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October 15, 2019

The Honorable Nicholas A. Mattiello
Speaker of the House
State House, Room 323
82 Smith Street
Providence, RI 02903

Dear Speaker Mattiello:

In Accordance with the requirements of Rhode Island General Laws 1-7-6, Entitled The Permanent Air Quality Monitoring Act, The Rhode Island Department of Health (RIDOH) presents the 2019 Air Monitoring at T.F. Green Airport Annual Report.

If you have any questions regarding this report, please do not hesitate to contact Seema Dixit, Associate Director of our Division of Environmental Health. Ms. Dixit can be reached by phone, at 222-7463, or Seema.Dixit@health.ri.gov.

Sincerely,

Nicole Alexander-Scott, MD, MPH
Director
Rhode Island Department of Health

CC: The Honorable Joseph M. McNamara, Chairman, House Committee on Health Education and Welfare
Danica Iacoi, Chief Legal Counsel to the Speaker of the House

Air Monitoring at T.F. Green Airport Annual Report

October 2019

RHODE ISLAND DEPARTMENT OF HEALTH

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Introduction

Chapter 1-7 of the *Rhode Island General Laws*, the *Permanent Air Quality Monitoring Act* (the Act), required the Rhode Island Airport Corporation (RIAC) to conduct long-term air monitoring at four sites located near T.F. Green Airport, to determine the impact of "air pollutants, which may be harmful to public health" on the "densely populated, primarily residential area of the city of Warwick" that surrounds the airport. §1-7-1 of the Act requires RIAC to monitor particle count, as an estimate of ultrafine particulate, and black carbon.

RIAC began monitoring in early 2008, using procedures and specifications outlined in a workplan developed in consultation with the Rhode Island Department of Environmental Management (DEM) and the Rhode Island Department of Health (RIDOH), as required in §1-7-1. Amendments to the legislation enacted in 2017 and 2019 eliminated some pollutants that were originally measured, allowed for more flexibility in siting the monitors, directed monitoring sites measure air quality impacts associated with aircraft operating on the extended runway and on neighborhoods adjacent to the airport facility as well as at the Winslow Park playing fields, and extended the sunset date of the monitoring requirements, as specified in §1-7-9 of the Act, from July 31, 2017, to July 31, 2021.

The updated legislation also requires RIDOH to "prepare an annual report which shall contain the department's findings, analysis, conclusions, and recommendations resulting from the data generated by and from the permanent air quality monitors (the monitors), as well as a summary of the data collected from the monitors." This document shall serve as the third annual report.

For additional information related to this report, please contact:

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Monitoring Strategy

Monitoring procedures used to measure the pollutants identified in §1-7-1 of the Act following the 2017 amendments use continuous monitors, which are electronic devices that record the pollutant level at discrete time increments. The monitors are used to measure ultrafine particles (particles smaller than 0.1 microns, measured as particle count) and black carbon (an indicator of diesel/jet fuel exhaust). Measurements for ultrafine particles are taken every ten (10) seconds. Measurements for black carbon are taken every minute. Monitoring stations are located at four (4) sites to the north, south, east, and west of the airport. Because the west site was predominantly upwind of the airport and more heavily impacted by road traffic from nearby Post Road and Interstate Route 95 (I-95), collection of data at that site will be discontinued and the monitoring equipment moved to a site to the southeast of the airport once an updated workplan has gone through regulatory approval, including a period for public comment.

- The **Field View** site (the south site) is located on Field View Drive less than 0.1 miles west of the taxiway to the main runway (Runway 5-23) and less than 0.2 miles northwest of the southwestern (5) end of that runway prior to the recent runway extension. Flights taking off on Runway 5 (to the northeast) idle in line in the section of the taxiway near the monitoring site while waiting for clearance and then turn a corner and enter the runway to begin take off. The site is 0.1 – 0.2 miles south of airport parking areas. Note that, at the time of the RIDEM/RIDOH monitoring study, the Field View monitoring shelter was in the yard of an occupied home, but the airport has since purchased and removed that and neighboring homes. The closest residence now is approximately 220 yards from the site.

- The **Lydick** site (the north site) is on Lydick Avenue in the Hoxsie neighborhood of Warwick, about 0.5 miles northeast of the northeast (23) end of the main runway. The area around this monitor is a residential neighborhood; the closest residence is approximately 25 yards from the monitor.

- The **Fire Station** site (the west site) is behind Fire Station #8, off Post Road in the Hillsgrove neighborhood. It is approximately 0.25 miles north-northwest of the northwest (16) end of the airport's secondary runway, 16-34; slightly more than 0.5 miles northwest of the main runway; and 0.57 miles north-northwest of the airport terminal building. The site is also near a variety of other pollution sources, including three high-traffic roadways: Post Road, which is about 0.07 miles to the east; Jefferson Boulevard, which is approximately 0.2 miles to the west; and Airport Road, which is less than 0.3 miles to the south.

- RIAC initially located the fourth (east) site, the **Pembroke** site, just east of the airport on Pembroke Avenue, the street closest to that side of the airport. At that time, occupied residences were located adjacent to the site. Those homes and residences on the next parallel street, Gayton Avenue, have since been purchased and removed by RIAC. Winslow Park, which had been located south of the airport, was moved to the Pembroke Avenue area to make room for the southern extension of the main runway. Since the Pembroke monitoring shelter was located in the area where the new park was being constructed, it was moved to a temporary site in a parking area on Wells Avenue at the beginning of

September 2014. The new park opened in 2015. After soliciting neighborhood input, at the end of June 2015, the monitoring shelter was moved to its current location, which is off Rowe Avenue, on the side of the park that is most distant from the airport and is adjacent to the closest residences on Wilbur Street.

Particle Count (PC) is measured continuously at the airport sites. Particle count (PC) monitors are used to measure levels of extremely small particles, also known as ultrafine particles (UFP). Those particles are so small and light that they contribute very little to the more commonly measured $PM_{2.5}$, which measure the mass of particulate matter. Although these very small particles contribute very little to the total particulate matter weight, UFP are far more numerous than other particles, so UFP levels correlate well with particle count.

UFP are largely emitted by combustion processes and tend to be elevated near areas with vehicle emissions, like busy roadways and airports. UFP levels drop off quickly with distance from the source, due both to dispersion of the particles in the air and processes of evaporation and condensation that reduce the number and increase the size of particles.

RIDEM and RIDOH routinely measure PC at two sites in Providence. One site is at the Urban League building in an urban residential area in South Providence. The second site is known as the Near Road site and is immediately adjacent to the busiest, most congested section of I-95. The measurements from those two sites provide a context for assessing airport measurements, which was explored in the 2017 report, but will not be re-addressed in this report.

According to the Environmental Protection Agency (EPA), there is "suggestive but limited" evidence that short-term UFP exposures are linked to respiratory and cardiovascular health effects. Toxic substances tend to be concentrated on UFP and tend to be absorbed better. Therefore, UFP are more likely to cause toxic effects than larger particles. Due to their very small size, UFP, when inhaled, can travel deep into the respiratory tract and pass across membranes in the body that would block the movement of larger particles. Therefore, they are theorized to have more significant cardiovascular and systemic toxicity but lower lung toxicity than larger particles. A 2015 study by the California EPA demonstrated that long-term exposure to UFP contributes to heart disease mortality. In particular, certain constituents of UFP, including copper, iron, other metal and elemental carbon (soot), were strongly associated with death from heart attacks.[1]

Black carbon (BC) is also measured continuously at the airport sites. Black carbon is formed by incomplete combustion of fuels and is therefore an indicator of vehicle, aircraft, and equipment exhaust. In an earlier study, RIDEM and RIDOH documented elevated BC levels at sites near the airport, including three of the current monitoring locations, when those sites were downwind of the airport. However, BC monitors, which are known as Aethalometers, are very sensitive to operational factors and require skilled maintenance. RIAC took over operation from its contractor and RIDOH's State Health Laboratories repaired the equipment in early 2018, improving the quality of data collected. Thus, this report outlines the first full year of high-quality BC data collected through this program.

