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Case Study: Hurricane Damage to Hotel Computer System

By

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Scope of Investigation

Evaluation of samples from a waterfront hotel computer system, collected after a hurricane, to determine the extent of damage caused to the electronic equipment within the hotel complex. The samples, collected on Q-tip swabs, were examined by energy dispersive x-ray analysis to determine the elements present. The analysis was done using a scanning electron microscope equipped with an x-ray spectrum detector. The detector was not capable of detecting hydrogen, helium, or beryllium, and would only detect elements present in concentrations of one half atomic percent, or higher. Tables of the relative quantitative analysis data are provided for each location sample examined.

Energy Dispersive X-ray Analysis

Outdoor Grill IDF

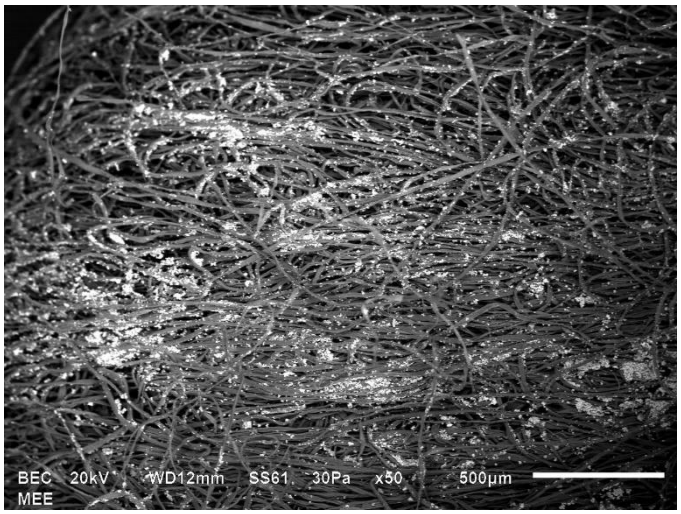

Figure 1 – 50X Outdoor Grill IDF Sample

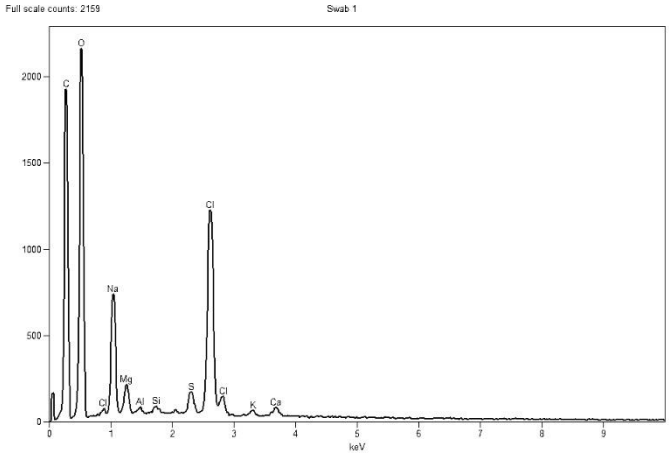

Figure 2 – Spectrum, Outdoor Grill IDF Sample

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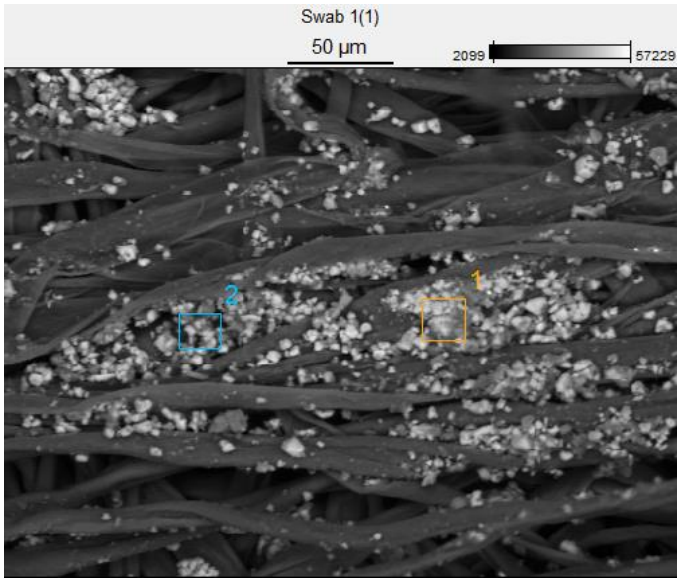

