positive hole correction factor.

‡ A "Version" indicated by "-x" after the Lab ID# with a value greater than 1 indicates a sample with amended data. The revision number is reflected by the value of "x".

§ Total CFU/m3 has been rounded to two significant figures to reflect analytical precision.

Fungal culture types listed without a count or data entry were not detected during the course of the analysis for the respective sample.

Client: Omega Environmental Services, Inc.: CA Date of Sampling: 09-20-2019  
 C/O: Ms. Irene Benavides, Mr. Kumar Gunaratna, Mr. Navid Salari Date of Receipt: 09-20-2019  
 Date of Report: 09-27-2019  
 Re: 2019-3488UCR; Pierce Hall-South Corridor

**CULTURABLE AIR FUNGI REPORT**

Location:	BC-4: Hallway West at Ceiling 1104		BC-5: Hallway West at Breathing Zone 1104		BC-6: QAQC	
Comments (see below)	None		None		None	
Lab ID-Version‡:	10738102-1		10738103-1		10738104-1	
Analysis Date:	09/27/2019		09/27/2019		09/27/2019	
Medium:	MEA		MEA		MEA	
	raw ct.	cfu*/m3	raw ct.	cfu*/m3	raw ct.	cfu*/m3
Aspergillus	1	18				
Aspergillus niger						
Botrytis						
Chaetomium						
Cladosporium	1	18	2	35		
Curvularia						
Epicoccum						
Fusarium						
Non-sporulating fungi						
Paecilomyces						
Penicillium			1	18		
Phoma						
Phoma/coelomycetes						
Rhizopus						
Stachybotrys chartarum						
Ulocladium						
Yeasts						
Positive Hole	342		342		0	
Sample volume (liters)	56.66		56.66		0	
<b>§ TOTAL CFU*/M3</b>		<b>35</b>		<b>53</b>		<b>N/A</b>

\* cfu = colony forming units Positive hole correction chart used for all calculations

**Comments:**

Note: Interpretation is left to the company and/or persons who conducted the field work. Variation is an inherent part of biological sampling. The presence or absence of a few genera in small numbers should not be considered abnormal.  
 NORMAL SPORE LEVELS: Indoor spore levels usually average 30 to 80% of the outdoor spore level at the time of sampling, with the same general distribution of spore types. Filtered air, air-conditioned air, or air remote from outside sources may average 5 to 15% of the outside air at the time of sampling. (These percentages are guidelines, only. A major factor is the accessibility of outdoor air. A residence with open doors and windows and heavy foot traffic may average 95% of the outdoor level while high rise office buildings with little air exchange may average 2%. Dusty interiors may exceed 100% of the outdoors to some degree, but will still mirror the outdoor distribution of spore types.)  
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Fungal culture types listed without a count or data entry were not detected during the course of the analysis for the respective sample.



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www.EMLabPK.com



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Phoenix, AZ: 1501 West Knudsen drive, Phoenix, AZ 85027 \* (800) 651-4802  
San Bruno, CA: 1150 Bayhill Drive, #100, San Bruno, CA 94066 \* (866) 888-6653

Weather	Fog	Rain	Snow	Wind	Clear
None	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Light	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Moderate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heavy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

REQUESTED SERVICES (Use checkboxes below)											
Non-Culturable			Culturable						Other Requests		
Spore Trap	Tape Swab Bulk		BioCassette™, Andersen, SAS, Swab, Water, Bulk, Dust, Soil, Contact Plates								
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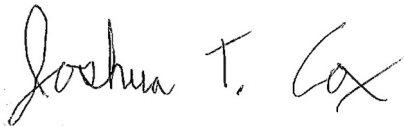
Report for:

**Ms. Irene Benavides, Mr. Kumar Gunaratna, Mr. Navid Salari**  
**Omega Environmental Services, Inc.: CA**  
4570 Campus Drive, Ste. 30  
Newport Beach, CA 92660

