pscleanair.org
Puget Sound Clean Air Agency

Wintertime Air Monitoring Studies

2014 – 2015

Contents

Overview

Three wintertime monitoring studies were conducted in the winter of 2014-2015 as part of an effort to better understand air quality in locations outside our permanent monitoring network. Through the monitoring project we hoped to: improve burn ban forecasting in King County, evaluate potential wood smoke communities, and explore potential redundancies in our network. The study covered three areas: Auburn/Algona, the area between Monroe and Skykomish off Highway 2, and Shoreline/Lynnwood/Lake Forest Park.

Auburn/Algona

The Auburn/Algona area is one of the top 15 Highly Impacted Communities (Hi-C) in our jurisdiction. Highly Impacted Communities face economic or historic barriers to participation in clean air decisions and are identified as at risk for degraded air quality. The Auburn/Algona community was identified through our agency's Hi-C analysis based on health indicators and proximity to pollution sources including diesel, wood smoke and industrial sources. Sources in the area include aircraft part manufacturers, Oak Harbor Freight, a rail yard, metal manufacturing, plastics manufacturing, and a number of auto body shops. Additionally, the community has comparatively high rates of asthma, chronic pulmonary obstructive disease (COPD), and cardiac illness.

Over the 2012-2013 winter season the agency conducted a wood smoke study in southern King and parts of Pierce County. The study showed particulate levels at two locations in Auburn that were comparable to the highest levels in Pierce County. Using the results of the 2012-2013 study, we designed a second study in Auburn/Algona to assess wood smoke levels in the areas identified in the Hi-C analysis. Based on the estimated nephelometer PM2.5 concentrations measured in the 2012-2013 study as well as the levels seen in this 2014-2015 study we plan to place a permanent monitor in Algona and may place a second, temporary, monitor in Auburn as a comparison with the Algona monitor and to capture wood smoke and diesel sources in the community.

Study Design

The study was designed to site a new permanent monitor to be used for winter burn ban forecasts in King County and ultimately support Objective 1.3 of the Agency's strategic plan. The study included a mobile monitoring route and three temporary monitors. The site locations and mobile route were designed to maximize spatial and temporal coverage of the study area. The mobile monitoring route was designed to diagnose microscale pockets of pollution and to identify polluted areas that may not have been captured by demographic data. Since the mobile monitors only provide a snapshot of pollution levels, we used the temporary monitoring sites to provide temporal coverage at locations that may represent average pollution levels in the study area.

The temporary monitor placement and mobile route were designed using the demographic information from the Hi-C work. The mobile route included census blocks where wood burning is used for home heating, as well as areas with older homes that may use uncertified woodstoves. Along the route, we placed three temporary monitors that collected data between November 2014 and March 2015. In November, we deployed two nephelometers in the Auburn/Algona area. Beginning in January we added a third site in Auburn using a dylos particle counter, correlated to a nephelometer, to gather data at a site that was not suitable for a nephelometer due to electricity constraints. Figure 1 shows the locations of the temporary monitoring sites, yellow stars, as well as the area covered by the mobile monitoring route, shaded in green.

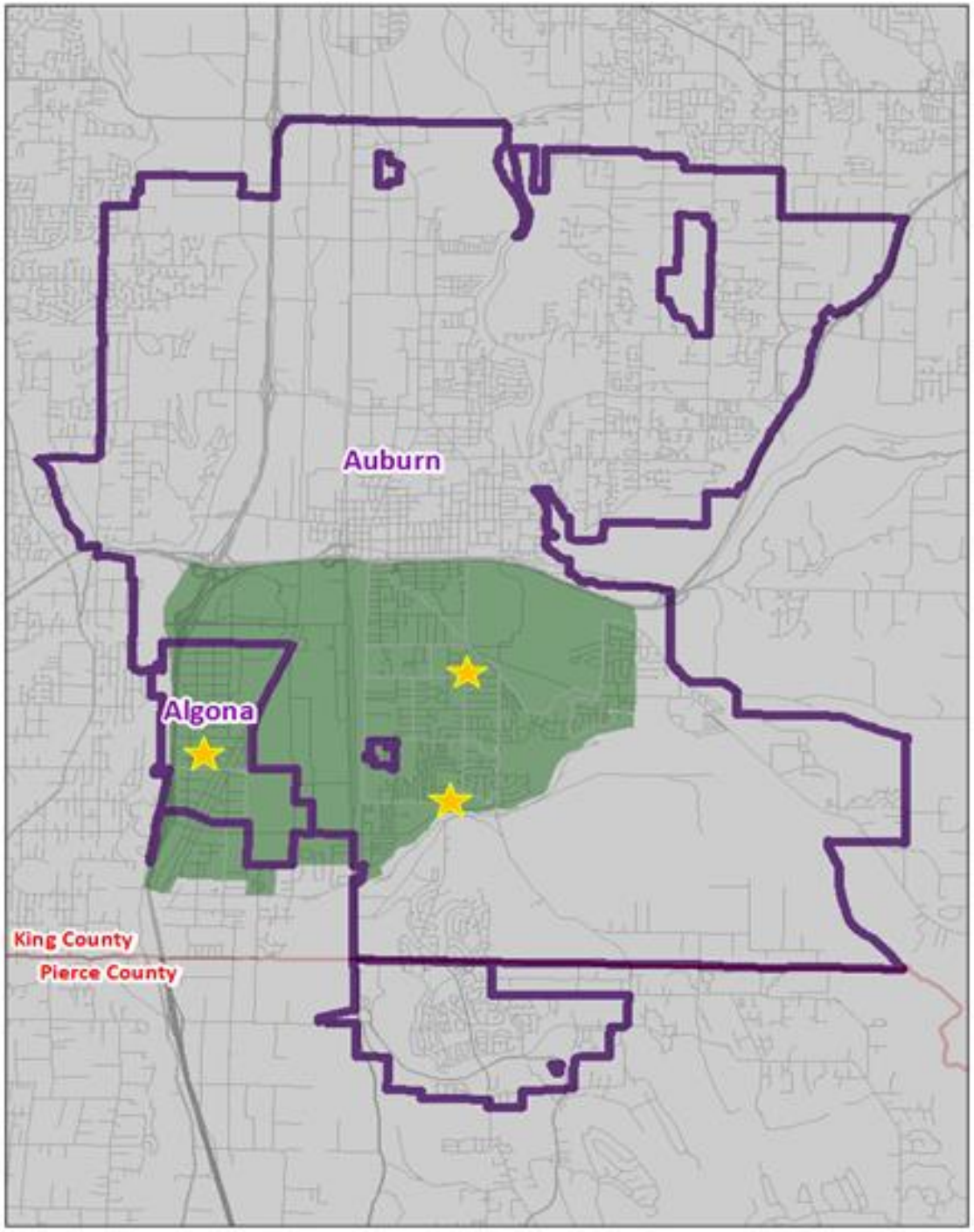

Figure 1 — Green area represents block groups identified in the Hi-C analysis and the locations of the three temporary monitoring sites, represented by yellow stars.