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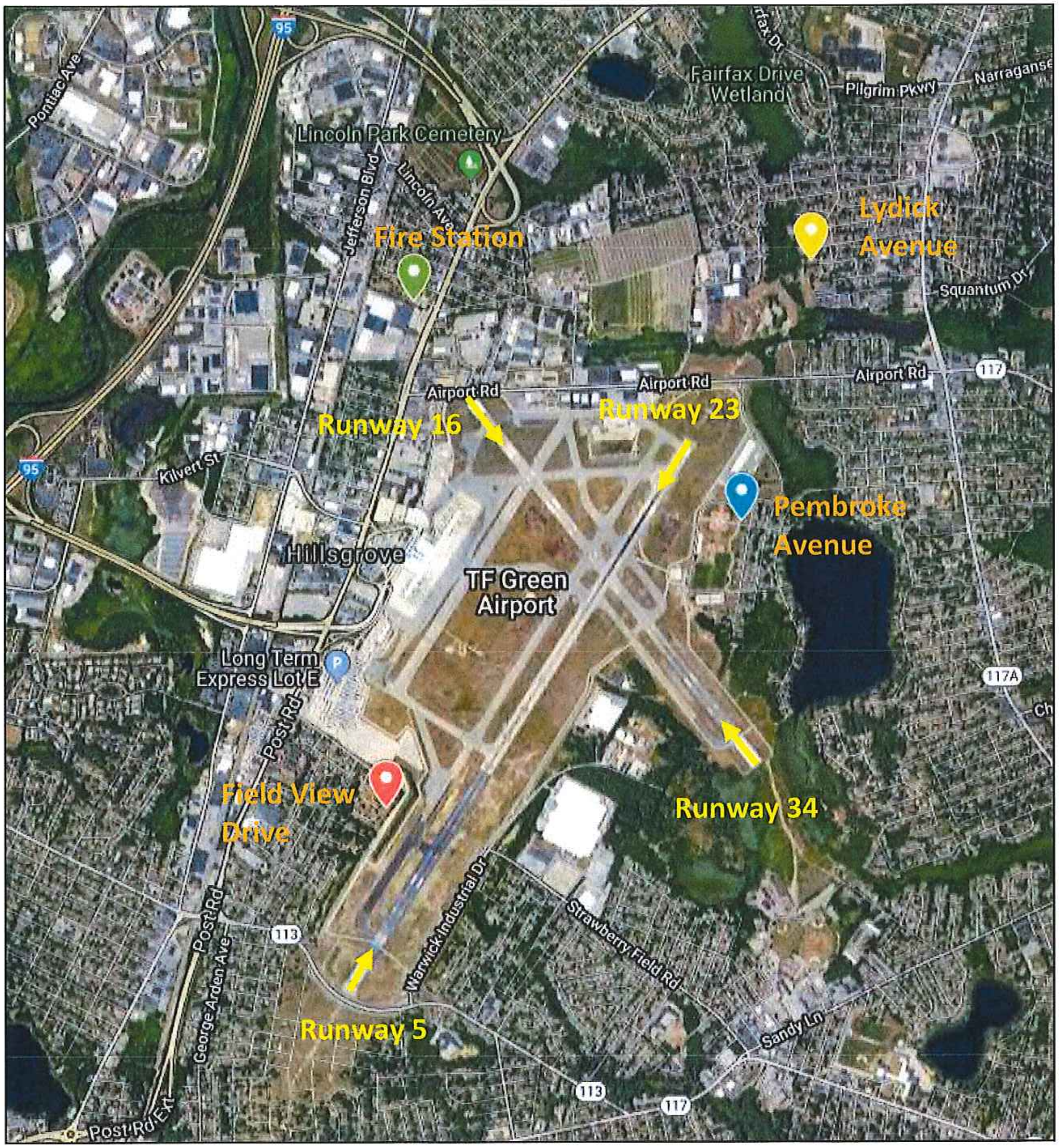
[1] Ostro, B et. Al, Associations of Mortality with Long-Term Exposures to Fine and Ultrafine Particles, Species and Sources: Results from the California Teachers Study Cohort, *Environmental Health Perspectives* 123(6), June 2015.

Figure 1: *Locations of RIAC Monitoring Sites and Locations of Runways*



Results and Discussion

Black Carbon (BC)

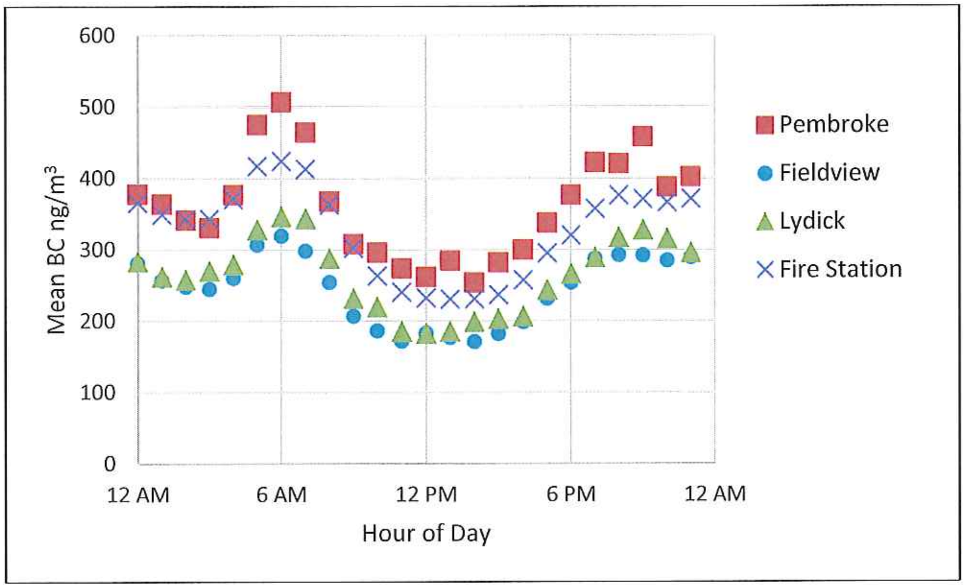
BC is one of the primary components of fine particulate matter ($PM_{2.5}$) that is thought to cause a variety of negative health effects. The health effects that have been associated with $PM_{2.5}$ measurements are also likely associated with BC measurements, and vice versa. RIAC monitors for BC, instead of $PM_{2.5}$, in the current investigation, as it can be monitored for shorter time periods than $PM_{2.5}$, with available equipment. BC results from incomplete combustion of liquid or solid fuels and contains toxic chemicals, such as polycyclic aromatic hydrocarbons, that can contribute to cancer and to chronic and acute cardiovascular and pulmonary diseases. There are no regulatory or health-based standards for BC, unlike for $PM_{2.5}$, but levels of BC are likely to correlate to levels of $PM_{2.5}$.

Due to repairs and maintenance to the monitors conducted by RIAC and RIDOH's Air Pollution Laboratory in Spring 2018, the issues that had limited analysis of the BC data in previous reports were resolved. The individual BC data points, collected every minute, remain highly variable, due to the sensitivity of the monitors to operational factors like the cycling of air conditioning fans. However, when multiple data points are used to calculate hourly or daily averages, the issues with variability are eliminated and the data provide a good estimate of BC levels in ambient air.

When the concentrations of BC during each hour are averaged over the entire year, a routine pattern of BC levels in the air emerges. BC levels increase in the early morning, peaking between 6 a.m. and 7 a.m., and then decline through the middle of the day before increasing through the afternoon with a smaller peak around 9 p.m. (Figure 2). The time trends were similar across all four sites. Levels are highest at the Pembroke site, almost as high at the Fire Station, and lower at the Lydick and Fieldview locations. These results are consistent with previous observations during a DEM investigation under a 2003 grant from EPA (2008 DEM Report), and somewhat similar to the results for UFP (2017 Annual Report).

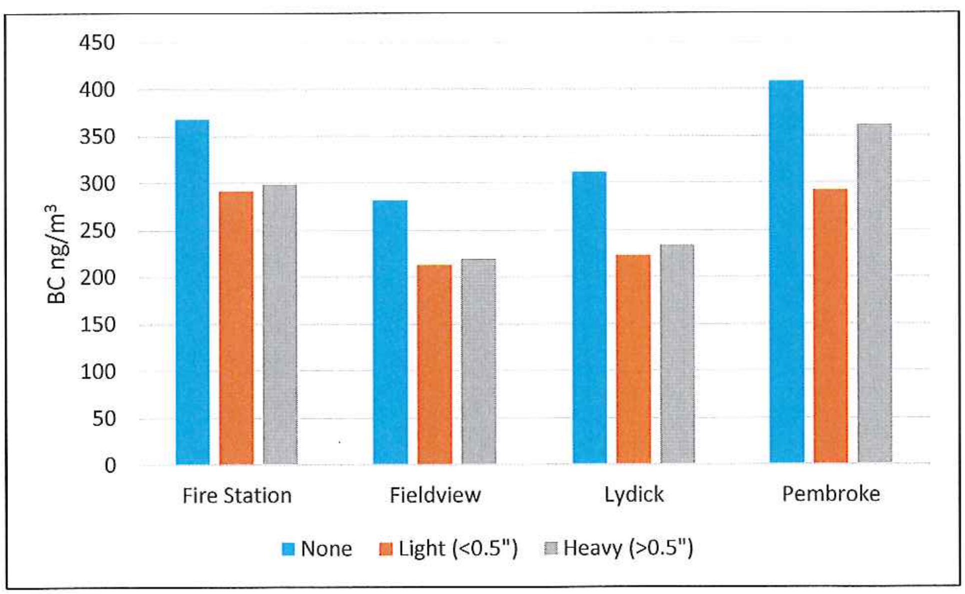
The peaks are presumably related to rush hours and other morning pollution, such as from startup of facilities. The reduction of pollution levels in the middle of the day is probably the result of patterns in wind speeds in Warwick. Although RIDOH didn't analyze the hourly weather data for this year, previous years have shown that wind speeds increase after sunrise and remain high through the middle of the day before decreasing. Wind speeds appeared to be a major predictor of BC levels in the initial EPA-funded DEM investigation, and that appears to be true with the current data as well.

Figure 2: *Average BC, By Hour*



RIDOH examined the relationship between the average daily BC levels and a variety of meteorological conditions, as well as activity levels at the airport. It is important to note that none of the weather conditions or airport activities examined is independent from the others. The weather conditions examined interact with one another and are also associated with which runways are used at the airport and the total number of operations at the airport.

Figure 3: *Daily BC Levels, By Precipitation*



Precipitation is one variable predicted to affect BC levels, as the particles of BC can be caught in the droplets and essentially washed out of the atmosphere. Days with any precipitation had approximately 25% lower BC levels than days with no precipitation (Figure 3). There did not appear to be more of a decline with higher levels of precipitation. One potential explanation for this is that days with light, misty precipitation during most or all of the day might result in lower precipitation totals, but more pollution reduction, than days with major storms where a large volume of precipitation is delivered in a short period of time.