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Regarding: Project: 2019-3488UCR; Pierce Hall-South Corridor  
EML ID: 2258125

Approved by:



Operations Manager  
Joshua Cox

Dates of Analysis:

1-Media fungi surface culture (Incl. Asp spp.): 10-01-2019

Service SOPs: 1-Media fungi surface culture (Incl. Asp spp.) (EM-PR-S-1040 & EM-MY-S-2584)  
AIHA-LAP, LLC accredited service, Lab ID #102297

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All samples were received in acceptable condition unless noted in the Report Comments portion in the body of the report. Due to the nature of the analyses performed, field blank correction of results is not applied. The results relate only to the samples as received.

Eurofins EMLab P&K ("the Company") shall have no liability to the client or the client's customer with respect to decisions or recommendations made, actions taken or courses of conduct implemented by either the client or the client's customer as a result of or based upon the Test Results. In no event shall the Company be liable to the client with respect to the Test Results except for the Company's own willful misconduct or gross negligence nor shall the Company be liable for incidental or consequential damages or lost profits or revenues to the fullest extent such liability may be disclaimed by law, even if the Company has been advised of the possibility of such damages, lost profits or lost revenues. In no event shall the Company's liability with respect to the Test Results exceed the amount paid to the Company by the client therefor.

Eurofins EMLab P&K's LabServe® reporting system includes automated fail-safes to ensure that all AIHA-LAP, LLC quality requirements are met and notifications are added to reports when any quality steps remain pending.

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Client: Omega Environmental Services, Inc.: CA Date of Sampling: 09-20-2019  
 C/O: Ms. Irene Benavides, Mr. Kumar Gunaratna, Mr. Navid Salari Date of Receipt: 09-20-2019  
 Re: 2019-3488UCR; Pierce Hall-South Corridor Date of Report: 10-01-2019

**FUNGAL CULTURE REPORT**

Lab ID-Version‡ Location Analysis Date	Sample Size/ Report Unit	Medium	Dilution Factor	Fungal ID	Colony Counts	CFU/unit	%
10738063-1 B-1 Hallway 1134 East at Ceiling-Duct Insulation B Analysis date: 10/01/2019	Size: 1 swab Unit: 1 swab	MEA	10	Non-sporulating fungi	17	170 § Total: 170	100 100
Comments:							
10738064-1 B-2 Hallway 1104 West at Ceiling-Duct Insulation B Analysis date: 10/01/2019	Size: 1 swab Unit: 1 swab	MEA	10	No fungi detected		§ Total: < 10	100
Comments:							

The limit of detection is a raw count of 1 at the lowest dilution plated. The analytical sensitivity is equal to 1 raw count/reporting unit x the dilution factor.


‡ A "Version" indicated by -"x" after the Lab ID# with a value greater than 1 indicates a sample with amended data. The revision number is reflected by the value of "x".

§ Total has been rounded to two significant figures to reflect analytical precision.





IAQ - Field Data Sheet


Project Number	2019-3488UCR	IH Name	T Seneviratne	
Project Name	Pierce Hall HAZ Mat Ass	Equip/SN	Hygrometer/Extech/1037978	
Project Site Address	UC, Riverside, CA	Equip/SN	Particle Counter/TSI 9306 LPC/	
Assessment Date	09/20/19	Equip/SN		

Outdoor Measurements: \_\_\_\_\_ Indoor Measurements: X

Sample location	Sampling Time	PM <sub>3</sub>	PM <sub>5</sub>	PM <sub>10</sub>	Temp °F	RH %	Comment/s
① 1 East S. Hall outside Rm 1134	120 sec	316445	173766	39968	67.2	69.5	no activity 9:06 am
② 2 West S. Hall outside Rm 1104	120 sec	93722	19764	4312	69.4	61.3	" 9:10 am
④ 3 Lobby	120 sec	143999	62347	14194	69.8	60.4	" 9:14 am
① 4 East S. Hall outside Rm 1134	12:22	118984	59766	13891	66.5	66.4	" 2 min
② 5 West S. Hall outside Rm 1104	12:25	104570	41864	8085	68.9	62.6	" 2 min
④ 6 Lobby	12:28	213917	78796	16861	71.9	53.6	" 2 min
7							
8							
9							
10							
11							
12							
13							
14							
15							

