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Results from the Peace Bridge Neighborhood Air Quality Study
August 2014 – September 2015

Presentation: September 20, 2016
Buffalo and Erie County Public Library
Niagara Branch - 280 Porter Avenue

History

Initial Study: Fall 2012 – Spring 2013 collected data prior to construction at the Peace Bridge Plaza

The study found that fine particulate matter ($PM_{2.5}$) was below National Ambient Air Quality Standards and black carbon (BC) was higher in the afternoon when truck traffic was heaviest

Many stakeholders voiced concern that the initial study missed summer months when traffic is higher, did not include ultrafine particles (UFP) and did not include a local background site

Current Study Objectives

- Developed with community and stakeholders
- One full year of data collection starting August 2014
  - Provides information on seasonal pollutant changes
  - Annual pollutant concentrations for comparison to standards and guidelines
- Goal to increase understanding of mobile source emissions ($PM_{2.5}$, BC, volatile organic compounds (VOCs), carbonyls and UFP)

Study Design:

Two fixed sites & community monitoring

- Busti Ave near Rhode Island St - close to and downwind of Peace Bridge operations and within the residential neighborhood (maximum impact site)
- PS198 International Preparatory School - within the same community but away from direct influence of Peace Bridge operations and I-190 (neighborhood background site)
- Community sampling effort for VOCs, $PM_{2.5}$ and UFP

Study Data Collection: Fixed Sites

Parameter	Busti Ave	PS198
Fine Particulate Matter ($PM_{2.5}$)	Aug 2014 – Sept 2015	
Ultrafine Particles (UFP)	Sept 2014 – Sept 2015	June – Sept 2015
Black Carbon (BC)	Aug 2014 – Sept 2015	
Meteorological Conditions	Aug 2014 – Sept 2015	not monitored
Carbonyls	Aug 2014 – Sept 2015	not monitored
Volatile Organic Compounds	Aug 2014 – Sept 2015	not monitored

Traffic Data for Study Period

- Buffalo and Fort Erie Public Bridge Authority provided vehicle count and classification for Peace Bridge traffic
  - Bridge crossings in both directions
  - Idling and delay information
- NYS Thruway Authority provided vehicle count and classification for I-190 traffic
  - Northbound at milepost 6.2 and 7.3
  - Southbound at milepost 6.4 and 8.2