Figure 3 – 400X Spectra Locations in Particles on Outdoor Grill IDF Sample

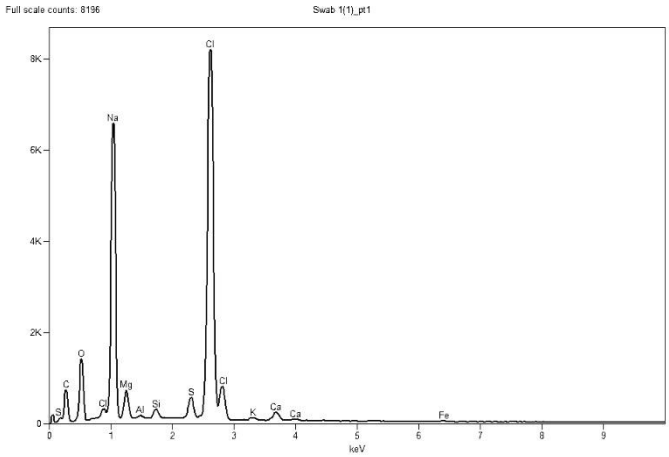

Figure 4 – Spectrum, Particles, Location 1, Outdoor Grill IDF Sample

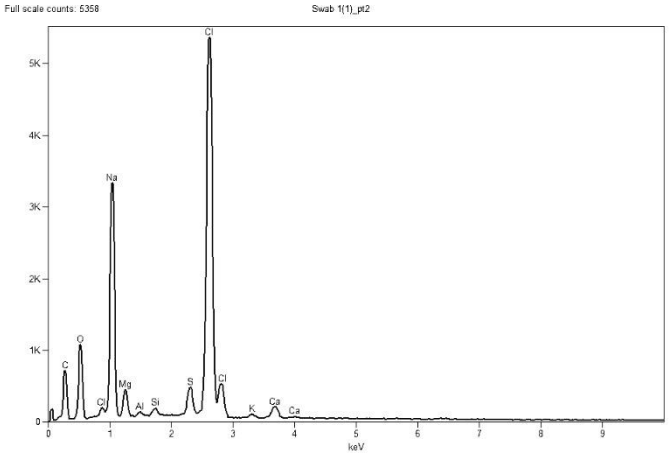

Figure 5 – Spectrum, Particles, Location 2, Outdoor Grill IDF Sample

Outdoor Grill IDF Sample (Percent by Weight)			
Element/Location	Total Area	Location 1	Location 2
Carbon	32.03	14.21	18.86
Oxygen	49.12	21.28	24.27
Sodium	6.52	24.39	18.62
Magnesium	1.18	2.53	2.09
Aluminum	0.15	0.21	0.25
Silicon	0.33	0.69	0.51
Sulfur	0.83	1.52	1.97
Chlorine	9.13	33.25	31.53
Potassium	0.25	0.39	0.38
Calcium	0.48	1.19	1.52
Iron		0.34	
Spectrum	Figure 2	Figure 4	Figure 5

The Outdoor Grill IDF, (Intermediate Distribution Frame), was exposed directly to sea water during the hurricane. The spectrum of the sample taken from the equipment there, Figure 2, shows the presence of elements that would be expected from sea water: sodium, magnesium, silicon, sulfur, chlorine, potassium, and calcium. Aluminum, also present, indicates corrosion of the device's housing. Figure 3 shows very fine particles collected on the surface of a sampling swab. The particles from two locations on the swab were analyzed. The presence of aluminum and iron, found in both Locations 1 and 2, indicates corrosion of the device's cabinet and hardware.