Results and Discussion

The study period covered three burn ban events, Nov 19th, Nov 30th, and January 1st and 2nd; each event was captured by at least one of the nephelometers in the study area. Figure two shows the hourly and the daily estimated PM2.5 concentrations over the study period. The Algona site consistently measures higher PM2.5 concentrations than the other sites in the study area. The differences in concentration are consistent with the monitor locations. The Algona site is centrally located near dwellings and typical activity for the neighborhood while the Auburn site, Mt. Baker Middle School, is set back further from pollution sources.

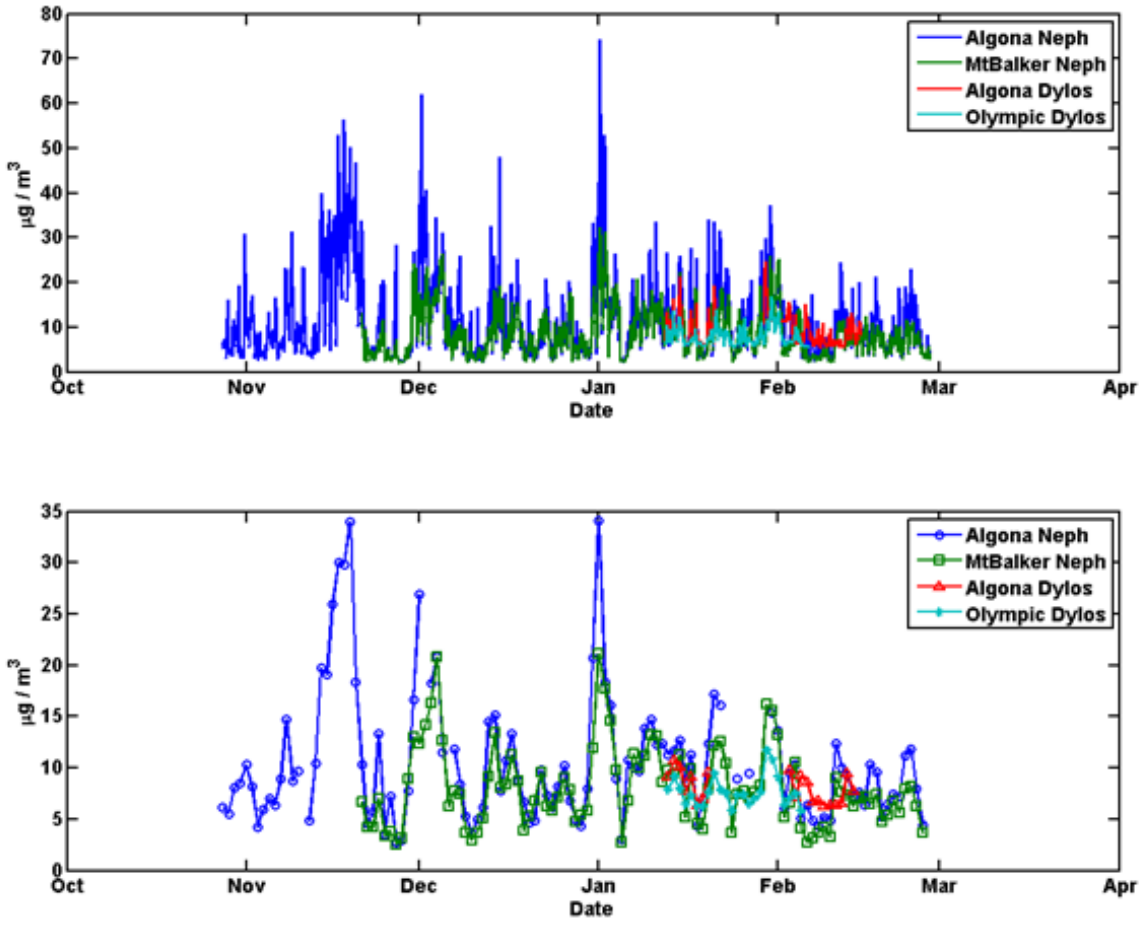

Figure 2 — Estimated PM2.5 levels from the Algona monitor (blue), the Auburn/Mt Baker Middle School monitor (green), the Algona dylos (red), and the Auburn/Olympic Middle School dylos (cyan)

The mobile route was designed to aid in our understanding of the air quality influences at the temporary sites. Our goal was to use the mobile data to identify any microscale influences at the monitoring site so we could avoid installing a new monitor in a location that was not neighborhood scale.

The Algona and Auburn monitors show pollution behavior that is consistent with other sites in King County. The burn bans called using our permanent monitors in King County were protective of air quality in Auburn and Algona; however, the levels observed in Algona were elevated, compared to the south King County monitors that currently represent the Auburn/Algona area, which are Kent and Duwamish.