Fixed Site Monitor Locations

1. Maximum impact site
2. Neighborhood background site

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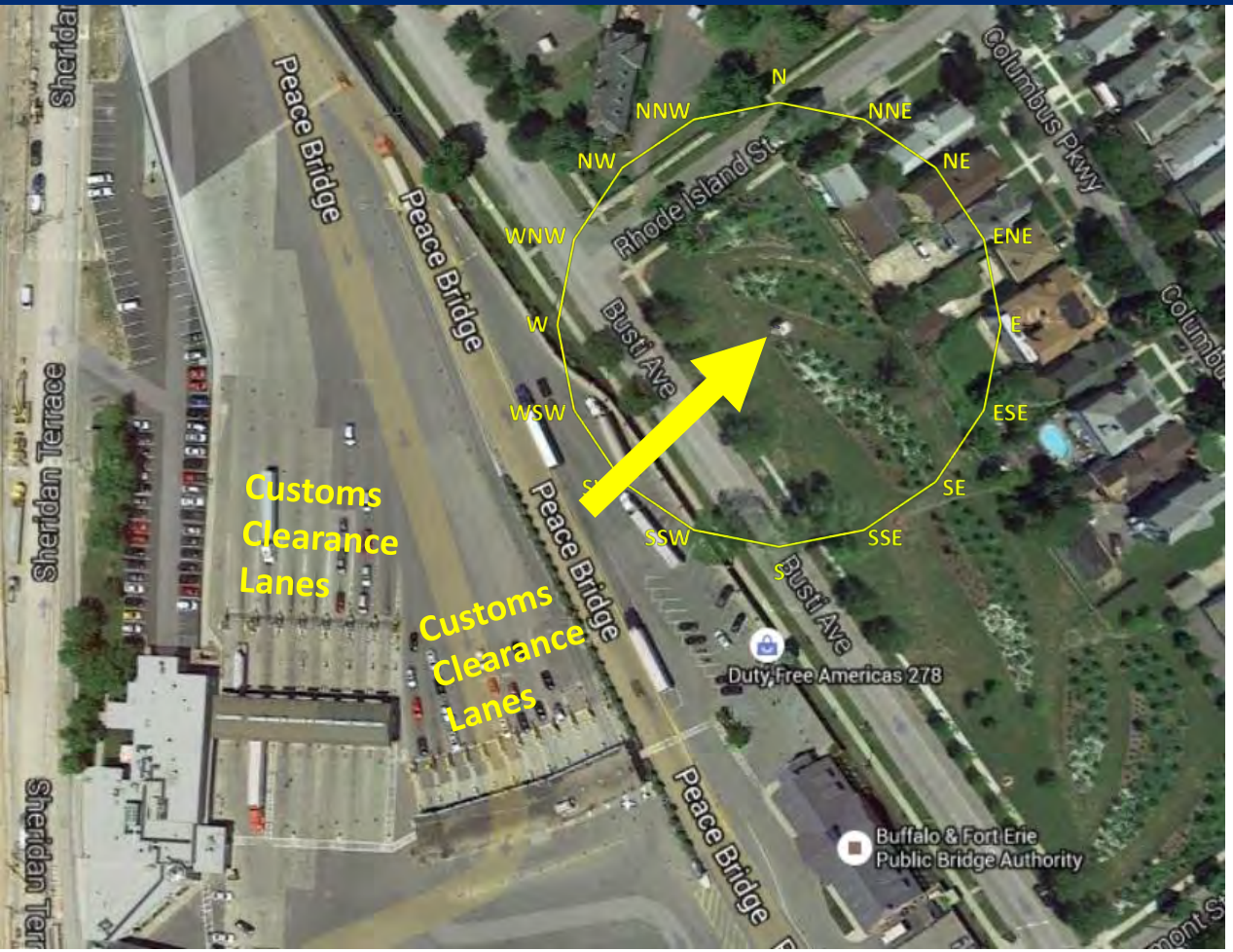

Maximum Impact Site

Located 40 yards downwind of congested customs clearance area

Yellow arrow shows the predominant wind direction

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Maximum Impact Site: Mobile Source Emissions

- Peace Bridge approximately 15,400 annual average daily vehicles (18-26% are trucks)
- I-190: 84,400 annual average daily vehicles (10% are trucks)
- Busti Ave: 1,582 annual average daily vehicles

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Neighborhood Background Site

- PS198 is on the corner of 14th St. and York Street
- York Street: 1,323 annual average daily vehicles

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Neighborhood Background Site

Instruments are situated above most nearby trees and rooftops

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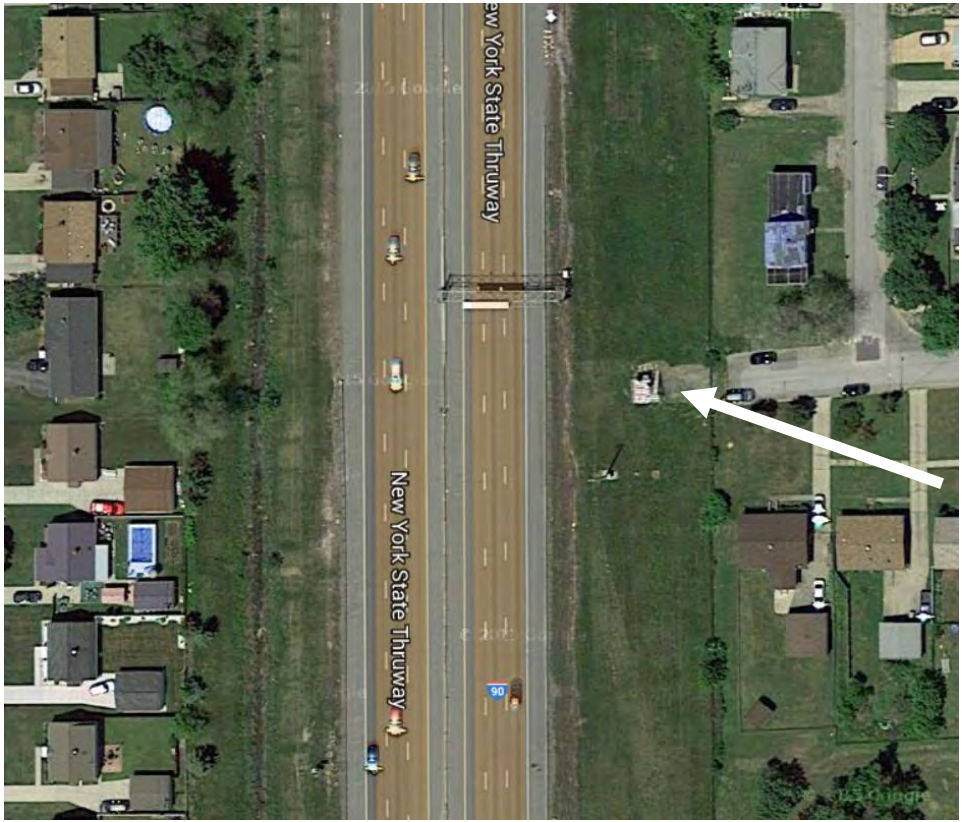
Buffalo Near Road Site