Notes:  
 PM<sub>10</sub> - Particulate Matter less than (<) 10 micrometers (µ); PM<sub>3</sub> - Particulate Matter < 3 µ; Mg/M<sup>3</sup> - Milligrams per cubic meter; ppm - Parts per million;  
 °F - Temperature in Fahrenheit; RH% - Percent Relative Humidity;

IAQ - Field Data Sheet

Project Number	2019-3488UCR	IH Name	T Seneviratne	
Project Name	Pierce Hall HAZ Mat Ass	Equip/SN	Hygrometer/Extech/1037978	
Project Site Address	UC, Riverside, CA	Equip/SN	Particle Counter/TSI 9306 LPC/	
Assessment Date	09/20/19	Equip/SN		

Outdoor Measurements:  Indoor Measurements:

Sample location	Sampling Time	PM <sub>3</sub>	PM <sub>5</sub>	PM <sub>10</sub>	Temp °F	RH %	Comment/s
③ 1 West entrance to Lobby	9:20	333342	84806	10424	68.1 <del>69.0</del>	60.5	minor activity, shaded
⑤ 2 East courtyard	9:17	385336	98410	12898	70.5	60.5	"
③ 3 West entrance to Lobby	12:31	406506	134918	19624	76.2°	46.7	no activity, shaded
⑤ 4 East courtyard	12:31	374259	130622	22279	58.8 <del>58.8</del>	50.8	no activity, shaded
5							
6							
7							
8							
9							
10							
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12							
13							
14							
15							

Notes:  
 PM<sub>10</sub> - Particulate Matter less than (<) 10 micrometers (µ); PM<sub>3</sub> - Particulate Matter < 3 µ; Mg/M<sup>3</sup> - Milligrams per cubic meter; ppm - Parts per million;  
 °F - Temperature in Fahrenheit; RH% - Percent Relative Humidity;

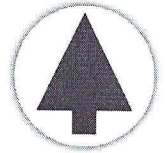




## Appendix 3

# Instrument Calibration Report

# INSTRUMENT CALIBRATION REPORT



**Pine Environmental Services LLC**

12524 130th Lane NE Unit A 114  
Kirkland WA 98034  
425-285-9102

## Pine Environmental Services, Inc.

**Instrument ID** 34983  
**Description** TSI 9306-04 Aerotrak  
**Calibrated** 9/18/2019 2:52:11PM

**Manufacturer** Tsi  
**Model Number** 9306-04  
**Serial Number/ Lot Number** 93061629015  
**Location** Seattle  
**Department**

**State Certified**  
**Status** Pass  
**Temp °C** 23.2  
**Humidity %** 48

### Calibration Specifications

**Group #** 1  
**Group Name** Zero Test  
**Test Performed: Yes**      **As Found Result: Pass**      **As Left Result: Pass**

### Test Instruments Used During the Calibration

<u>Test Standard ID</u>	<u>Description</u>	<u>Manufacturer</u>	<u>Model Number</u>	<u>Serial Number / Lot Number</u>	<u>(As Of Cal Entry Date)</u>	
					<u>Last Cal Date/ Opened Date</u>	<u>Next Cal Date / Expiration Date</u>

### Notes about this calibration

**Calibration Result** Calibration Successful  
**Who Calibrated** Tony Nguyen

All instruments are calibrated by Pine Environmental Services LLC according to the manufacturer's specifications, but it is the customer's responsibility to calibrate and maintain this unit in accordance with the manufacturer's specifications and/or the customer's own specific needs.