Figure 3 shows the highest daily values of PM2.5 at the King County monitoring sites in the 2014-2015 winter season, the 8th highest value (in green) represents the numerical 98th percentile PM2.5 level. We show the 98th percentile because it is the statistic EPA uses over a longer time period of three years to determine compliance with the health-based daily PM2.5 air quality standard. The South L monitor in Pierce County is included for reference. We estimated the PM2.5 concentrations from the dylos instruments at Algona and Olympic Middle School using the dylos to nephelometer correlation at Algona. That correlation allows the conversion between counts and light scatter. Then we apply the same relationship between light scatter and concentration that we used at the other study sites, the Kent nephelometer correlation. The equation for counts and light scatter is

Counts = 0.84*(light scatter) + 17

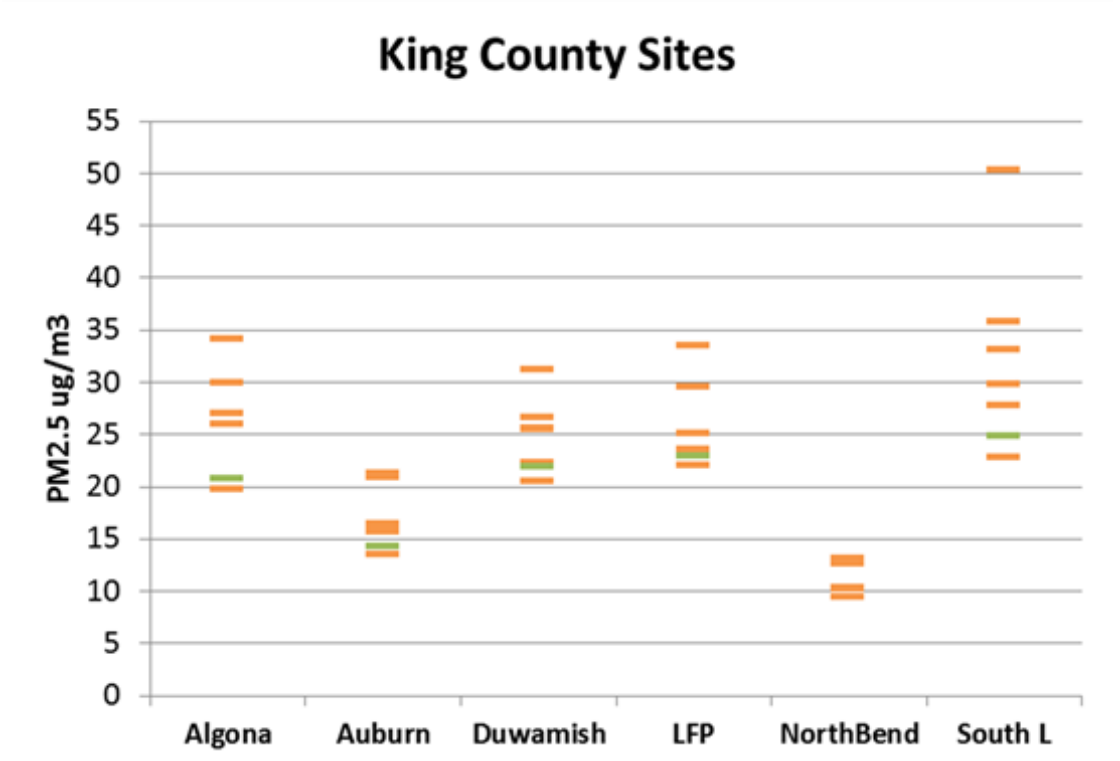

Figure 3 — Top daily average PM2.5 values in King County. The green line represents the 98th percentile value

Measurements from five mobile runs were used to assess the air quality in the areas around the temporary monitoring sites. The runs took place at a variety of times and pollution levels. The background runs took place around mid-day on December 17th and in the early evening on December 29th. The three remaining runs took place on November 18th from 7:40 am to 9:27 am, December 2nd from 8:38 am to 10:43 am, and December 3rd from 18:15 to 20:22.

Ideally, mobile runs would take place at a similar time each day. Since the data is only a snapshot of pollution levels, it is easier to interpret data if the snapshots occur at the same time and place. With that information, we can better understand what the spatial distribution looks like.

The results of the mobile monitoring portion of the study are shown in figure four. The shading on the route represents the average pollution level in the grid cell. Each grid cell contains the data points collected on December 29th and December 3rd, a background night and an elevated night, respectively. The mobile route concentrations shown in figure four represent a snapshot of the pollution levels. Each night we completed two laps around the study area. We chose not to complete additional laps in one run because the pollution levels change quickly with time.

Overall, the levels captured on the mobile runs are consistent with the levels measured at the temporary locations for the same times. In figure four, the color of the star represents the monitored levels at the temporary site for the same time shown on the map. I have also included the locations for the two monitors used in the 2012-2013 winter study, represented by a triangle.