Figure 4: *Average BC, By Wind Speed, Fire Station Site*

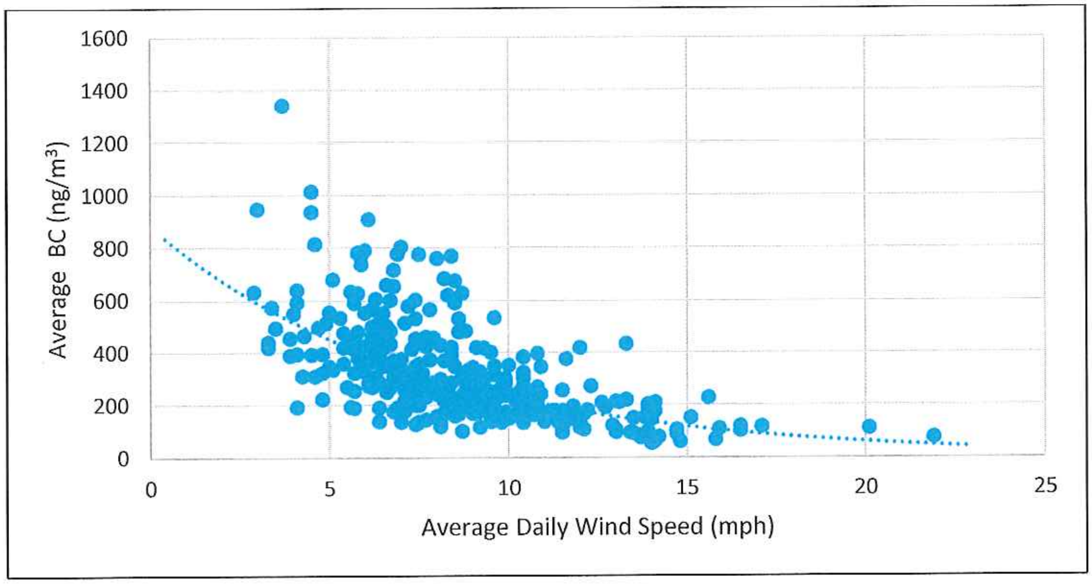


Figure 5: *Average BC, By Wind Speed, Fieldview Site*

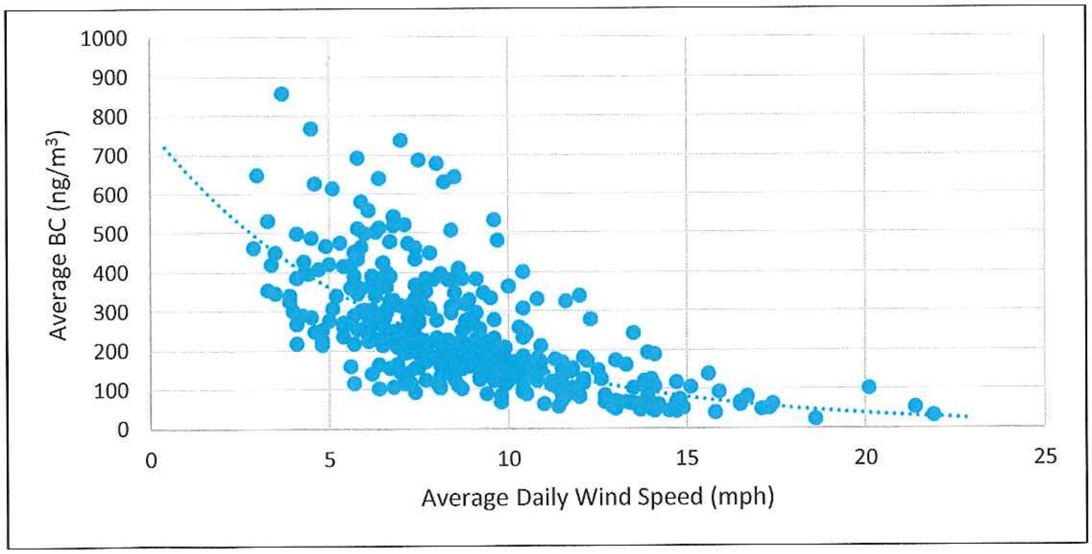


Figure 6: *Average BC, By Wind Speed, Lydick Site*

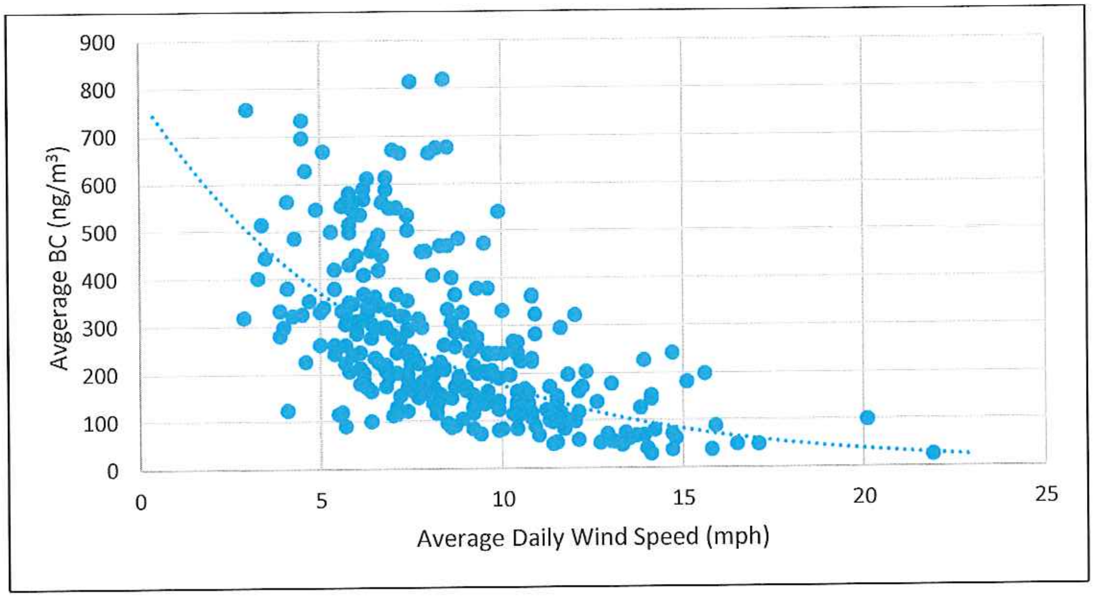
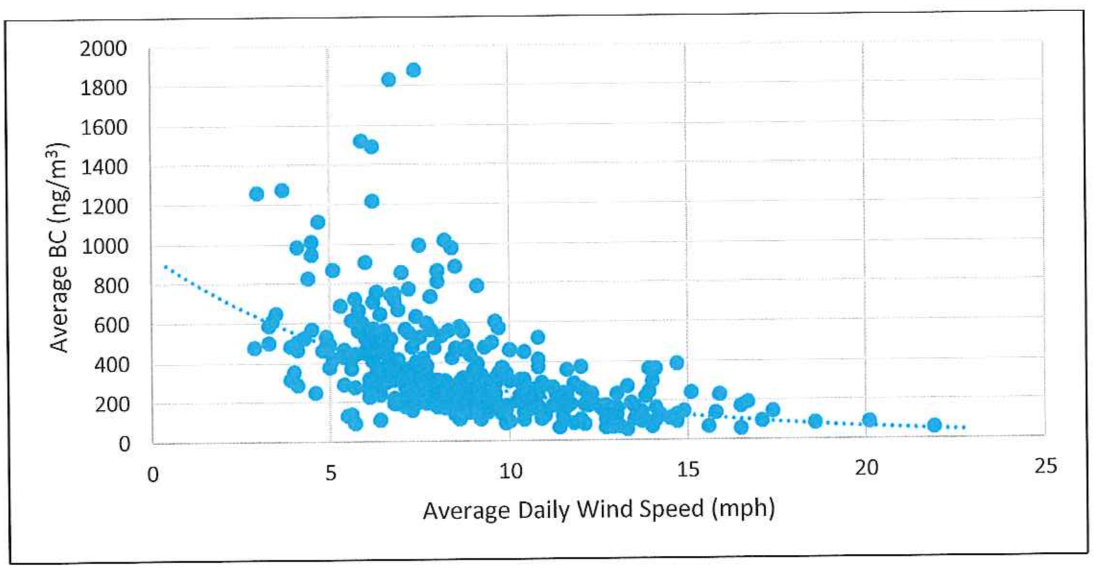


Figure 7: *Average BC, By Wind Speed, Pembroke Site*



Average daily wind speed was strongly associated with daily BC levels, with low levels observed on high-wind days, and higher levels observed on low-wind days at all four sites (Figures 4-7). Higher wind speeds disperse pollution away from the point of generation. Similar effects have been seen for BC and other pollutants in earlier years of airport monitoring and at other pollution monitoring sites.