**Notify Pine Environmental Services LLC of any defect within 24 hours of receipt of equipment**  
**Please call 800-301-9663 for Technical Assistance**



# CERTIFICATE OF CALIBRATION

TSI Incorporated, 500 Cardigan Road, Shoreview, MN 55126 USA  
Tel: 1-800-874-2811 1-651-490-2811 Fax: 1-651-490-3824 <http://www.tsi.com>

ENVIRONMENT CONDITION		
TEMPERATURE	76.3 (24.6)	°F (°C)
RELATIVE HUMIDITY	23	%RH
BAROMETRIC PRESSURE	29.14 (986.8)	inHg (hPa)

MODEL	9306-04
SERIAL NUMBER	93061629015
CUSTOMER INST ID	

<input checked="" type="checkbox"/> AS LEFT	<input checked="" type="checkbox"/> IN TOLERANCE
<input type="checkbox"/> AS FOUND	<input type="checkbox"/> OUT OF TOLERANCE

AEROTrak CALIBRATION KIT			
MEASUREMENT VARIABLE	SYSTEM ID	DATE LAST CALIBRATED	CALIBRATION DUE DATE
7201-02F	E004434	10-02-2018	04-30-2019
FLOW METER	E005682	05-15-2018	05-31-2019

PARTICLE STANDARDS				
PARTICLE SIZE	STANDARD UNCERTAINTY	STANDARD DEVIATION	LOT NO.	EXPIRATION DATE
0.303 µm	0.003 µm	0.0047 µm	196947	4/30/2021
0.508 µm	0.004 µm	0.0085 µm	204667	11/30/2021
0.994 µm	0.0075 µm	0.010 µm	200992	8/31/2021
2.92 µm	0.015 µm	0.03 µm	181443	2/28/2020
5.020 µm	0.015 µm	0.06 µm	179268	1/31/2020
9.850 µm	0.03 µm	0.13 µm	202929	9/30/2021

TSI does hereby certify that the calibration performed on the above described instrument meets the requirements of ISO 21501-4. TSI does hereby certify that the above described instrument conforms to the original manufacturer's specification (not applicable to As Found data) and has been calibrated using standards whose accuracies are traceable to the United States National Institute of Standards and Technology (NIST) or has been verified with respect to instrumentation whose accuracy is traceable to NIST, or is derived from accepted values of physical constants. TSI is registered to ISO-9001:2015.

*Mai Vu*

CALIBRATED

March 21, 2019

DATE





# CERTIFICATE OF CALIBRATION

TSI Incorporated, 500 Cardigan Road, Shoreview, MN 55126 USA  
Tel: 1-800-874-2811 1-651-490-2811 Fax: 1-651-490-3824 <http://www.tsi.com>

## SIZE CALIBRATION AND VERIFICATION OF SIZE SETTING

NOMINAL PARTICLE SIZE	GAIN STAGE	DIGITAL CUTPOINT	EXPANDED UNCERTAINTY
0.3 $\mu\text{m}$	A	40	4.1%
0.5 $\mu\text{m}$	A	350	3.9%
1 $\mu\text{m}$	B	7	3.9%
3 $\mu\text{m}$	B	58	3.7%
5 $\mu\text{m}$	B	172	3.6%
10 $\mu\text{m}$	B	570	3.6%

## COUNTING EFFICIENCY

PARTICLE SIZE	ACTUAL	ALLOWABLE RANGE	PASS/FAIL
0.3 $\mu\text{m}$	51%	50% $\pm$ 20%	Pass
0.5 $\mu\text{m}$	94%	100% $\pm$ 10%	Pass

## SIZE RESOLUTION

PARTICLE SIZE	MEASURED	ALLOWABLE RANGE	PASS/FAIL
0.5 $\mu\text{m}$	7.8%	$\leq$ 15%	Pass