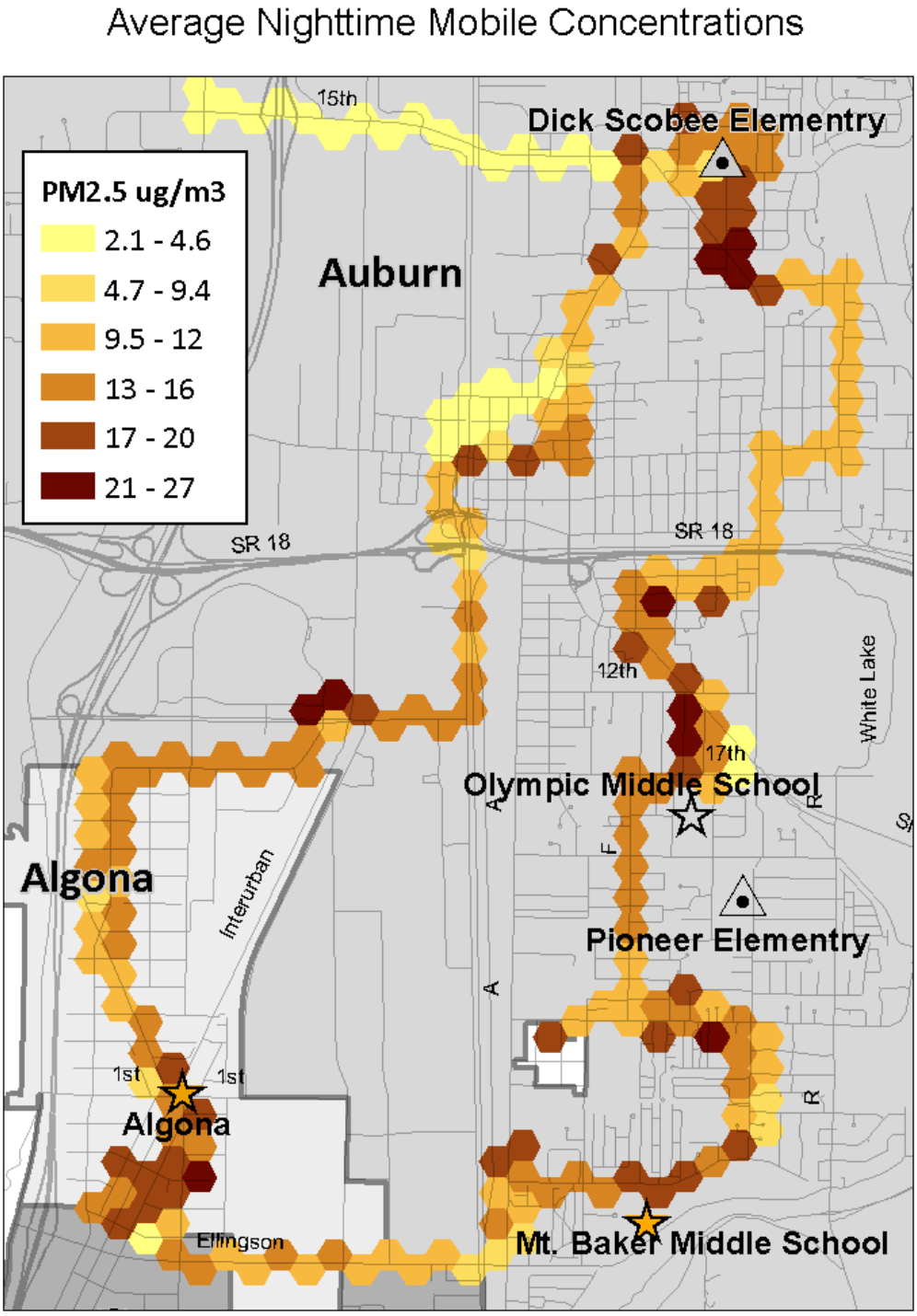

Figure 4 — Average night time PM2.5 concentrations from two mobile routes. Stars represent 2014-2015 monitor locations and triangles represent 2012-2013 monitoring locations.

Conclusions/Next Steps

Based on the elevated PM2.5 levels observed at the Algona monitoriong site during the 2014-2015 winter study the agency plans to place a permanent monitoring site at Algona that will be used for burn ban forecasting in King County. This site should capture the pollution that pools in the Auburn Valley during winter inversion events as well as other pollution sources in the area.

An additional mointor may be placed in Auburn to monitor pollution levels and to ensure that the monitored levels we saw at Algona were not a result of microscale influences. The monitor may be placed in a location that can capture pollution from other PM2.5 sources in the area such as diesel from trains and trucks. We will plan to collect community input before placing another monitor.

An important take away from the 2014-2015 winter study was a better understanding of the capibilities and challenges of mobile monitoring. While mobile monitoring gives a snaphot of the spatial distribution of pollution, the coordination and timing of runs plays a large role in the interpretation of the mobile data. In this study it is difficult to draw strong conclusions from the mobile data due to the limitations of the mobile run schedule.

Highway 2

The 2014-2015 winter study along Highway 2 was designed to meet two strategies from objectives 1.3 and 1.5 from our agency's stratiegic plan. The study assessed PM2.5 concentrations in communities that were identified as highly impacted by wood smoke. The communities are located in a part of our jusrisdiction that has not previously been studied. Studying the area will help inform our forecasts, with emphasis on strategy A and B from objective 1.5, monitor in more places and tailor forecasts to progressively smaller areas of our jurisdiction, as well as Strategy A of Objective 1.3, to identify communities with high 24-hour wood smoke levels.

Study Design

Between December 2014 and February 2015, four temporary monitors were placed along Highway 2 in Snohomish and King County. The monitor locations were identified through the Highly Impacted Communities analysis of the top wood burning communities in our jurisdiction. The temporary monitors were placed in Monroe, Sultan, Startup, and Skykomish. Due to the remote nature of the sites and resource limitations, we opted not to target mobile runs to capture wood smoke events. Instead, we collected mobile PM2.5 concentrations on our regularly scheduled site maintenance runs.

The study used small particle counters called Dylos to estimate PM2.5 concentrations at the four locations. The particle counters have been used in other winter studies and we have found them to represent wood smoke well. They were ideal for this study because they can be battery powered and siting does not require access to a power supply. We worked with communities to place and hang the battery opperated Dylos from a telephone pole at each site. Three of the sites were set-up in mid December 2014: Sultan, Startup, and Skykomish. The Monroe site faced leasing challenges and a Dylos

was not placed at the site until mid-January. The project scope had originally included a nephelometer at the Monroe site to be used as a reference for the Dylos, but due to the leasing issues the Nephelometer was not placed at the site. All the instuments were set up for a four week period and have an overlap of least a few days in January.

The locations of the temporary monitors and the moniotoring route are shown in Figure 5.