Main Server

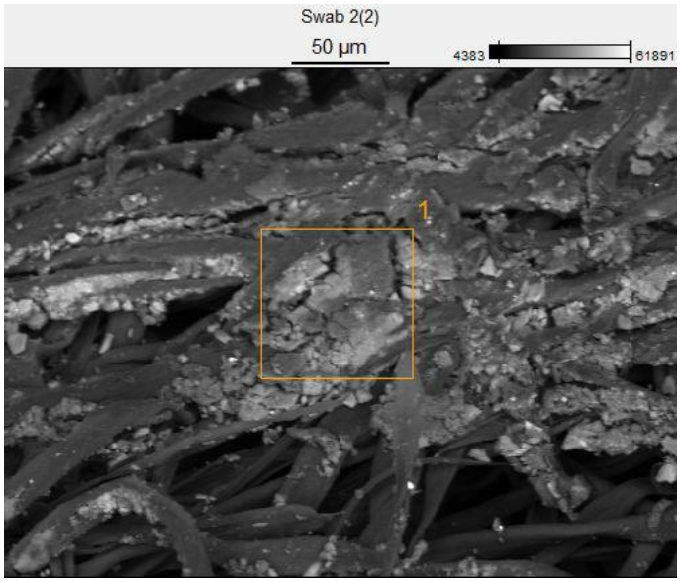

Figure 6 – 400X Spectrum Location on Main Server Sample

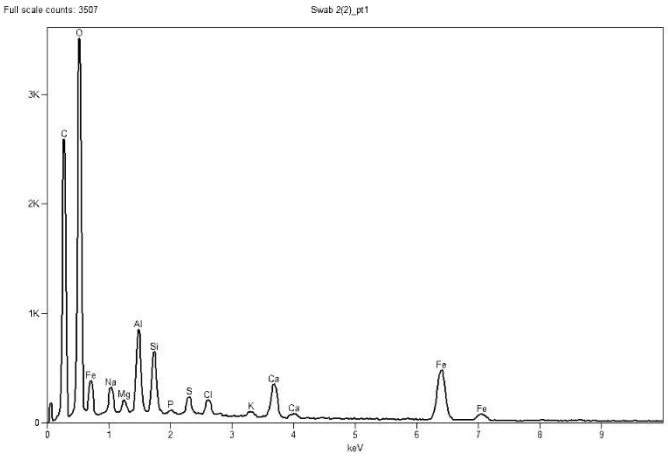

Figure 7 – Spectrum, Location 1, Material on Main Server Sample

Main Server Sample (Percent by Weight)	
Element/Location	Location 1
Carbon	25.83
Oxygen	48.80
Sodium	2.30
Magnesium	0.74
Aluminum	3.56
Silicon	2.55
Phosphorous	0.19
Sulfur	0.81
Chlorine	0.85
Potassium	0.33
Calcium	2.49
Iron	11.54

Figure 6 shows the material removed from the Main Server. The material appears to be gummy in nature. The spectrum is shown in Figure 7. The high levels of aluminum, iron, and phosphorous, along with sea salt, can explain this gummy condition. Phosphorous, in the form of iron phosphate, is often used as a primer for better paint adhesion on aluminum and would cause a gummy residue. There are clear indications of corrosion on this server housing.