## FALSE COUNT RATE

SAMPLE TIME (MIN)	SAMPLED (L)	MEASURED COUNTS (#)	CONCENTRATION ( $\#/m^3$ )	95% UCL ( $\#/m^3$ )	ALLOWABLE RANGE ( $\#/m^3$ )	PASS/FAIL
30	85	1	11.78	55.4	$\leq$ 70.7	Pass

## SAMPLING FLOW RATE (L/MIN)

NOMINAL	ACTUAL	ERROR	ALLOWABLE RANGE	PASS/FAIL
2.83	2.83	0.0%	$\pm$ 5%	Pass

## SAMPLING TIME $\uparrow$

MEASURED	ALLOWABLE RANGE	PASS/FAIL
$< \pm$ 0.1%	$\pm$ 1%	Pass

## RESPONSE RATE $\uparrow$

MEASURED	ALLOWABLE RANGE	PASS/FAIL
0.08%	$\leq$ 0.5%	Pass

## MAXIMUM PARTICLE CONCENTRATION $\uparrow$

210000000 $\#/m^3$ @10% Coincidence Loss
--

$\uparrow$  Tested and verified during product development

## CALIBRATION INTERVAL

CALIBRATION DATE	EXPIRATION DATE
March 21, 2019	March 21, 2020



## Appendix 4

# **Research Paper: Total Particulates and Health Effects**

## **Total Particulates and their Effects on Human Health**

### Particulate Matter

Particulate matter (PM) is defined by the US Environmental Protection Agency as a complex mixture of extremely small solid particles and liquid droplets made up of many components including acids, organic chemicals, metals, and soil or dust particles (EPA 2017). PM is generated from a variety of sources and includes particles of many sizes, measured by their aerodynamic diameter, which is the diameter of the idealized spherical shape of an irregularly shaped particle. Respirable particulate matter, or the fraction of total particulates that is inhalable, is categorized by size. Widely-monitored criteria pollutants designated by EPA are those with diameters between 2.5 and 10 micrometers (PM<sub>10</sub>) and less than or equal to 2.5 micrometers (PM<sub>2.5</sub>). Ultrafine particles are defined as those with an aerodynamic diameter less than 0.1 micrometers. For comparison, the diameter of fine beach sand is approximately 90 micrometers in diameter. Nuisance dusts, also known as “particulates not otherwise regulated” are defined by NIOSH as dusts from solid substances without specific occupational exposure standards as defined by the OSHA Z-tables (CDC NIOSH).

### *Classifying Particulate Matter*

Among total ambient particulate matter, the respirable fraction, or those with an aerodynamic diameter of 10 micrometers or less, is of primary health concern. PM<sub>2.5</sub>, also known as fine particulate matter, remains airborne for extended periods due to its small size and light weight. These particles can travel large distances through indoor or outdoor environments. PM<sub>10</sub>, also known as coarse particulate matter, is often formed by suspension of settled dust, evaporation of sprays, and mechanical processes including sanding, crushing, grinding, and drilling. PM<sub>10</sub> does not remain airborne for long periods of time due to its larger particle size and heavier weight. These particles are often found deposited downwind of emission sources. Unlike coarse and fine particulate matter, ultrafine particulate matter, or PM less than 0.1 micrometers in aerodynamic diameter, are not regulated. These particles are small enough to penetrate lung tissue and enter the bloodstream directly, where they can have deleterious effects on many organ systems (Tanrikulu et al 2010). Toxicological and physiological studies have led to the generally established consideration that PM<sub>2.5</sub> has the greatest effect on human health (Pope & Dockery 2006).

### *Sources of Particulate Matter*

Particulate matter releases include primary emissions, where particles are directly emitted, and secondary emissions, where particles are formed from chemical reactions in the atmosphere. These emissions can originate from mobile sources such as vehicle emissions or stationary sources including factories and refineries. Primary mobile sources include vehicle and air traffic, diesel trucks, and construction equipment, among others. A significant amount of ambient particulate pollution is generated from combustion of fossil fuels in power plants (Sarkar 2015). Additional sources of particulate matter pollution include natural processes, including wildfires, volcanos, and lightning, in addition to area sources such as pollution from cities and agricultural areas. (NPS



2018). In low income countries, biomass burning for cooking processes is a significant contributor to particulate matter pollution (Jiang & Bell 2008).