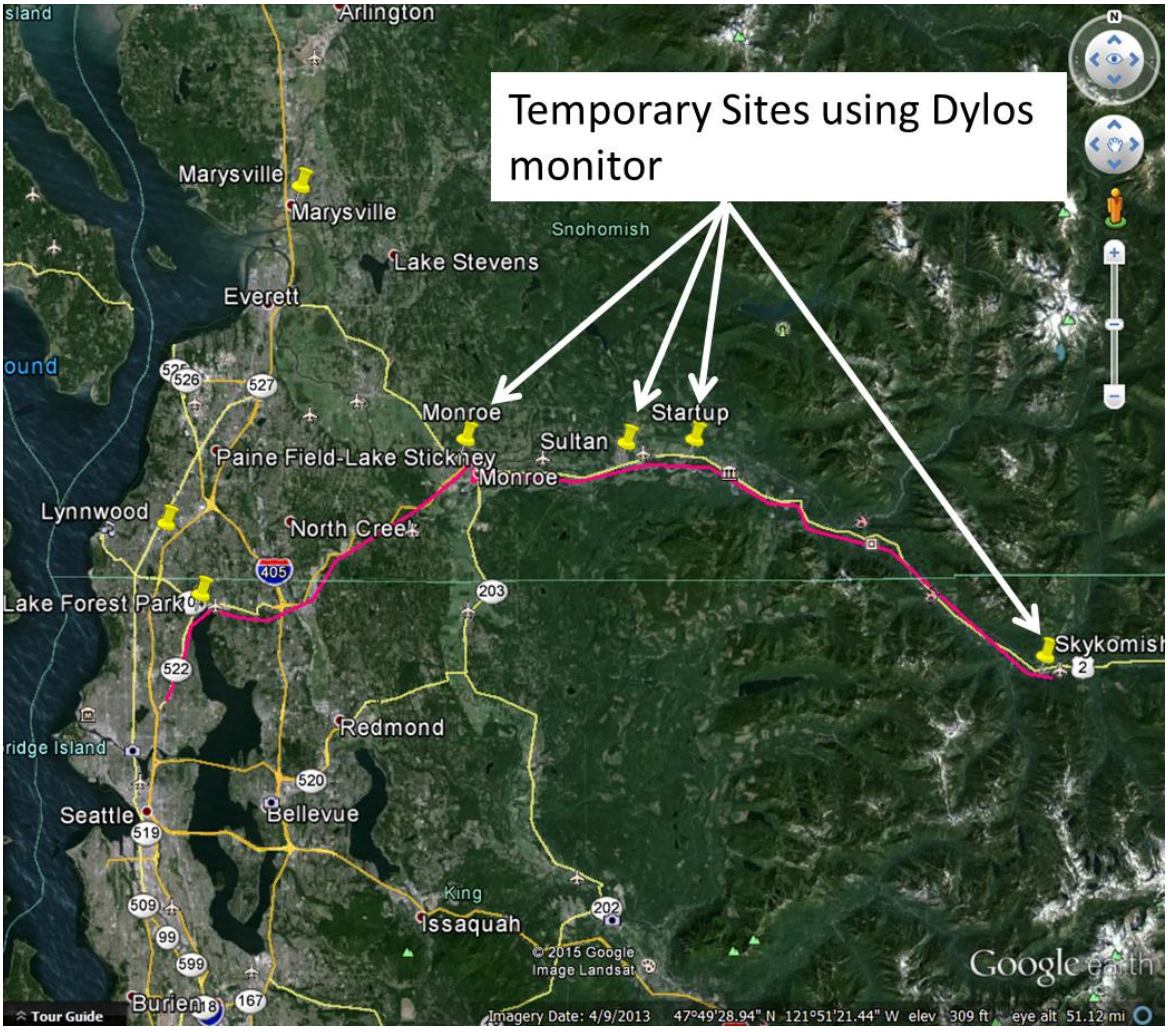

Figure 5 — Shows the study locations (yellow push pins) along the Highway 2 route (red line)

Results

The monitored pollution levels collected as part of the winter study represent particle counts. These counts can be related to light scatter and concentration when we have co-located measurements with a nephelometer. Since we did not have a nephelometer in this study we used the relationship between

light scatter and particle counts from other winter studies to estimate PM2.5 concentrations. All of the results presented in this report are based on relationship between light scatter and PM 2.5. We used the light scatter to PM2.5 relationship derived at Puyallup and the following relationship between counts and light scatter:

Counts = 2.885(light scatter) + 0.094

The hourly and daily values for PM2.5 are shown in figure 6. The highest values were measured in Sultan followed by Startup. We captured one period of elevated PM2.5 at all four sites. That event showed similar behavior between Monroe and the other sites however, Monroe had lower values. The pattern of pollution at each site is consistent with the pattern we see at Marysville. While we can't say what the absolute concentrations were at each site, we do see the highest study values when Snohomish County was under a burn ban. This suggests that the Snohomish burn bans based on PM2.5 levels at our Marysville monitor, represented by stars in figure 6, protect the air quality on Highway 2.

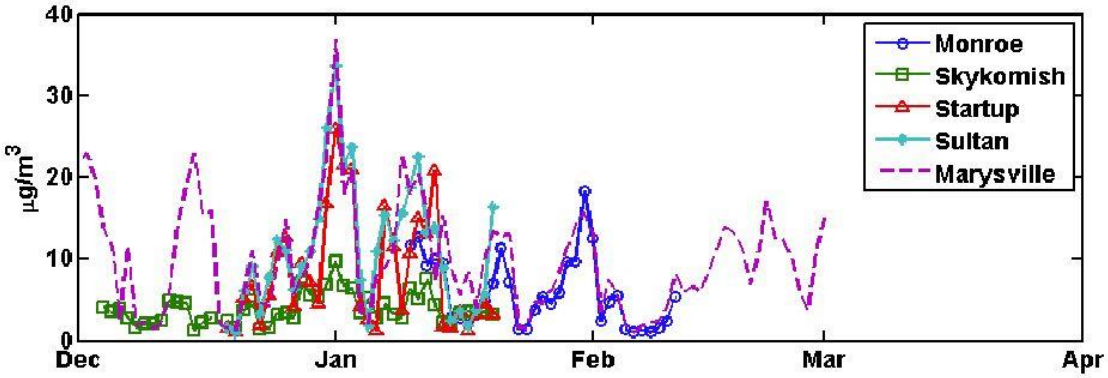

Figure 6 — 24-hour average PM2.5 concentration estimates for the study period. The Marysville concentrations are included for reference, represented by black stars.

While we did not conduct mobile runs during night time inversion events, a mobile nephelometer collected data along the route on instrument maintenance runs. The PM2.5 levels represent a snapshot of the average pollution levels in the winter time in the study area. Figure 7 shows spatially averaged PM2.5 concentrations represented by 500m hexagons. Data points from each run that lie within the 500m hexagon are averaged together to represent the color shown in Figure 7. PM2.5 concentrations are generally low along the route with increases in concentration when the instrument travels through populated areas.