Figure 8: *Effect of Wind Direction on BC, Fire Station Site*

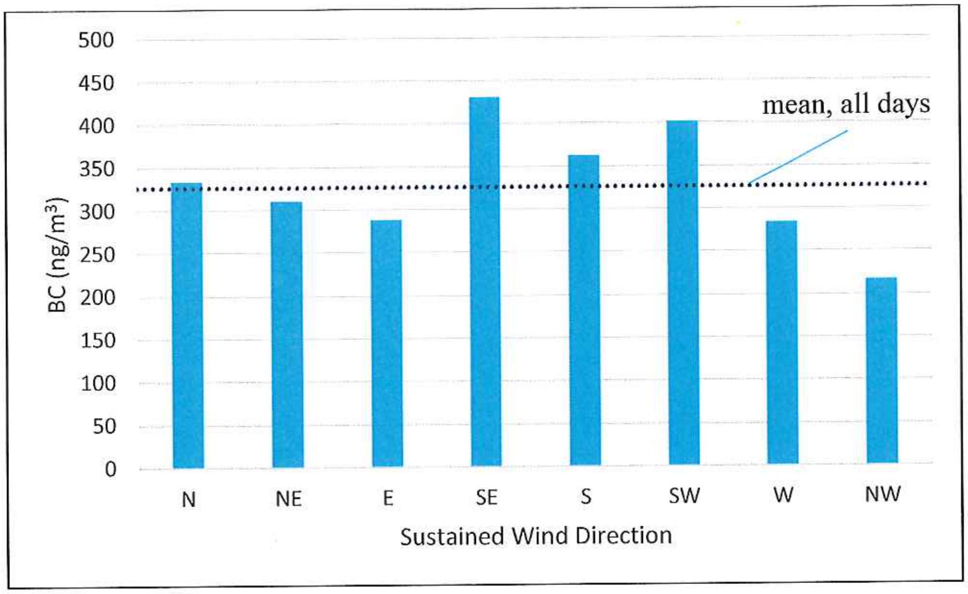


Figure 9: *Effect of Wind Direction on BC, Pembroke Site*

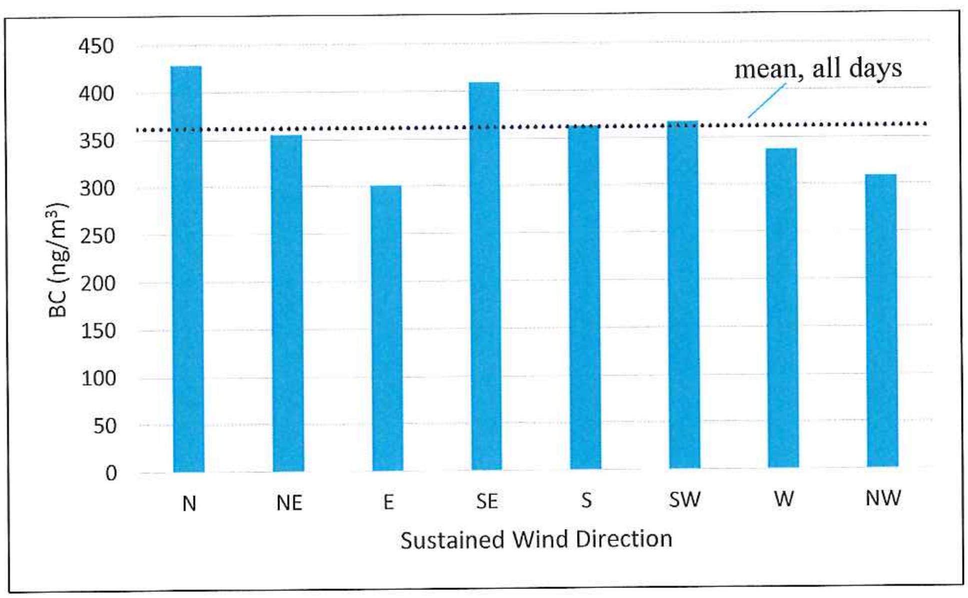


Figure 10: *Effect of Wind Direction on BC, Lydick Site*

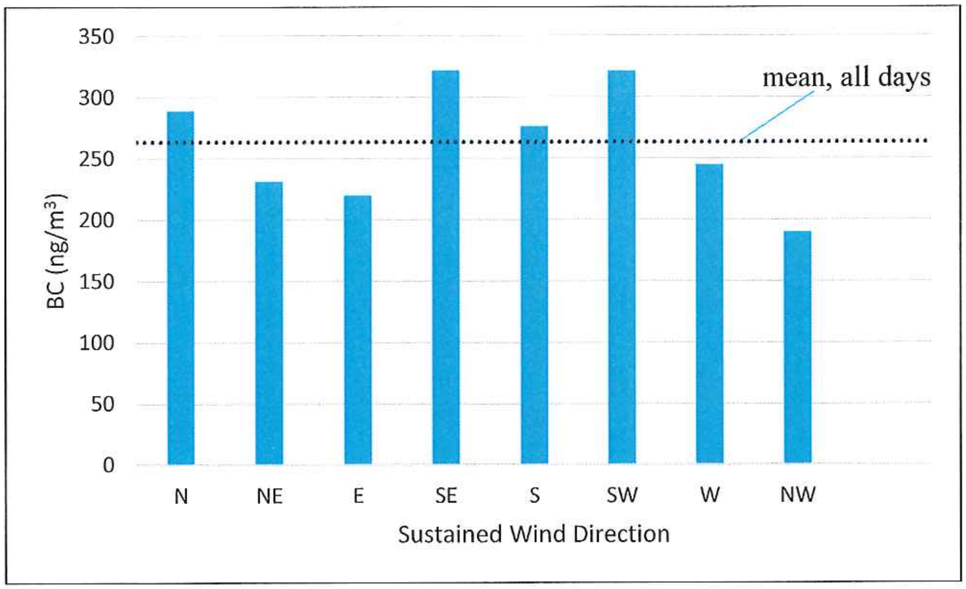
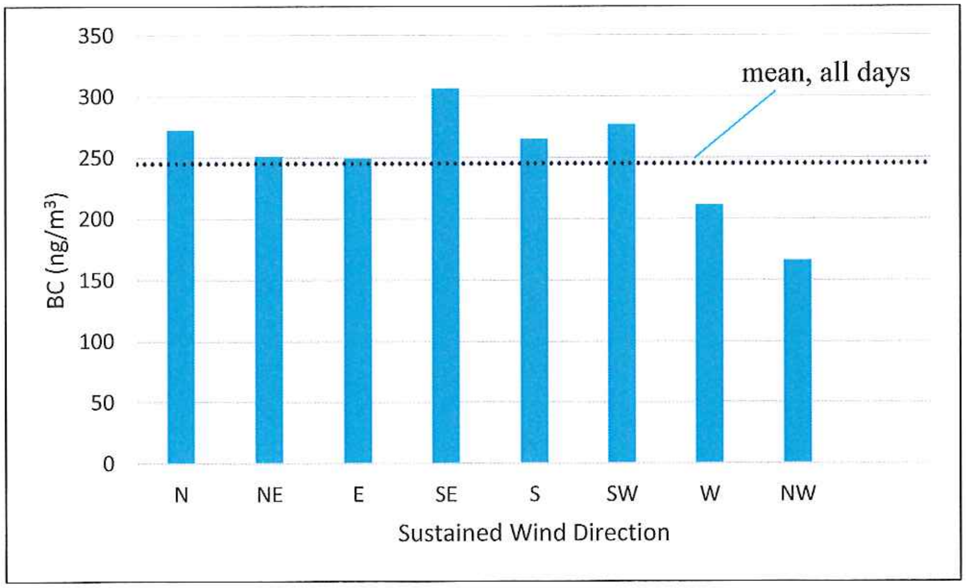
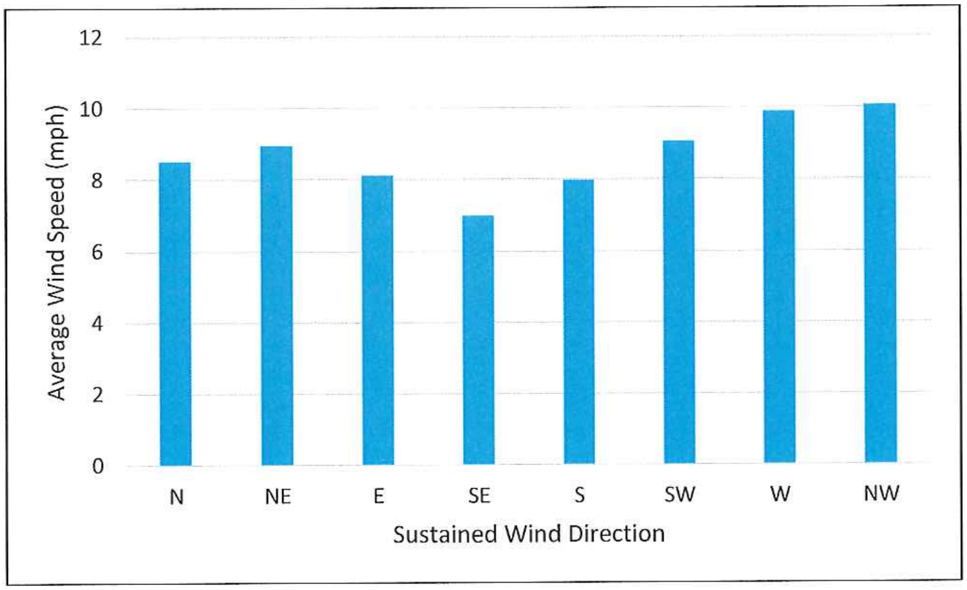


Figure 11: *Effect of Wind Direction on BC, Fieldview Site*



Wind direction appears to be an important factor in BC levels; when the wind is blowing from a pollution source to a location, that location would be expected to have higher levels of BC than when the wind was blowing away. The relationship between wind direction and BC levels was not as clear as it was for PC in previous years (see 2018 report). BC can stay suspended and travels much further from a pollution source than UFP, and thus the effects from sources further away play a more important role. All four sites registered very low levels of BC when the wind was from the northwest (Figures 8-11). Pembroke decreased the least when winds were from the northwest, possibly because it was the only site downwind from the airport on those days, but it still had close to its lowest BC measurements on those days.

Figure 12: *Relationship of Wind Direction and Speed*



The low levels of BC with winds from the northwest and high levels with winds from the southeast may reflect that high winds occurred from the northwest and the lightest winds occurred with winds from the southeast (Figure 12). However, the relationship between wind direction and BC levels across all four monitors are not fully explained by wind speed. For example, winds from the southwest had above average wind speeds and above average pollution levels at all four sites. This might reflect more pollution generation from off airport sources to the southwest, possibly as far away as New York City, relative to other directions such as the northeast.