Guest MDF

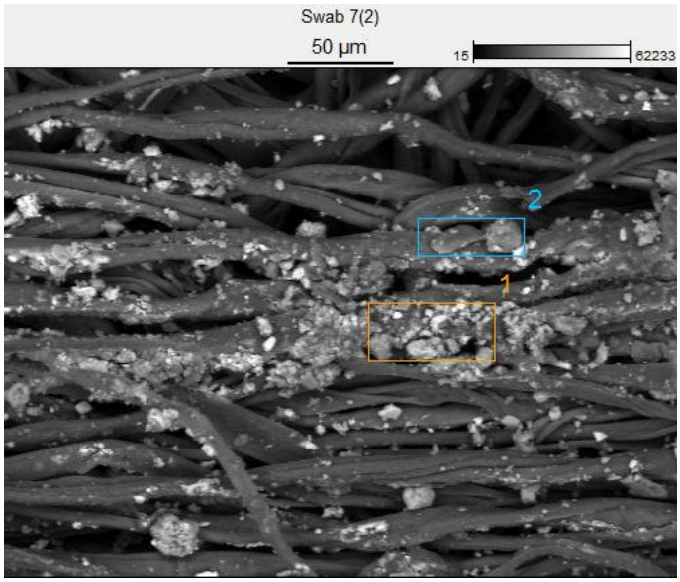

Figure 8 – 400X Spectra Locations,
Guest MDF Sample

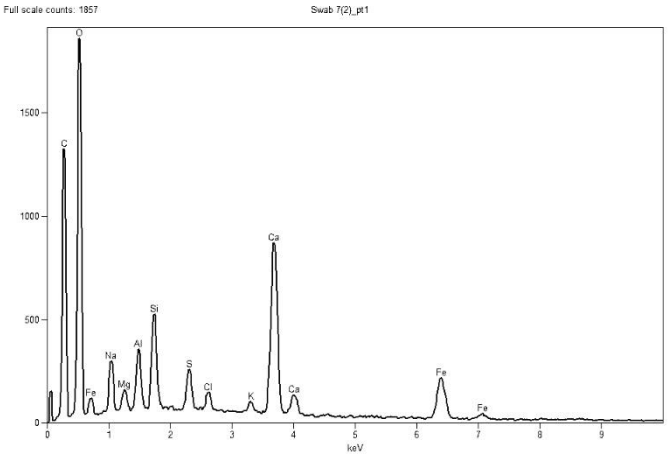

Figure 9 – Spectrum, Location 1,
Guest MDF Sample

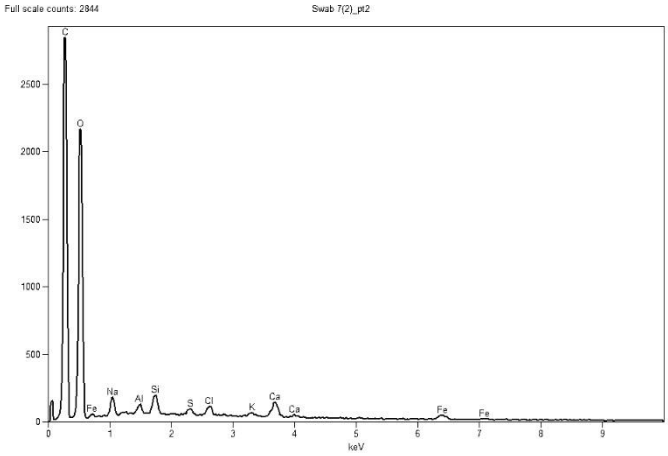

Figure 10 – Spectrum, Location 2,
Guest MDF Sample

Guest MDF Sample (Percent by Weight)		
Element/Location	Location 1	Location 2
Carbon	20.57	34.99
Oxygen	48.88	57.40
Sodium	3.34	1.53
Magnesium	0.98	
Aluminum	2.20	0.53
Silicon	3.42	1.16
Sulfur	1.52	0.42
Chlorine	0.76	0.73
Potassium	0.51	0.28
Calcium	10.35	1.57
Iron	7.47	1.40

Figure 8 shows spectra locations for the Guest MDF, (Main Distribution Frame), Sample. The spectrum for Location 1 is shown in Figure 9. The high levels of magnesium, silicon, sulfur, and calcium are likely the result of sheet rock dust from repairs being done in the hotel when samples were taken. Figure 10, Location 2, shows the presence of sea salt, plus iron.