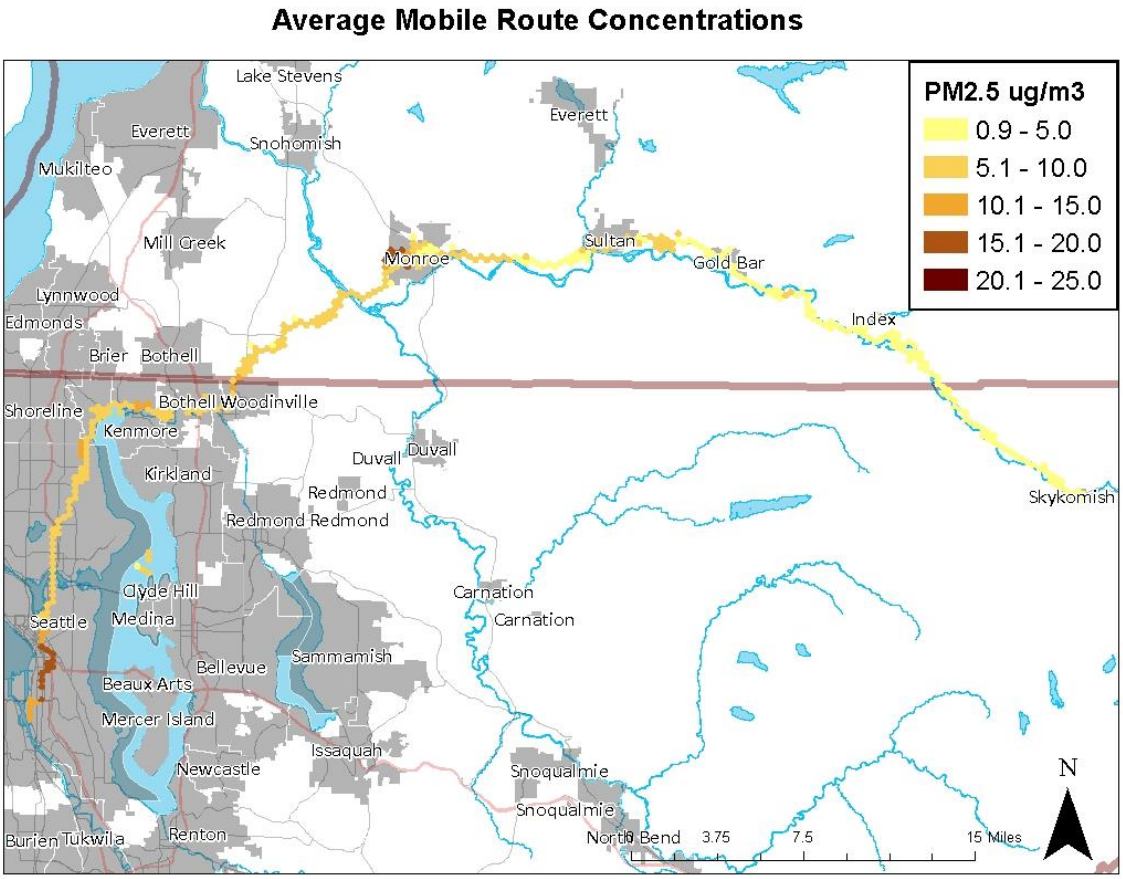

Figure 7 — Average mobile route concentrations over the Highway 2 study period. Colors represent the average of each drive and should be interpreted as a snapshot of daytime pollution levels in the winter

Conclusions

Despite the uncertainties in the absolute values of PM2.5 at each site in the study, we can infer that the pollution levels are either the same or lower than the existing permanent monitoring sites in Snohomish County. Figure 8 shows the highest daily PM2.5 values measured at each site in Snohomish County over the winter season, with the 98th percentile PM2.5 value shaded in green and the South L Pierce County site included for reference.

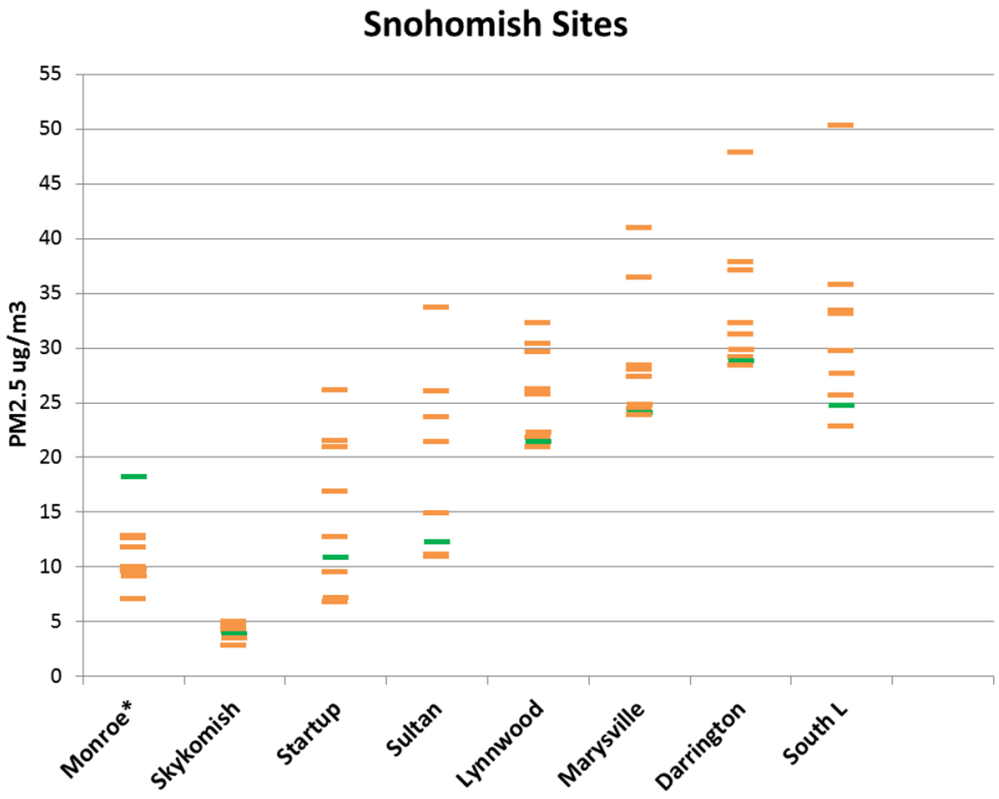

Figure 8 — Top daily average PM2.5 values in Snohomish County. The green line represents the 98th percentile value

The winter study gives us a better understanding of the relative wintertime pollution levels in an area that has not been as studied and monitored as other parts of Snohomish County. The burn bans issued for Snohomish County in the period of the monitoring study were concurrent with the elevated levels in the study locations. While we still have gaps in our understanding of the area, we have a better sense for the relative pollution levels between study sites.