Figure 13: *Deviation from Mean BC, By Wind Direction and Site*

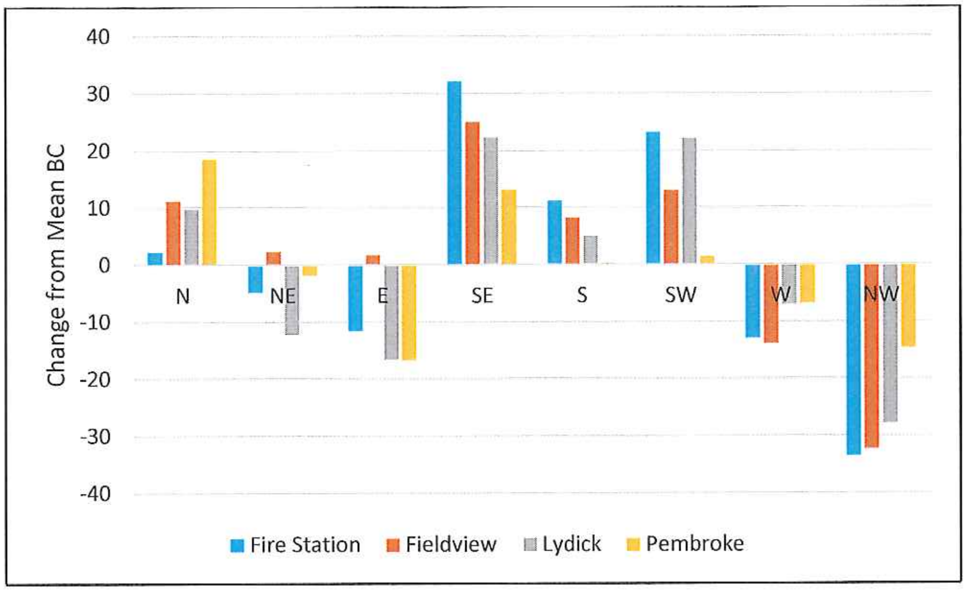
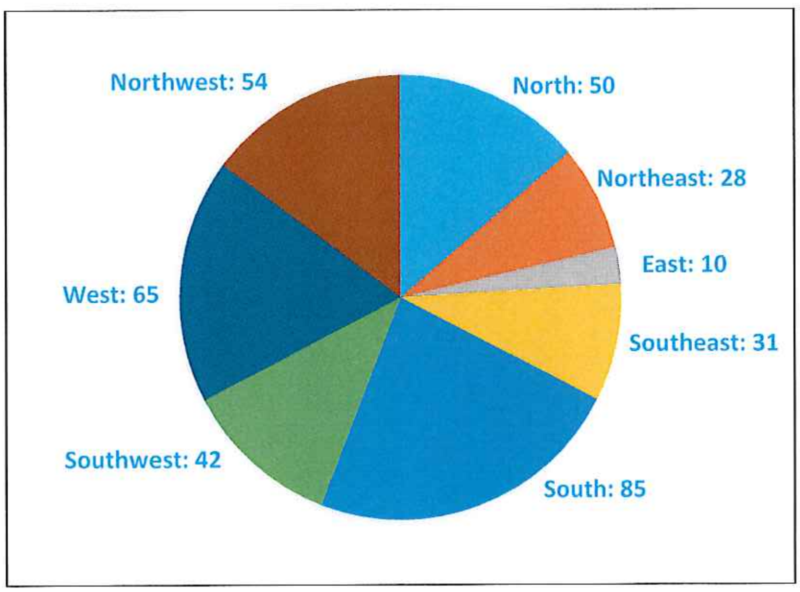


Figure 14: *Number of Days, By Wind Direction*



Overall, the complex interactions between wind direction and BC levels at the four monitors makes it difficult to pinpoint sources of pollution that are driving those BC levels. Airport activities may be a factor in BC levels measured at a given monitor, as a site downwind of the airport was more likely to have higher than average BC than a site upwind of the airport (Figure 13). For example, Fieldview, which lies southwest of the airport, was the only site to have above average pollution levels with winds from the northeast or east. However, there appear to be a variety of other factors, including pollution from other sources and wind speed that contribute as much as airport activities to the BC levels at a given site. Given that winds from the west or south are more frequent than other directions, Pembroke and Lydick are downwind of the airport more often than the other two monitors and likely see a larger percentage of BC from sources associated with the airport (Figure 14).

Figure 15: *Average BC, By Temperature, Fire Station Site*

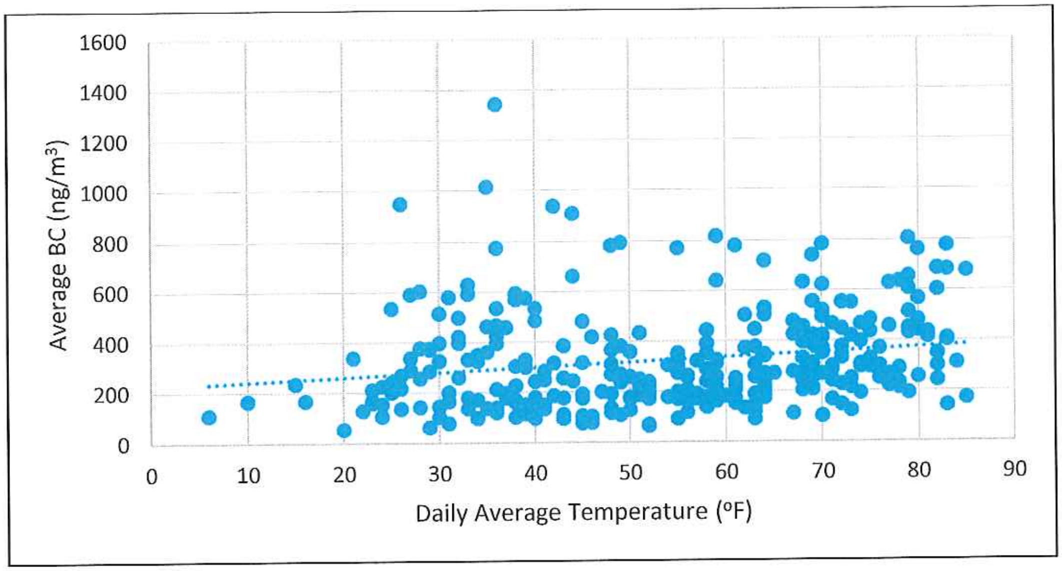


Figure 16: *Average BC, By Temperature, Fieldview Site*

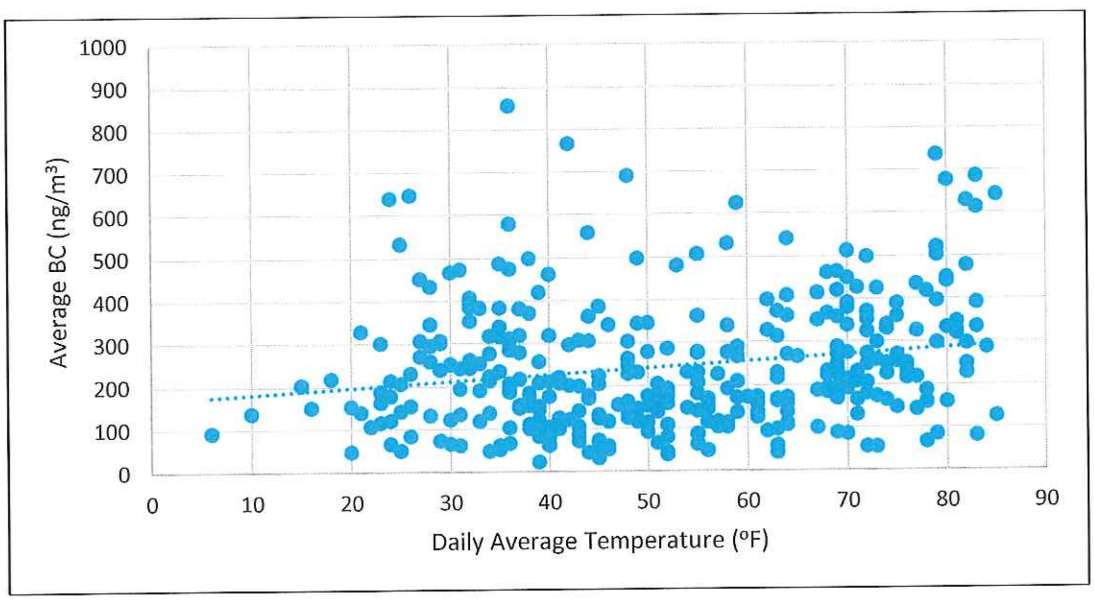


Figure 17: *Average BC, By Temperature, Lydick Site*

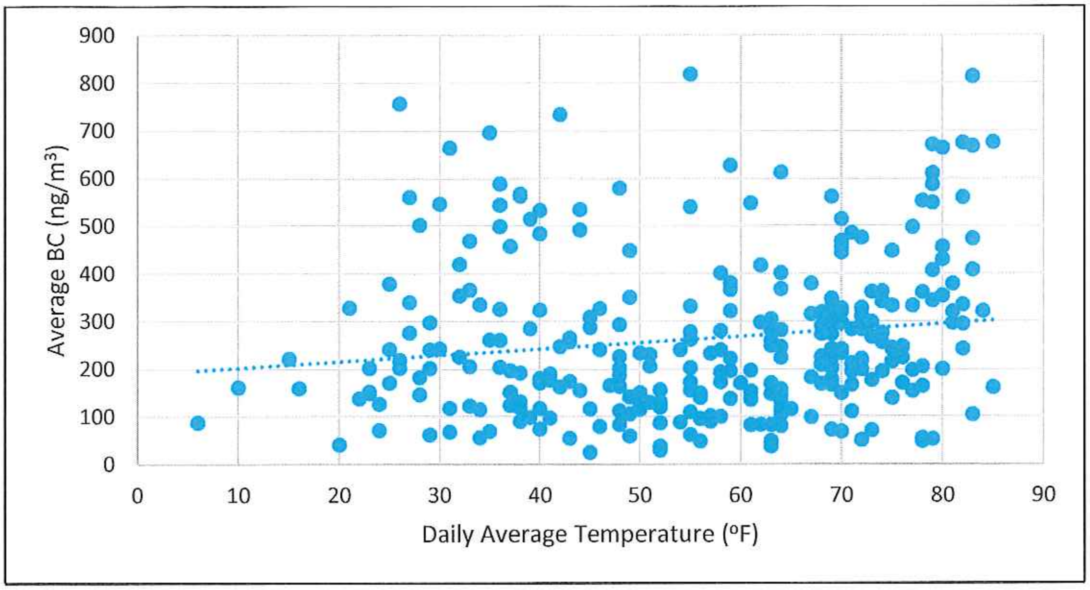
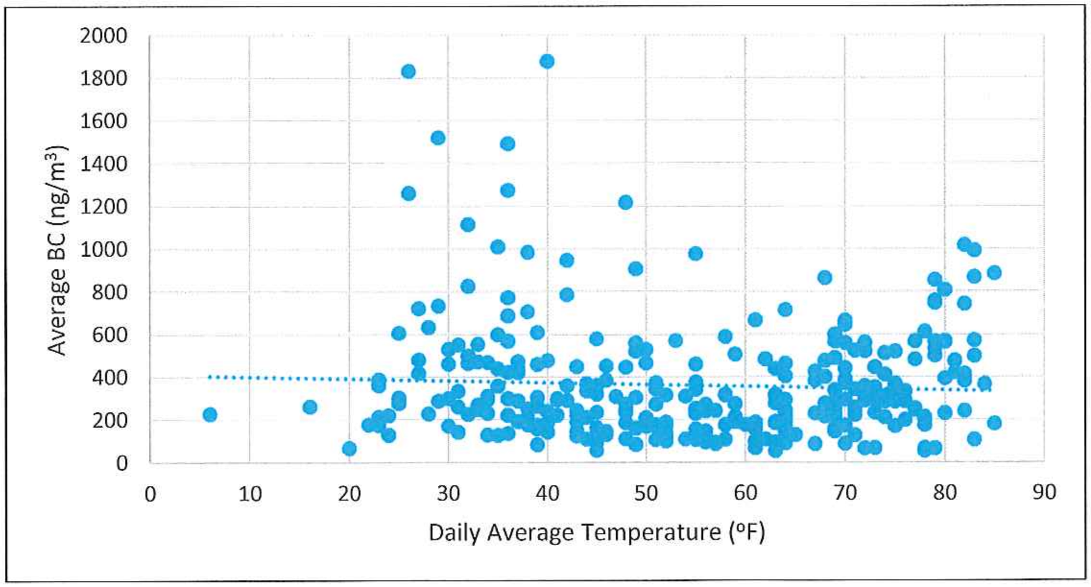