### *Constituents of Particulate Matter*

The composition of particulate matter pollution varies greatly and depends on the source and size of particle emitted. Particulate matter consists of chemical, biological, and inert materials. These may include acids, metals, organic chemicals, pollen, fungal spores, fine soils and salts, smoke and ash, and many others (Morakinyo 2016). Course particles, or  $PM_{10}$ , are often derived from the aerosolization or resuspension of dust, soil, pollen, mold spores, and other materials. Fine and ultrafine particles, or  $PM_{2.5}$  and  $PM_{0.1}$ , are primarily generated from combustion processes including that of vehicle fuel, power generation, and other industrial processes. These activities may generate sulfate and nitrite particles, acids, metals, polycyclic aromatic hydrocarbons, and volatile organic compounds, among others. Ultrafine particulate matter is primarily emitted through combustion processes, but generally has a short half-life and will often aggregate to form larger structures but remain as  $PM_{2.5}$  (Pope III & Dockery 2006).

### Pathways of Exposure to Particulate Matter Pollution

#### *Respiratory Exposure*

The primary route of exposure to airborne particulate matter is nasal or oral inhalation (WHO) of aerosolized respirable particulates. Particle size is the key factor which influences deposition of particles in the respiratory system. Particles with a large aerodynamic diameter ( $>30$  microns) are retained in the upper respiratory system of the head by the mechanisms of the nasal filtration system, including nasal hairs, mucus lining the nose, and impaction where the flow of air changes direction. Course particulates that do not deposit in the nose may settle in the tracheobronchial region, where they may be cleared by the cilia and mucous membrane that line the airways to be excreted by coughing or swallowing (Dockery & Pope 1994). Particles with smaller aerodynamic diameters, including fine and ultrafine particles, are capable of penetrating deeper into lung tissues, and can potentially be deposited in the alveoli, a highly vascularized region of the lung where the exchange of gases takes place. Once inhaled, particles may either be deposited somewhere along the respiratory tract or exhaled, depending on several physiological and particle-related factors (WHO 2018). Soluble particles may enter the body by dissolution at the tracheobronchial region and lower. As with all PM exposure, toxicity of inhaled ambient urban particulates and combustion products depends on the type of metal compounds and combustion-generated organic content that is present (Dockery & Pope 1994). The respiratory health effects of particulate matter exposure will be discussed below.

#### *Ingestion Exposure and Effects*

Ingestion exposure to airborne particulates can occur via contamination of food. When contaminants, including polycyclic aromatic hydrocarbons (PAH) are emitted by mobile or stationary sources, they are adsorbed onto particulate matter in the environment, where they are capable of migrating into environmental media including soil and surface water via wet or dry deposition (ECSCF 2002). For example, contaminants generated by combustion may be adsorbed

to airborne particulate matter and could impact soil and surface water during a precipitation event. It is here that contaminants may be taken up by plants used as food and can pollute the food and water supply significantly (Beamish 2011). Ingestion exposure to particulate matter has been linked to health risks including cancer in animal studies (ECSCF 2002, Garcia-Perez et al. 2010), appendicitis (Kaplan et al. 2009), bowel infections (Orazio et al. 2009), and inflammatory bowel disease (Kaplan et al. 2010). However, effects of ingestion exposure to airborne particulates is shown to be dependent on the chemical constituents of the particulate matter (Hu et al 2012).