- Data were compared to Busti monitor results
- The EPA requires near-road monitoring
  - In cities over 1 million people
  - For nitrogen dioxide, $PM_{2.5}$ and carbon monoxide
- Buffalo site on I-90 between Exits 51 and 52
- 125,000 annual average daily traffic

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Study Findings

Findings: Traffic Information

- Peace Bridge traffic volume
  - Trucks are consistent across seasons and much higher during the week
  - Automobiles are higher in summer and weekends
- I-190 traffic volume
  - Trucks are consistent across seasons and higher during week
  - Automobiles relatively consistent across seasons and lower on weekends.

Findings: Fine Particulate Matter Concentrations

- $PM_{2.5}$ is well below daily and annual National Ambient Air Quality Standards (NAAQS)
- Primarily from regional sources
- Modest increase at the Busti monitor on the weekdays during late morning to afternoon which tracks pattern of mobile source emissions
- Highest for the winter season at both monitoring sites

Findings: Black Carbon Concentrations

- Significantly higher at the Busti monitor than PS198 and corresponds with weekday Peace Bridge truck traffic
- Busti site is similar to Buffalo near-road site
- Higher in the summer than winter
- Evidence of weekend evening sources at the neighborhood background site

Findings: Ultrafine Particle Counts

- Significantly higher at the Busti monitor than PS198 and corresponds with weekday Peace Bridge truck traffic
- Higher in the winter than in the summer
- Lower at the Busti monitor in comparison to the Buffalo near-road monitor which is closer to the thruway

Findings: Behavior of Ultrafine Particles

- UFP decreases within yards of emission source
- UFP concentrations are sensitive to environmental factors
- UFP much lower in summer
  - Higher temperatures promote conversion of particles to gases
  - Humidity allows small particles to stick together, becoming larger particles

Findings: Mobile Source Indicators

- UFP and BC are better indicators of mobile source emissions than $PM_{2.5}$
  - Both UFP and BC diminish quickly downwind from sources
  - Both UFP and BC were more closely associated with truck emissions than automobile emissions
  - Traffic incidents including sports events primarily impacted automobile traffic and had little effect on pollutant measurements

Findings: Air Toxics

- Some of the vehicle-related VOCs and carbonyls were found above DEC's annual guideline concentrations – but these same air toxics are found above guideline concentrations throughout the State
- Vehicle-related VOCs and carbonyls were found at the same levels as other monitoring sites in New York
- The 1-hour VOC community sample results were all below short-term guideline concentrations

Findings: Overall

- For fine particulate matter, the levels were well below federal standards and most of it comes from sources much farther away from this neighborhood.
- For air toxics, the air quality in this neighborhood is similar to other urbanized areas of the state.