The study also provided a valuable experience working with our wood smoke survey instruments. The Dylos instruments are an excellent resource for remote sampling sites that require quick deployment; however, using them without a more established method makes data interpretation difficult. This calls into question how useful the data are as a survey tool if a larger and more resource intensive instrument is needed to provide interpretable results.

Shoreline/Lynnwood/Lake Forest Park

Study Design

The Shoreline/Lynnwood/Lake Forest Park winter monitoring study was designed to assess the North King and South Snohomish monitoring network. As part of strategic plan objective 1.5, strategy A, the agency conducted a 2014 monitoring network review to assess the spatial coverage and potential gaps and redundancies in our monitoring network. The network review identified potential redundancies between the Lynnwood and Lake Forest Park monitors. The Lake Forest Park monitor is an important monitor for King County Burn Ban forecasting, as it often measures pollution levels that are the highest in the county. To assess how spatially representative the Lake Forest Park site is, we set out two nephelometers in Shoreline, up the hill from the Lake Forest Park monitoring station. The Shoreline Community is similar in housing type and density to the community around the Lynnwood monitor. Since we have potential redundancies between the Lynnwood and Lake Forest Park monitors, the study included a mobile route designed to assess the spatial variability between the Lynnwood site, the Lake Forest Park site, and the two nephelometers placed in Shoreline.

The mobile route was designed to pass by each of the monitoring sites, including the temporary sites in Shoreline, while also covering a large area around the sites. This would provide the best spatial coverage and assess whether or not there are mesoscale effects near the monitoring stations. The route is shown in Figure 9. Mobile monitoring runs were conducted on evenings when elevated pollution levels are forecast to occur. The dates and times of the mobile runs were as follows: December 15, 2014 (13:30-15:30), December 29, 2014 (14:00-15:30) and (18:00-19:40), December 30, 2014 (8:00-10:00) and (18:00-19:40), January 2, 2015 (10:00-12:00), and January 3, 2015 (17:30-19:40). Figure 9 shows the average concentrations observed along the mobile route. The measurements represent a snapshot of pollution levels. They represent the moment when the vehicle was in each location. The concentrations in Figure 9 have been adjusted to represent the average concentrations over the study period scaled to represent pollution levels that would have been seen if each measurement had been made at 8PM. Since wood smoke from residential heating is likely the main source of pollution in the area, the levels can vary from hour in the evening and typically build as the night goes on. Adjusting the levels to 8PM allows for a better comparison between sites.

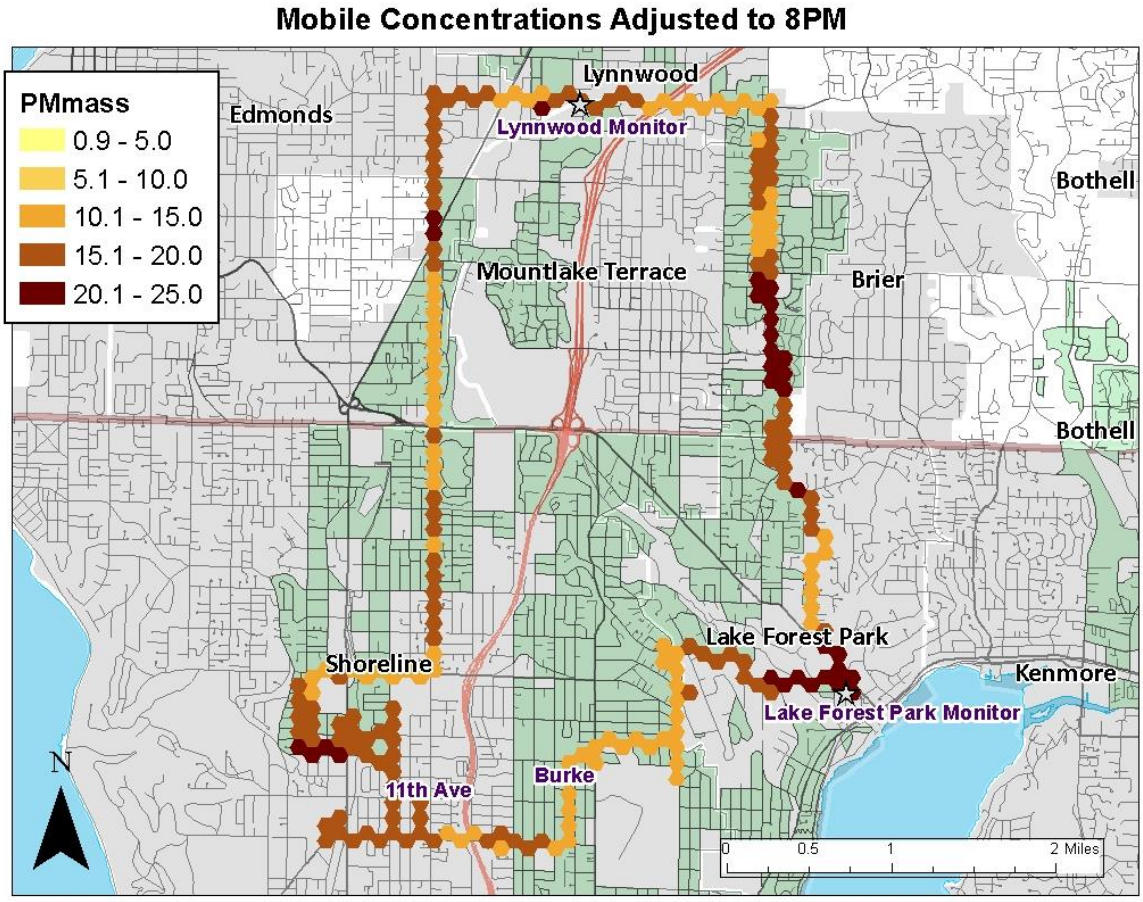

Figure 9 — Average mobile PM2.5 concentrations adjusted to 8PM

Results

Wood smoke levels at the temporary monitoring sites were generally consistent with the PM2.5 levels measured at our permanent monitoring sites. The daily 24-hour average PM2.5 concentrations are shown in Figure 10.