### *Dermal Exposure and Effects*

Exposure to particulate matter can also occur via dermal pathways when airborne particulates are present. Dermal exposure to particulate matter occurs when aerosolized particulates in the environment are deposited onto skin and absorbed into the epidermis through hair follicles and sweat glands (Thompson 2018). Deposition and absorption of particles is dependent upon a range of physical and chemical properties of the particle and skin surface, including particle size, surface roughness, wetness, and temperature (Thompson). Thompson suggests that after all factors are considered, the average daily dermal exposure to particulate matter is around 50-100 micrograms, which is in line with a study by Vaananen and colleagues (2005), who found PAHs deposited onto the wrists of road pavers at approximately  $70\text{ng}/\text{cm}^2$ . After deposition on the skin, particles move from the epidermis to the dermis, then diffuse into the bloodstream via the vasculature in the hypodermis, or third layer of skin (Thompson).

Studies have shown an increased inflammatory response following dermal exposure to particulate matter (Park et al 2018). Jin and colleagues found in an in vivo study on mice that reactive oxygen species (ROS) were produced following dermal treatment with particulate matter. Additionally, barrier-disrupted skin was seen to have deeper penetration of particulate matter (Jin 2018). Another study found that dermal exposure to  $\text{PM}_{10}$  aggravated atopic dermatitis, increased hyperpigmentation, and contributed to aging in the skin (Kang et al 2014).

### Health Effects of Inhalation Exposure to Particulate Matter

The World Health Organization estimates that 4.2 million premature deaths worldwide were attributed to ambient air pollution in 2016 (WHO 2018). The health effects of PM inhalation exposure are discussed below. Future mentions of PM refer to the respirable fraction, or PM with aerodynamic diameter less than 10 micrometers.

### *Respiratory Effects*

Since inhalation is the primary route of exposure to particulate matter, the most prevalent health outcomes resulting from exposure are respiratory effects. An inflammatory response elicited by particulate matter deposition in the airways is a common effect of exposure, which occurs by multiple channels and mechanisms (Thompson 2018). Lakey and colleagues describe a mechanism for which particulate matter exposure generates reactive oxygen species (ROS) leading to oxidative stress and adverse health effects (2016).



Particulate matter exposure has well studied effects on airway disease such as asthma, chronic obstructive pulmonary disease (COPD), and pneumonia. One study of Canadian children under 9 years old found that increased 3-day mean increase in  $PM_{2.5}$  concentration of  $5.92\mu g/m^3$  increased the risk of asthma-related emergency room visits by 7.2% (Weichenthal et al. 2016). Pothirat and colleagues found an acute exacerbation of COPD with  $PM_{2.5}$  and  $PM_{10}$  exposure (2019). Hwang et al found a risk ratio of 1.07 for pneumonia for each  $10\mu g/m^3$  increase in  $PM_{2.5}$ . PM exposure exacerbated symptoms in people with these diseases and contributed to increased respiratory symptoms and reduced lung function in those exposed (Pope and Dockery 2006).

### *Cardiovascular Effects*

The cardiovascular system is another body system which is affected by exposure to particulate matter. Both short- and long-term exposure to ambient aerosolized particulates have been linked to cardiovascular mortality and morbidity (Pope & Dockery 2006). Fine particulate matter ( $PM_{2.5}$ ) is most consistently associated with cardiovascular morbidities (Ito et al 2011). The relationship between PM exposure and ischemic stroke are well documented. One study found that for every  $10\mu g/m^3$  increase in  $PM_{2.5}$ , the odds of stroke were 1.13 (Lin et al 2017). Xia et al demonstrated that acute exposure to  $PM_{2.5}$  contributed to increased cardiac arrest, particularly in those with history of stroke or who are older in age (2017). Hypertension, which is a risk factor for heart disease, was linked to PM exposure in a study which found that for every  $10\mu g/m^3$  increase in  $PM_{2.5}$ , the odds of hypertension was 1.14. Jacobs et al found that fine particulate matter exposure was significantly associated with increases in systolic blood pressure and pulse pressure (2012) and Dockery et al showed a significant association between fine particulate matter and ventricular tachyarrhythmias (2011). Ambient particulate exposure has been shown to significantly contribute to cardiopulmonary disease, particularly in those susceptible or at increased risk of disease.