Figure 18: *Average BC, By Temperature, Pembroke Site*



Temperature did not appear to be a significant driver of BC levels (Figures 15-18). There was a weak positive association between temperature and BC at three of the sites, and a weak negative association at Pembroke.

Figure 19: *Average BC, By Barometric Pressure, Fieldview Site*

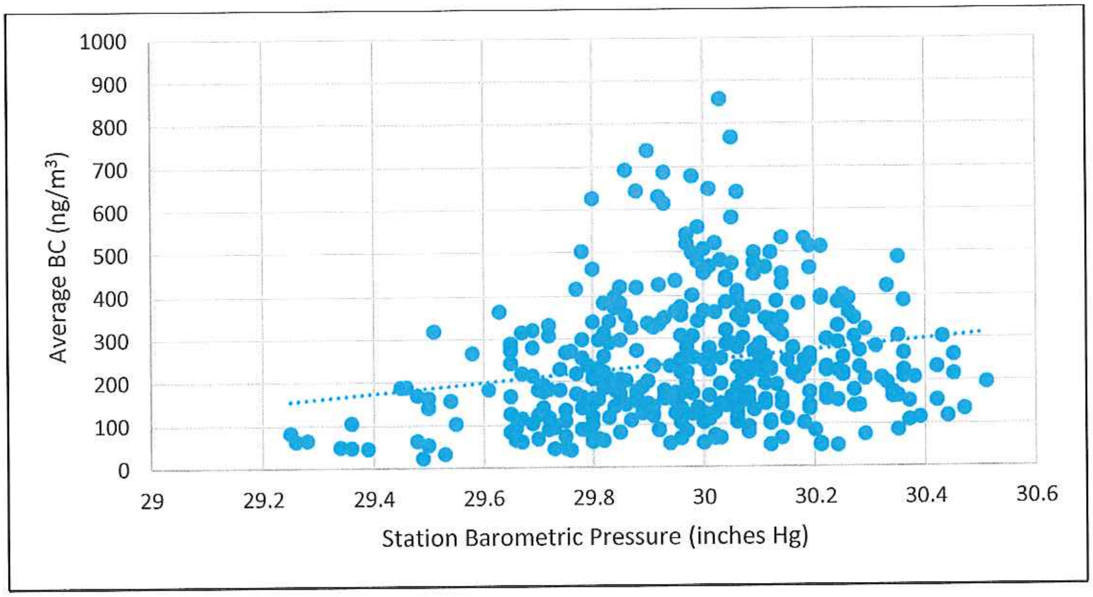


Figure 20: *Average BC, By Barometric Pressure, Fire Station Site*

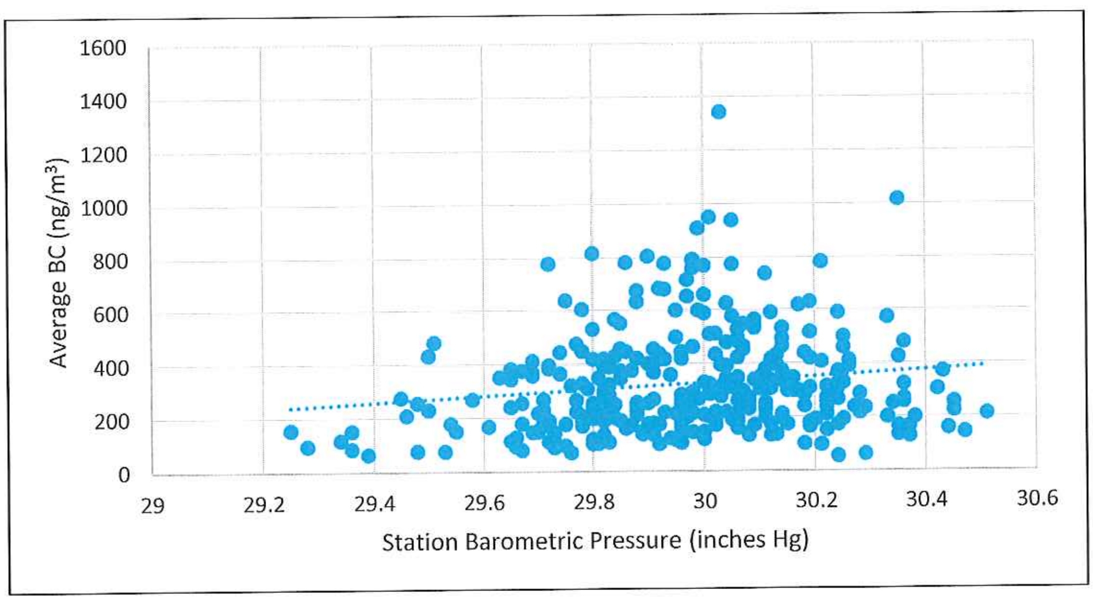


Figure 21: *Average BC, By Barometric Pressure, Lydick Site*

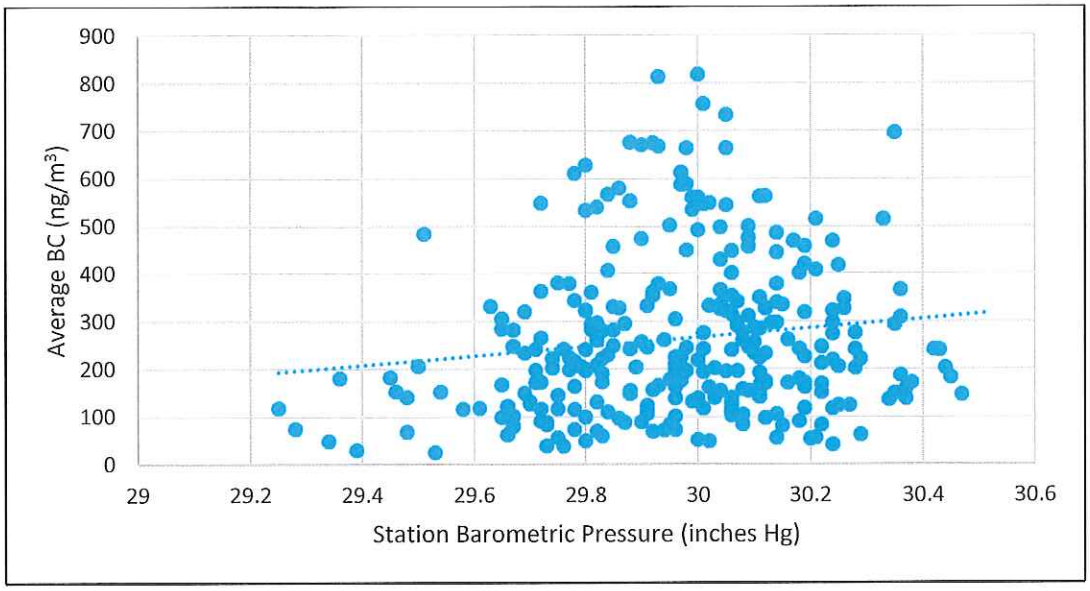
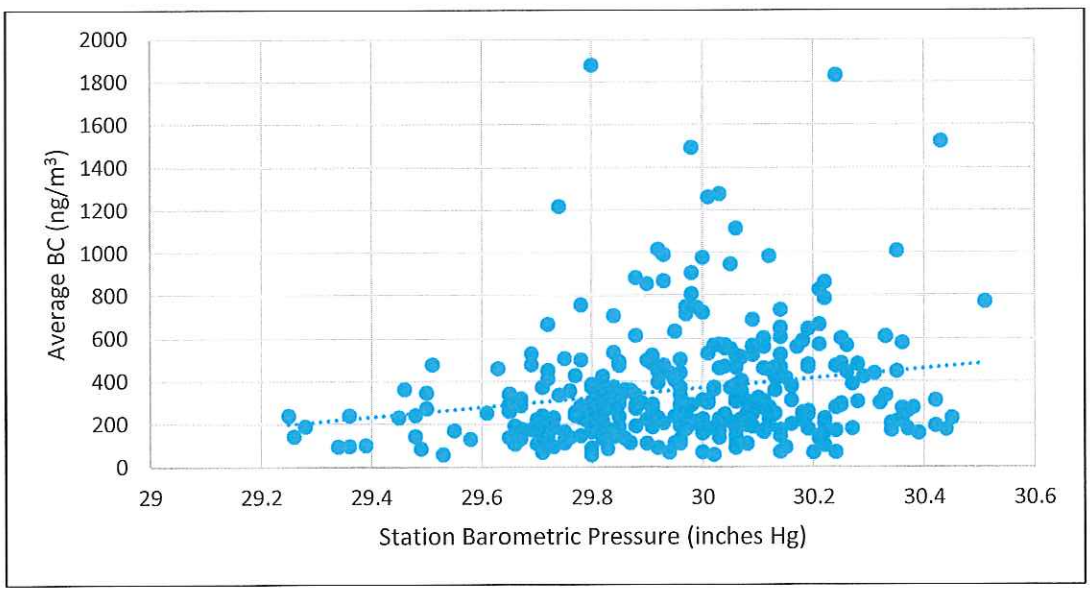


Figure 22: *Average BC, By Barometric Pressure, Pembroke Site*



There was a positive association between barometric pressure and BC levels at all four sites (Figures 19-22). High pressure systems are associated with low winds and little or no precipitation, while low pressure systems typically are accompanied by increased winds and precipitation. In addition, higher pressure systems can be associated with temperature inversions, which can trap pollutants closer to the ground and prevent them from rising into the atmosphere.