Findings: Overall

- The study included two pollutants which do not have a standard or guideline: UFP and BC
  - A small, measureable increase in UFP and BC that corresponds with truck travel patterns on the Peace Bridge
  - Local increases in UFP and BC quickly diminish downwind from sources

Study Instrumentation

Instrumentation: $PM_{2.5}$

Thermo Environmental Inc.
TEOM 1400B

- Collects particles smaller than 2.5 microns
- Reports 1-hour average concentration

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Instrumentation: Black Carbon

Magee Scientific Model AE21 and the newer Model AE33

- Black Carbon is $PM_{2.5}$ particles that absorb light (1000x more than other species)
- Reports 1-hour average concentration

Instrumentation: VOCs, Carbonyls

- EPA collection and laboratory analysis methods are the same procedures used for all air toxics sites in DEC network
- 24-hr air samples collected once every 6 days

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Instrumentation: Ultrafine Particle Number

- API Model 651
- Condensation Particle Counter (CPC)
- Lower size cut 7nm
- 2nd Unit was on loan from the manufacturer

This is the first instrument designed for ambient air quality monitoring
Data units are # of particles/cm^3 averaged hourly

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Instrumentation: What was added?

A UFP monitor was added to the background site on June 11th to capture the summer months when traffic on the Peace Bridge is heaviest

A UFP monitor was also added to the Buffalo near road site on the same day

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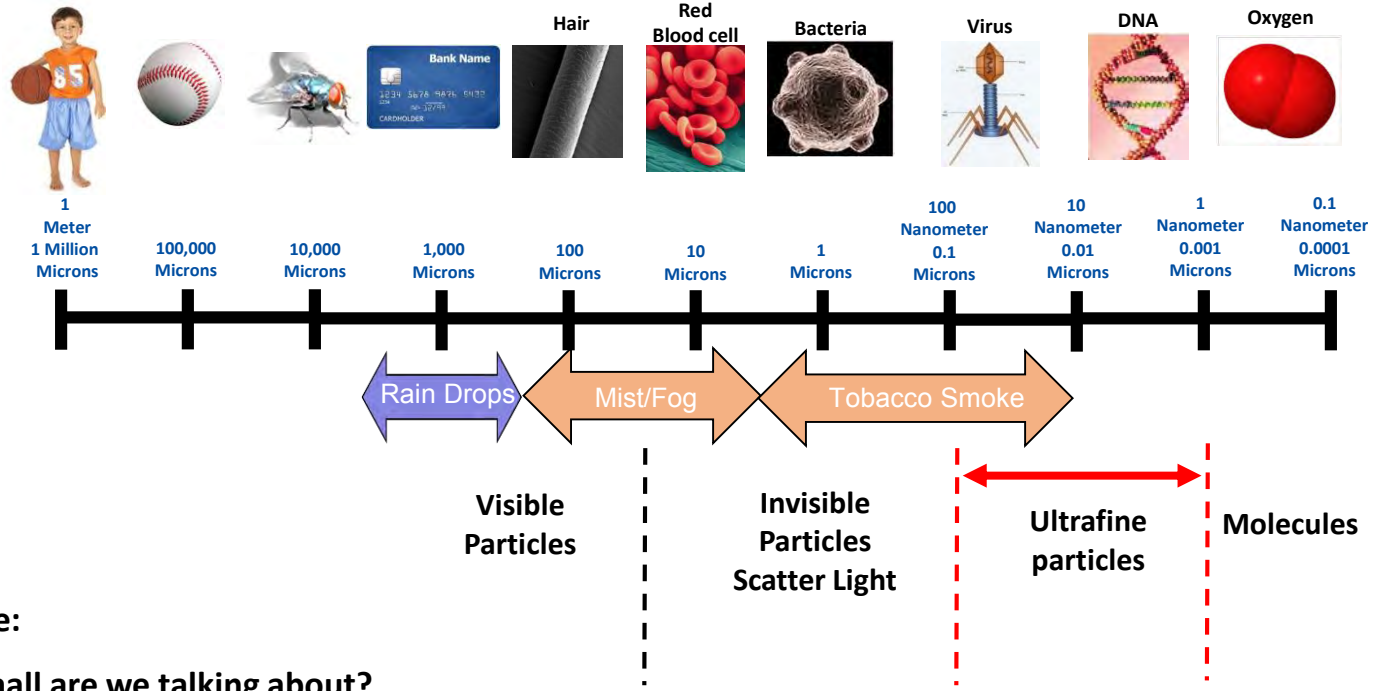
Ultrafine Particles



UFP Size:

How small are we talking about?