### *Reproductive Effects*

In addition to cardiopulmonary health risks, particulate matter exposure has been linked to reproductive effects and adverse birth outcomes when pregnant mothers are exposed. Studies of maternal exposure to  $PM_{2.5}$  have been linked to low birth weight (LBW) (Pedersen et al. 2016) and small for gestational age (SGA) (Stieb et al. 2016). A study conducted among twin pairs in Shanghai, China found a significant association between increased within-pair weight difference and intertwin birth weight discordance among children born to mothers exposed to  $PM_{2.5}$  and chemical constituents of sulfate and ammonium during the third trimester (Qiao 2019).

### *Central Nervous System Effects*

In addition to the increased risk of stroke previously described, PM can have adverse effects on the central nervous system in humans. In vitro studies show neurotoxic effects of  $PM_{2.5}$  and  $PM_{0.1}$  (Gillespie et al. 2013), and some ultrafine particulate matter (aerodynamic diameter less than 2.5 microns) is capable of entering the bloodstream and crossing the blood brain barrier (Shmid et al 2009, Ding et al 2016) where chemical constituents can have direct effects on the brain.

## *Cancers*

Epidemiological and toxicological studies of health outcomes following exposure to specific chemical constituents of particulate matter have demonstrated carcinogenic effects to multiple organ systems. For example, a cross sectional study of industrial workers exposed to PM containing poly aromatic hydrocarbons (PAHs) and nitro-PAHs showed a significant increased risk of lung, skin, and bladder cancers not attributed to other occupational exposures (Boffetta et al. 1997). The European Commission linked arsenic, cadmium, chromium, and nickel- containing PM to cancers, and determined that lung cancer is the critical effect following inhalation exposure to PM. Additionally, it was determined that genotoxic carcinogenicity due to PM exposure occurs via direct as well as indirect mechanisms (European Commission). The International Agency for Research on Cancer classifies both particulate matter and outdoor air pollution as carcinogenic to humans (IARC 2013).

## *Other Effects*

Increased hospital and emergency department admissions related to asthma or other respiratory issues resulting from PM exposure are widely demonstrated (Strickland et al 2010, Thurston et al 1994, Lall et al 2011) in many urban regions of the world. Cytotoxicity by both fine and course particulate matter has been demonstrated in in-vitro studies (Osornio-Vargas et al 2003). Exposure to biological components of PM, including endotoxins, mold spores, and pollen grains can lead to effects such as asthma related deaths (Targonski et al 1995), repeated wheeze (Bolte et al 2003), increased inflammation and phagocytosis (Alexis et al 2006), and increase in allergies (Adhikari et al. 2004), skin rash, headache, and fatigue (Morakinyo et al 2016).

## Regulations around Ambient Particulate Matter

The US Environmental Protection Agency was required to set National Ambient Air Quality Standards (NAAQS) by the Clean Air Act. These standards identify six criteria air pollutants for which standards have been developed. The regulated pollutants are carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter (both PM<sub>2.5</sub> and PM<sub>10</sub>), and sulfur dioxide. PM has both 24-hour and 1-year standards for both fine and course particulate matter. The 24-hour standards for PM<sub>2.5</sub> and PM<sub>10</sub> are 35 µg/m<sup>3</sup> and 150 µg/m<sup>3</sup>, respectively. CDC-NIOSH has set a standard for “Particulates not otherwise regulated”, or those not included in the NAAQS standards or otherwise regulated by federal agencies, including inert or nuisance dusts. This standard is an OSHA permissible exposure limit of 15mg/m<sup>3</sup> for total dusts, and 5mg/m<sup>3</sup> for respirable dust. The American Conference of Governmental and Industrial Hygienists has set a Threshold Limit Value (TLV) for nuisance dust of 10mg/m<sup>3</sup>.

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