Figure 23: *Airport Operations and BC, Fire Station Site*

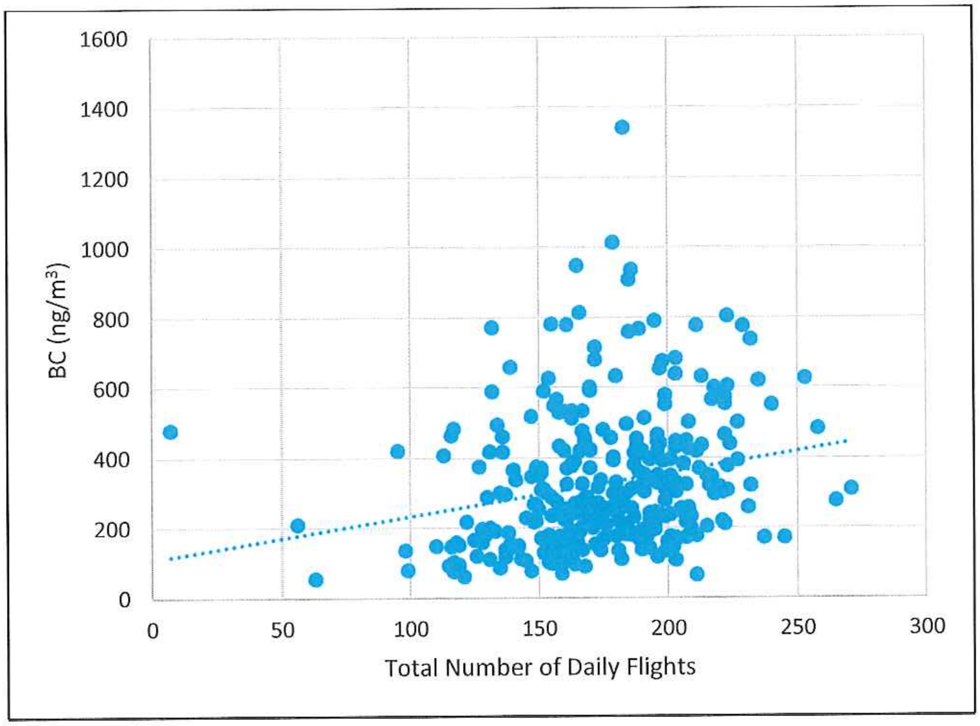


Figure 24: *Airport Operations and BC, Fieldview Site*

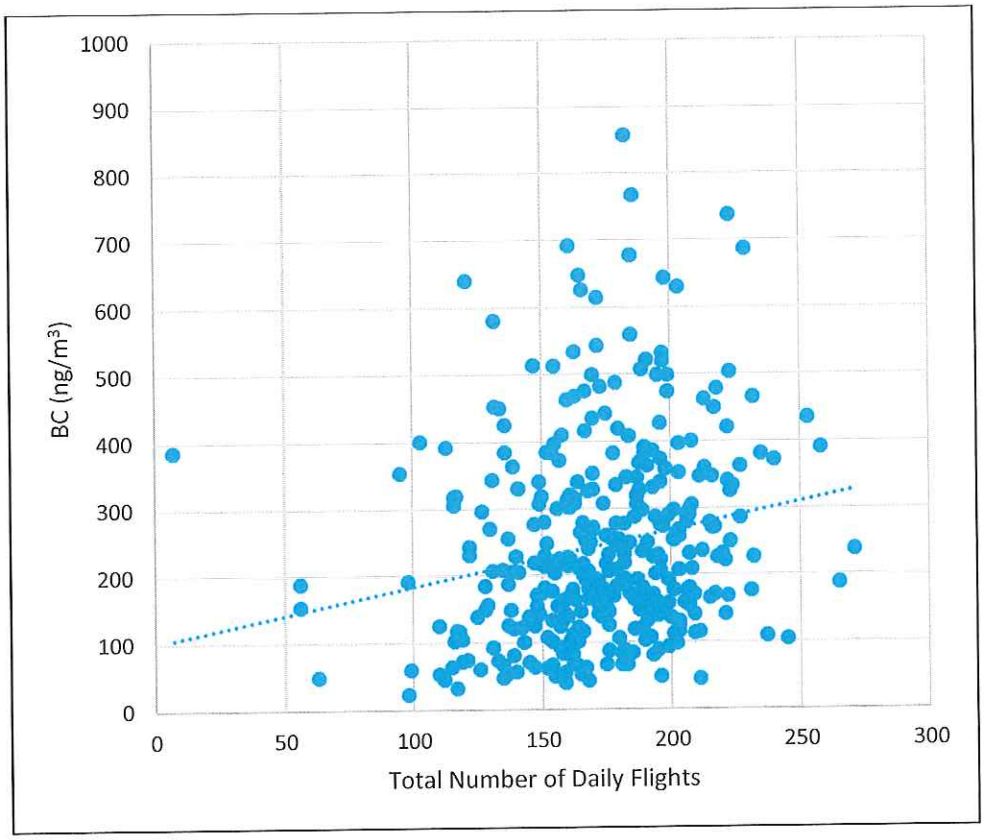


Figure 25: *Airport Operations and BC, Lydick Site*

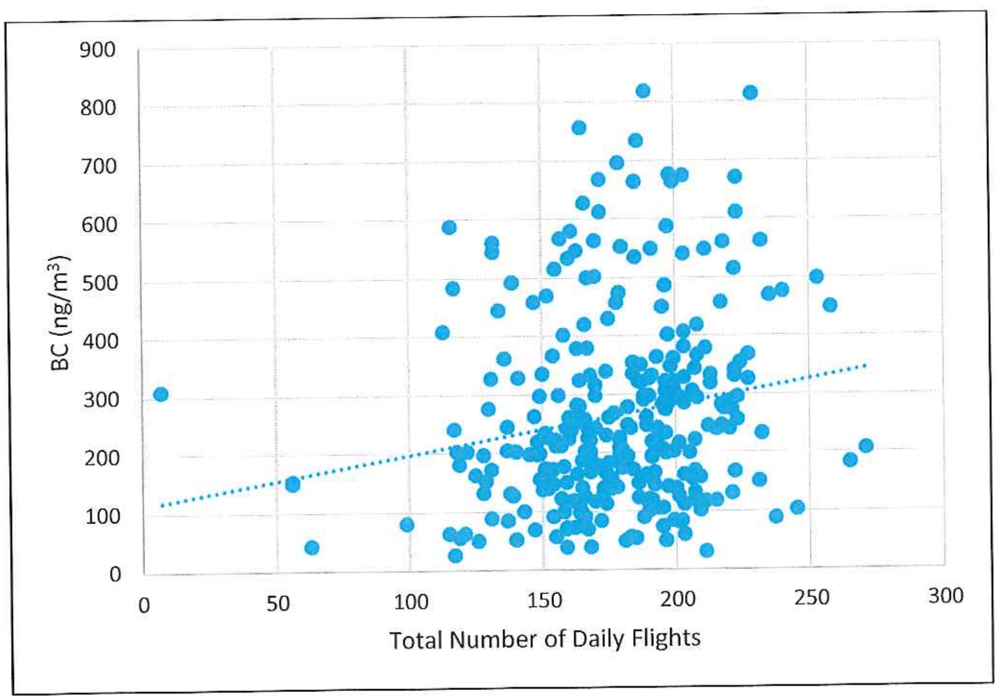


Figure 26: *Airport Operations and BC, Pembroke Site*

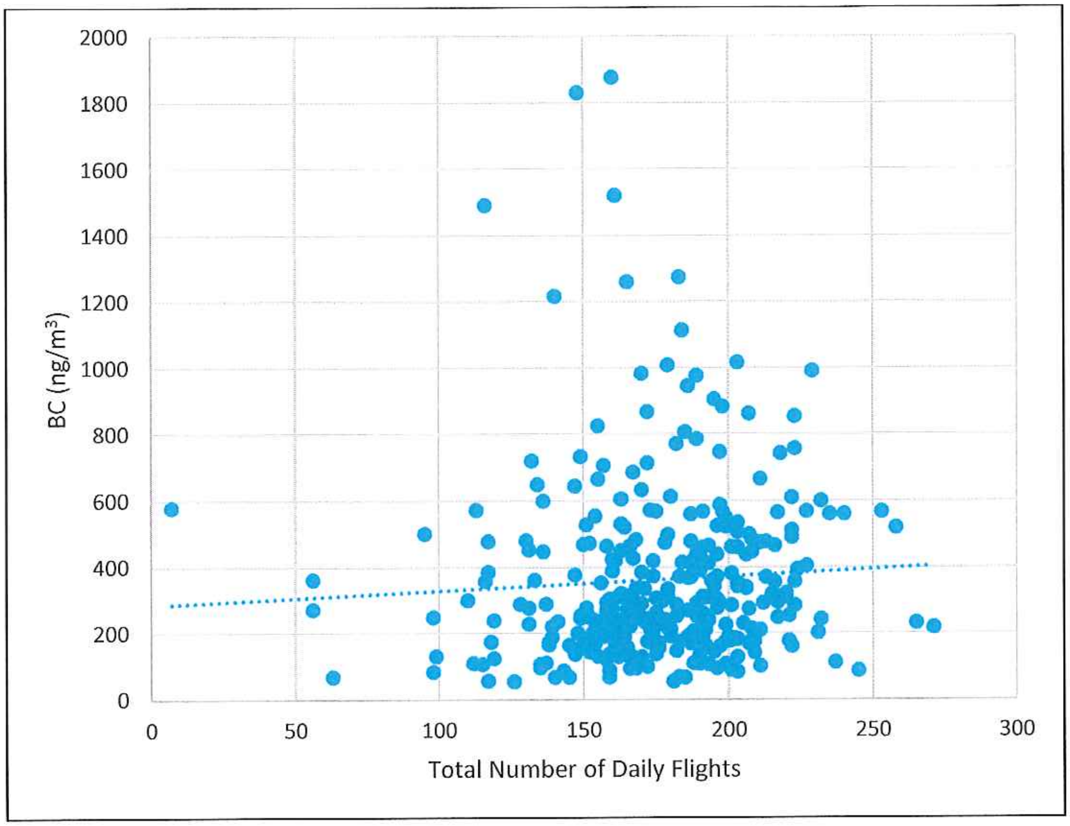


Figure 27: *Relationship Between Wind Speed and Flights*

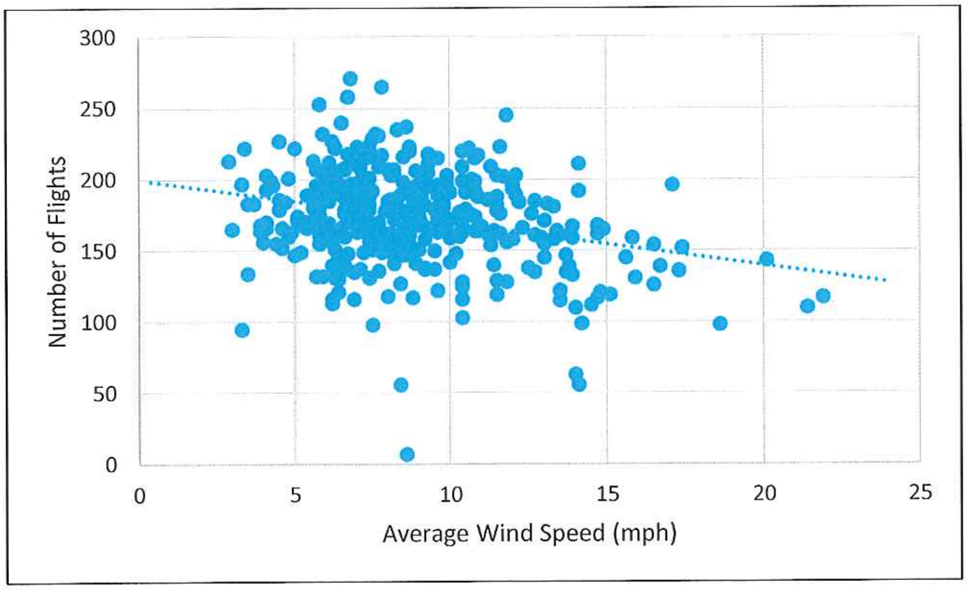
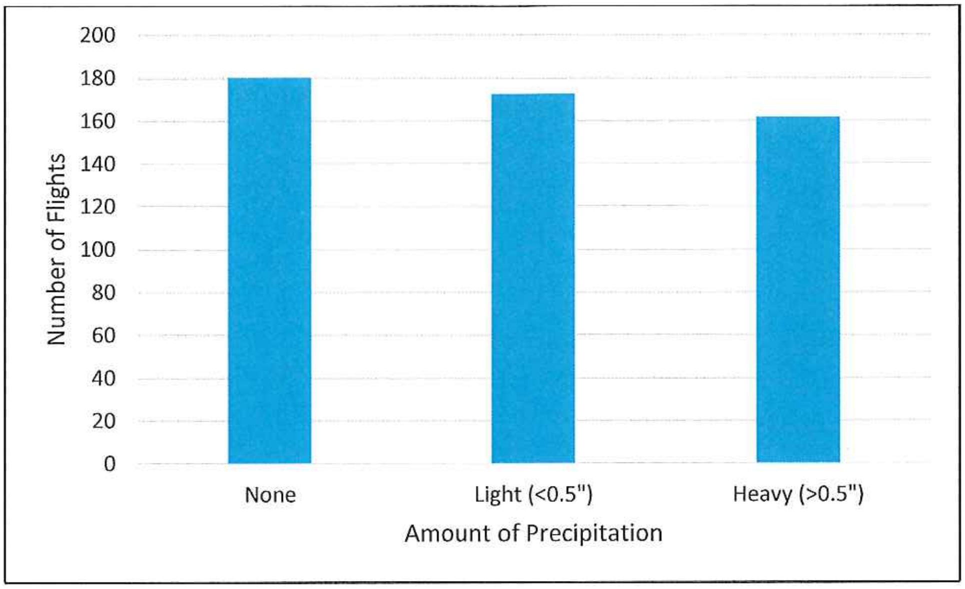


Figure 28: *Relationship between Precipitation and Flights*



There was a positive association between the number of daily flights operating out of the airport and BC levels at all four monitors (Figures 23-26). The increased BC generation from additional flights could partly explain this relationship, but it is not possible to isolate that effect from the effects of wind speed and precipitation on flights. While it is rare for T.F. Green Airport to cancel flights due to local weather conditions, regional weather conditions often cause cancellations at other airports in the region that will reduce flight numbers at T.F. Green. It is likely that the stronger relationship between flight numbers and BC levels from July 1, 2018, to June 30, 2019, relative to PC data from the previous data collection period, could primarily be a result of differences in weather between the two years. There was relatively little snow in winter 2018/2019, particularly compared to winter 2017/2018. Heavy snow reduces flight numbers but also causes snow removal operations at the airport, potentially resulting in relatively high pollution levels despite few flights.

Particle Count (PC)

There was a recurring malfunction of the equipment used to monitor PC during the time period of July 1, 2018, to June 30, 2019, that made it very difficult to determine when the monitors were collecting data that reflected ambient pollution levels. Because of this issue, the PC data for the 2018-2019 period was not analyzed. RIAC is aware of the problem and has been working with RIDOH's Air Pollution Laboratory to resolve the issue. RIAC is now in the process of having the units sent to the manufacturer for repair and recalibration and believes that this problem will be fully corrected. For a detailed analysis of particle data collected through this program, see the 2017 and 2018 Annual Reports.

Conclusions and Recommendations

After review of the monitoring results for 2018-2019, RIDOH makes the following conclusions and recommendations:

- Observed BC levels were highest at the Pembroke and Fire Station sites and much lower at the Fieldview and Lydick sites.
    - The range of BC levels observed at Pembroke and Fire Station were similar to a comparison site at the Urban League building in Providence.
    - The range of BC levels observed at Fieldview and Lydick were similar to a comparison site in a residential neighborhood of East Providence.
    - The higher levels at the Fire Station site are most likely explained by the proximity of major roads, including I-95 and Post Road.
    - Of the currently operating monitoring sites, Pembroke may be the most influenced by airport operations.