- **A Micron is a Millionth of a Meter**
- **A Nanometer is a Billionth of a Meter**
- **Wavelength of Visible Light: 390 – 700 nm**

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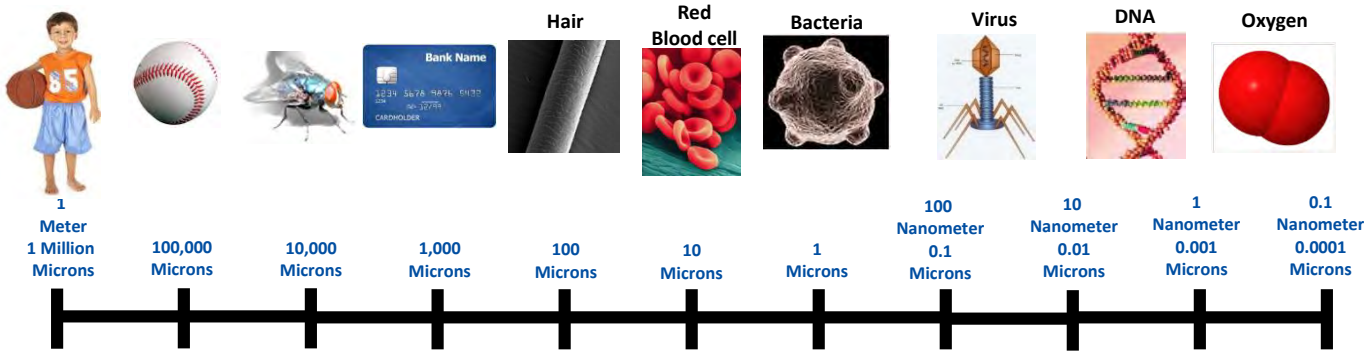

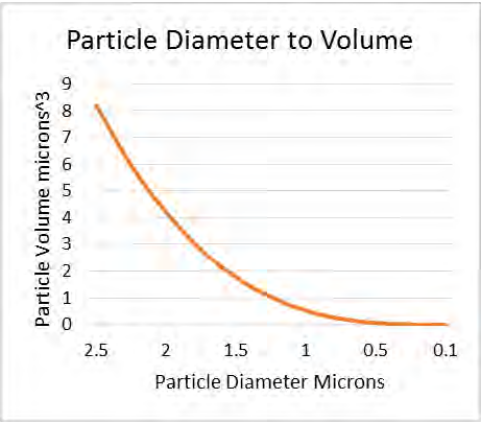

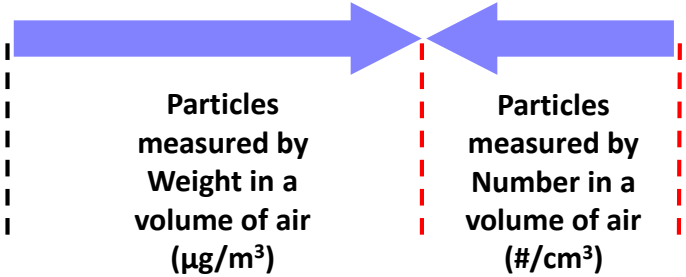

A 100 nm particle has 0.0064% of the volume of a PM-2.5 particle

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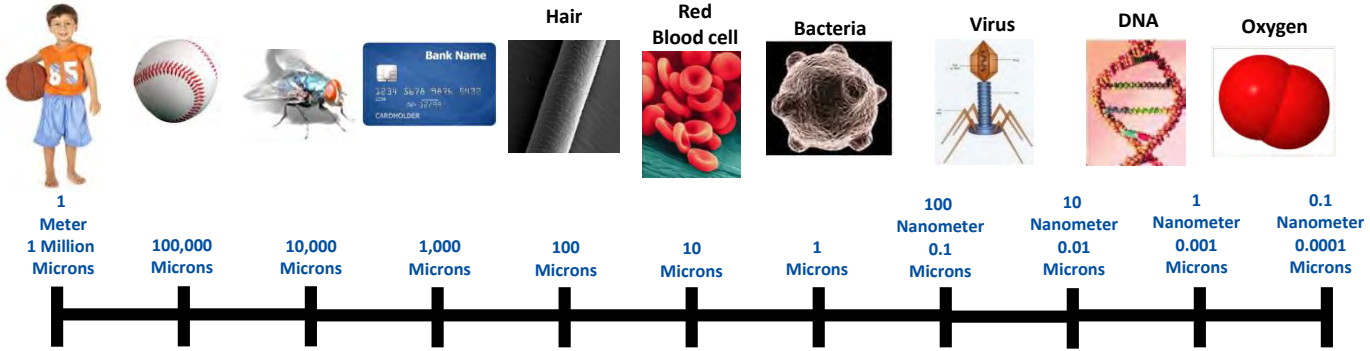