Electronics Closet IDF

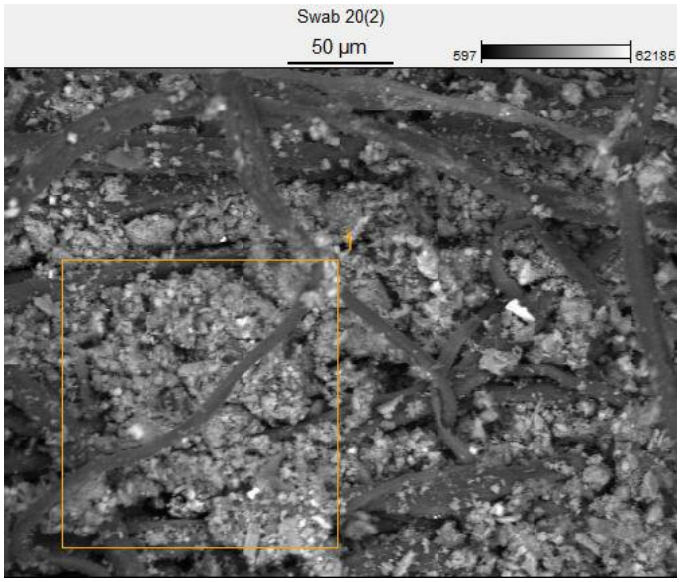

Figure 11 – 400X Spectrum Location,
Electronics Closet IDF Sample

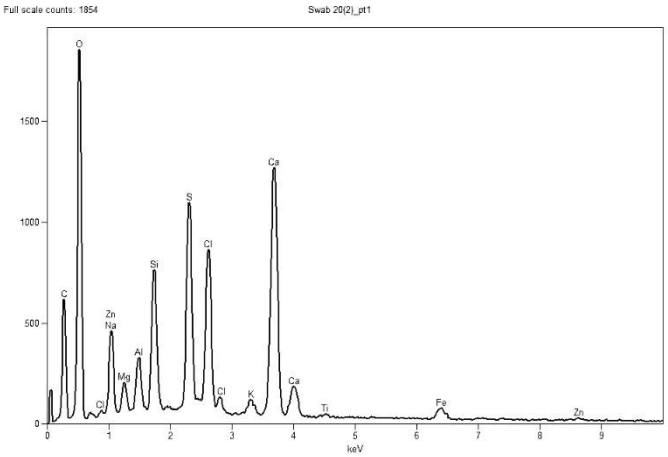

Figure 12 – Spectrum, Location 1,
Electronics Closet IDF Sample

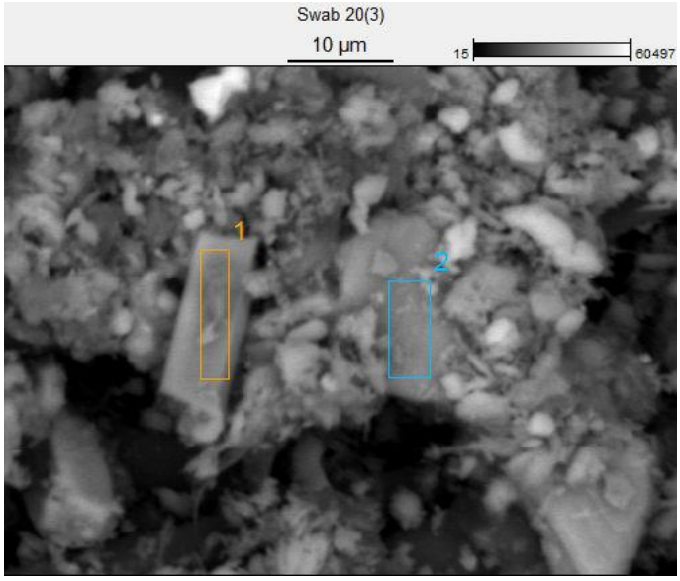

Figure 13 – 2000X Spectra Locations,
Electronics Closet IDF Sample

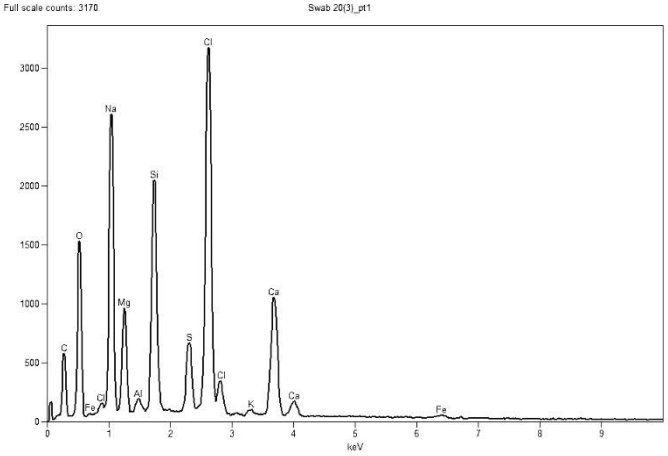

Figure 14 – Spectrum, Location 1,
Electronics Closet IDF Sample

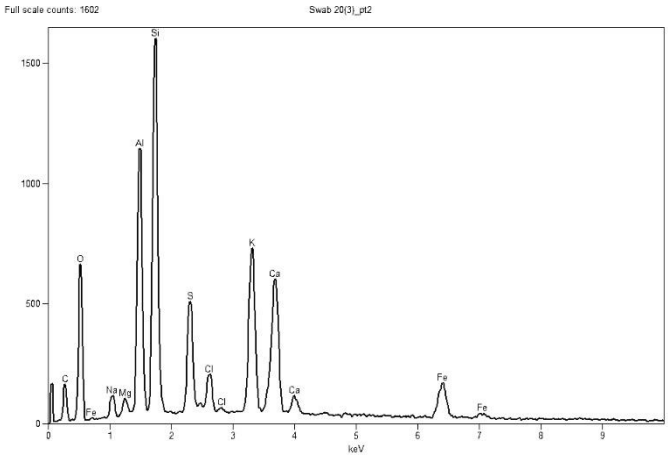

Figure 15 – Spectrum, Location 2, Electronics Closet IDF Sample

Electronics Closet IDF Sample (Percent by Weight)			
Element/Location	General	Location 1	Location 2
Carbon	11.33	11.33	6.92
Oxygen	46.84	29.76	29.62
Sodium	4.08	14.34	1.52
Magnesium	1.20	4.73	0.81
Aluminum	1.71	0.53	10.11
Silicon	4.22	8.89	15.54
Sulfur	6.75	3.14	5.48
Chlorine	6.37	17.77	1.86
Potassium	0.65	0.31	10.28
Calcium	13.82	8.37	10.44
Titanium	0.25		
Iron	2.03	0.83	7.42
Zinc	0.75		

Figure 11 shows the general spectrum location for the Electronics Closet IDF Sample. The spectrum is shown in Figure 12, and indicates the presence of sea salt, sheet rock dust, and corrosion of cabinet materials. Figure 13 shows the lower right corner of Box 1 in Figure 11. The two crystals, Locations 1 and 2, were of interest. Location 1 is a sea salt crystal, and Location 2 appears to be a clay material, as indicated by high levels of aluminum and silicon.