- BC levels fluctuated during the course of the day, with peaks around sunrise and sunset and lowest levels through the middle of the day. These results are consistent with previous observations and likely correspond to the effects of rush-hour traffic on BC production and trends in wind speed throughout the day.
- As previously observed for PC data, meteorological conditions are major determinants of the average levels of BC measurements, as demonstrated at each of the monitoring stations:
    - Wind speed appeared to be the strongest influencer of BC levels. Higher wind speeds disperse pollutants and prevent their buildup.
    - The relationship between wind direction and BC levels was more complex than previously observed for PC. BC can travel much longer distances from a source than PC, and thus, sources further from Warwick could be contributing to BC levels measured around the airport, in addition to local sources, including airport operations.
- There was a positive association between total flights out of the airport and BC levels at the airport, although this association may be confounded by the effects of wind speed and precipitation on both BC levels and flight numbers. Both high wind speeds and precipitation were associated with fewer flights and with BC levels.
- The data collected suggest that the presence of the airport, and its associated activities, contributes to BC levels, but plays a smaller role in determining BC levels in most of Warwick than other factors. Wind speed appears to be the dominant factor in determining BC levels, with contributions from other meteorological conditions. Combustion of fuels at other local and regional pollution sources also contribute to the BC levels in Warwick.
- Consistent PC data was not available for analysis for the 2018/2019 time period due to intermittent power and equipment failures. RIAC, with RIDOH assistance, has corrected the problem and does not anticipate continued issues. Data from previous years were of sufficient quality, so it is likely that this was a relatively short-term problem.
- After consulting with the general public, RIDOH and RIDEM now recommend that the Pembroke monitor remain at its current location to ensure the comparability of past and future data collected east of the airport. A monitoring site to the southeast of the airport

is needed to fill a data gap, as a health investigation identified concerns about residents' health in neighborhoods in southeastern Warwick.[2] RIDOH has met with RIAC and DEM to determine a suitable location and has selected a location near Graymore Avenue and Cole Avenue, south of the airport and southeast of flight paths on the main runway. RIAC is issuing a regulatory change that will move the monitoring equipment from the current Fire Station location to the new site.

- RIDOH intends to examine the data collected through this program in the context of newly available health-outcome data for the neighborhood.
- RIDOH encourages RIAC to examine options to mitigate pollution in the vicinity of the Pembroke monitor, particularly the fields and playground of Winslow Park, as the area around Pembroke monitor appears to see the biggest impact to air quality of the areas sampled.

[2] R. Vanderslice and J.P. Fulton, "Neighborhood Health Differentials in Warwick, RI: An Analysis of Risk Factors," *Med Health R I.* 2012 October ; 95(10): 331–333.