One of the Shoreline sites, Burke, was consistently elevated compared to the other temporary site in Shoreline. The difference is likely due to geography or microscale pollution effects. This assertion is based on the distribution of pollution observed on the mobile route, which showed pockets of pollution in the Shoreline/Lynnwood/Lake Forest Park area. However the data also shows that the area is generally well represented by our permanent monitoring sites at Lynnwood and Lake Forest Park. Figure 11 shows a comparison of the highest daily average PM2.5 concentrations at all the sites in the Shoreline/Lynnwood/Lake Forest Park winter monitoring study, with the 98th percentile value

highlighted in green. Figure 11 helps illustrate the similar distribution of PM2.5 at each monitoring site. This helps to illustrate that the permanent monitors show similar pollution levels as surrounding areas.

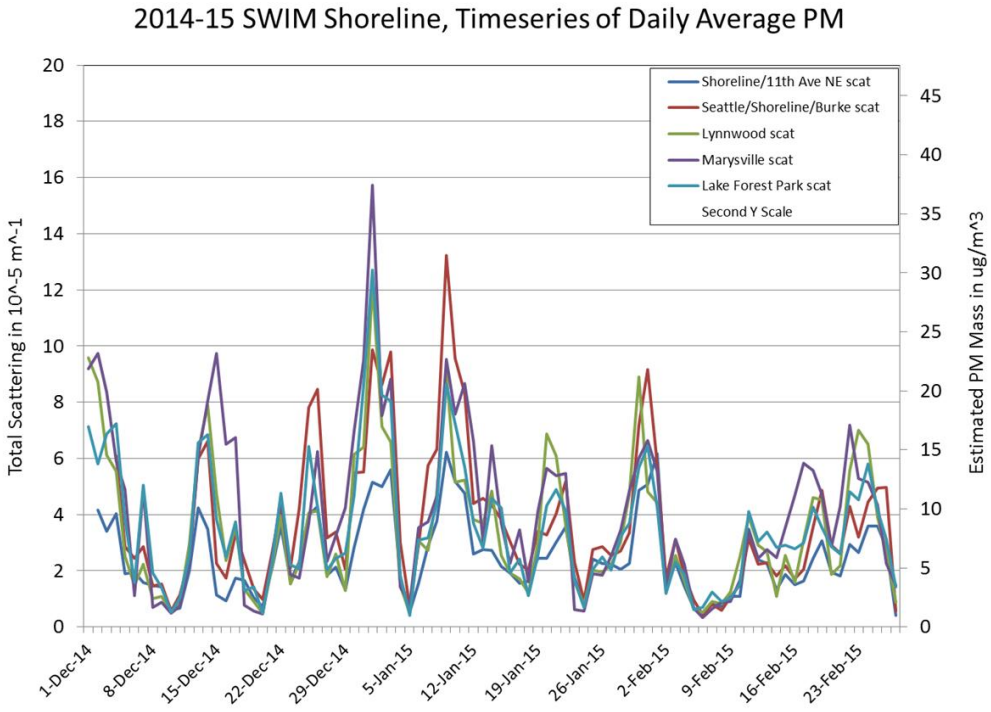

Figure 10 — Daily average PM2.5 concentrations at the monitoring sites in the study. The Marysville monitor was also included for reference.

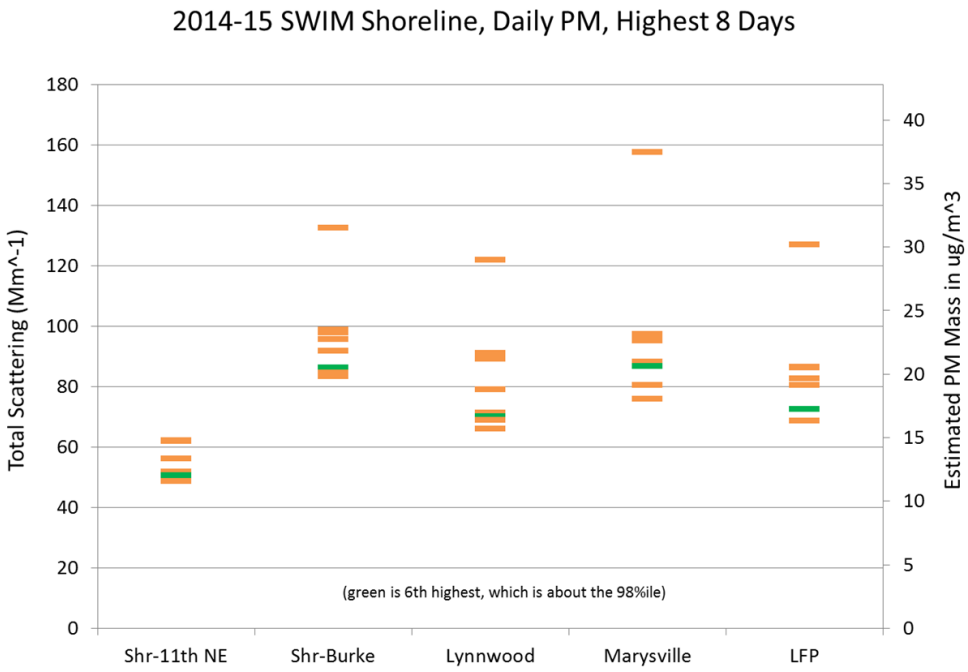

Figure 11 — Highest daily PM2.5 values at each monitoring site over the 2014-2015 winter.

Conclusions

The Shoreline/Lynnwood/Lake Forest Park winter monitoring study confirmed that there are redundancies in our existing monitoring network between Lynnwood and Lake Forest Park. From the mobile analysis and a comparison of the monitoring data, we consistently see comparatively lower concentrations at the Lynnwood monitor. Lake Forest Park shows elevated levels that are as high as, or higher than, other locations in the study area. Maintaining Lake Forest Park or identifying a Shoreline site as the monitor to call north King County burn bans is the recommendation from this report. We will need to asses logistics such as monitoring site availability, rent, safety (Lake Forest Park monitoring site sits atop a tall shopping center roof), and ability to discontinue monitoring at the Lynnwood site per State network before moving forward. These considerations are beyond the scope of this report.