Outbuilding 2nd Floor IDF

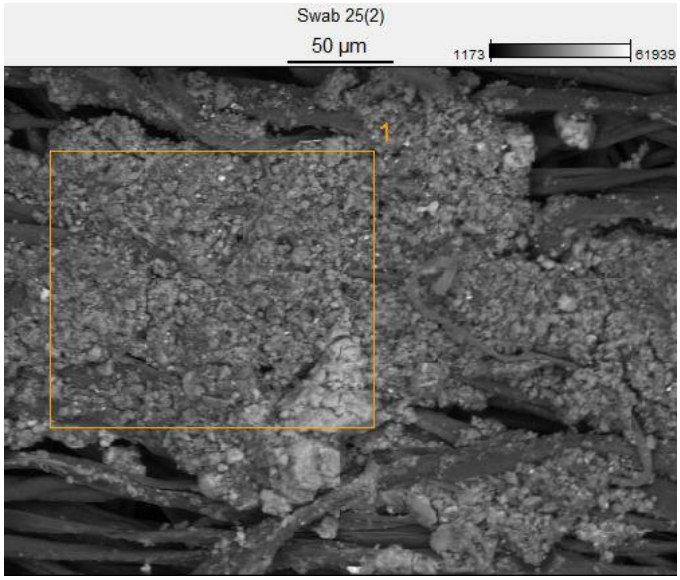

Figure 16 – 400X Spectrum Location, Outbuilding 2nd Floor IDF Sample

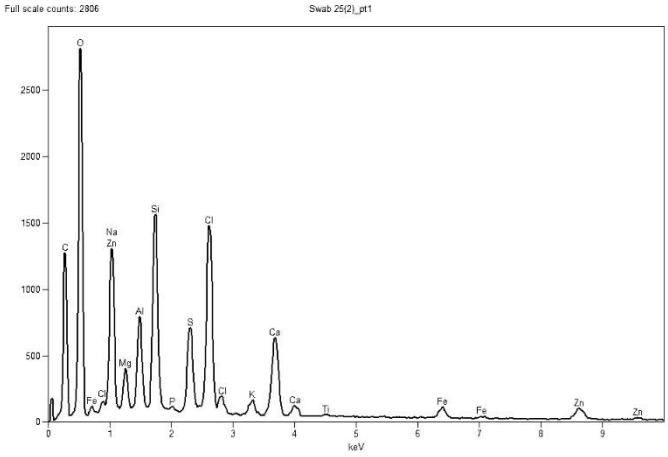

Figure 17 – Spectrum, Location 1, Outbuilding 2nd Floor IDF Sample

Outbuilding 2nd Floor IDF Sample (Percent by Weight)	
Element/Location	Location 1
Carbon	18.68
Oxygen	43.05
Sodium	5.40
Magnesium	1.49
Aluminum	2.91
Silicon	6.24
Phosphorous	0.14
Sulfur	3.15
Chlorine	7.52
Potassium	0.68
Calcium	4.60
Titanium	0.22
Iron	1.61
Zinc	4.30

Figure 16 shows the spectrum location for the Outbuilding 2nd Floor IDF Sample. The spectrum, Figure 17, shows sea salt, and corrosion products from cabinet materials and hardware, as indicated by aluminum, iron, and zinc. The presence of titanium is likely due to paint pigment.

Discussion

There was sea salt, as indicated by sodium, magnesium, sulfur, chlorine, potassium, and calcium, found at all the locations sampled. Sea salt is very damaging to electronic equipment. Sea salt is hydroscopic, which means it absorbs water from the air, making it corrosive and conductive when water is present, either as a liquid or as high humidity. The primary corrosive elements are sulfur and chlorine. These two elements will corrode electronic components, with or without the presence of electrical current.

There was no evidence of corrosive biological activity found, but it may have been present. The presence of sulfur can result in activity by sulfur oxidizing or reducing bacteria, under the right conditions. These bacteria produce hydrogen sulfide or sulfuric acid, both of which are corrosive to electronic components.

Summary of Findings

Sea salt was found in samples from every location examined in this evaluation. Most locations showed the presence of aluminum, which was the result of corrosion of aluminum cabinet and housing materials. Many locations showed the presence of iron. The source of iron was steel equipment hardware. Zinc was found in some of the samples. Zinc was likely used for the plating of hardware and steel cabinet materials. The presence of aluminum, iron, and zinc indicated that corrosion was occurring on the outside of the electronic equipment. It was highly likely that corrosion was also occurring on the inside of the equipment cabinets and housings.