Total Suspended Particulates

PM10

PM2.5

Ultrafine particles

45 Years:

Evolution of PM NAAQS

- **1971 – Total suspended particles**
- **1987 – PM_{10} daily 150, Annual 50 $\mu g/m^3$**
- **1997 – $PM_{2.5}$ daily standard 65 $\mu g/m^3$**
- **2006 – $PM_{2.5}$ daily standard 35 $\mu g/m^3$**
- **2012 – $PM_{2.5}$ annual standard lowered from 15 to 12 $\mu g/m^3$**
- **2017 – ? (NAAQS currently under review)**

Ambient Ultrafine Particles are not regulated in the US

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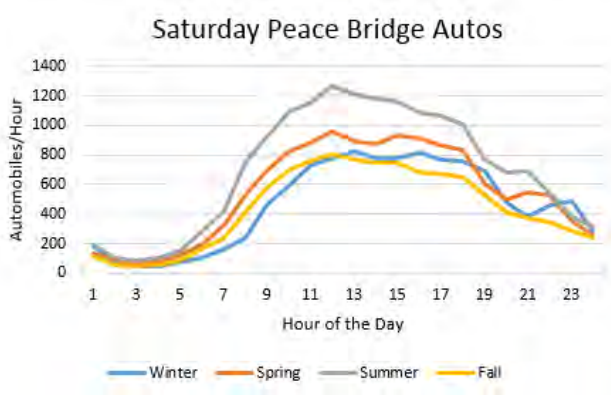
Study Results

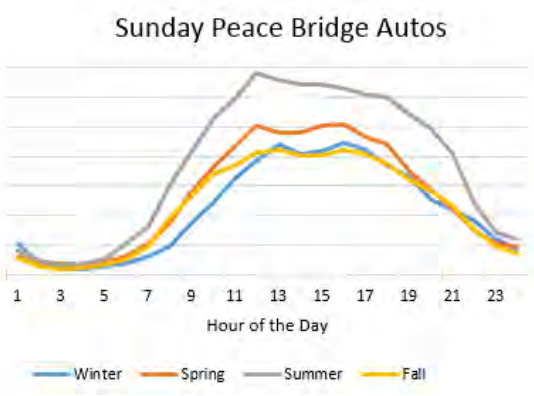
Results: Peace Bridge Traffic

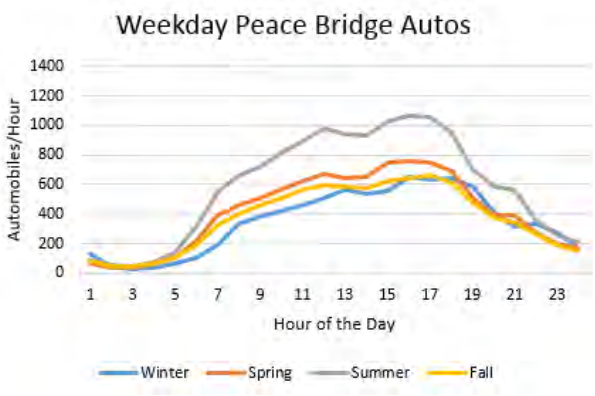
- ADT: Average Daily Traffic
- Total AADT: 14,904 autos, trucks and buses, east and westbound
- Truck traffic is very consistent year round
- Auto traffic is higher in the summer

Peace Bridge Traffic	Eastbound Autos	Eastbound Trucks	Eastbound % Trucks	Westbound Autos	Westbound Trucks	Westbound % Trucks
Fall ADT	5,845	1,745	23.0%	5,748	1,666	22.5%
Winter ADT	4,582	1,644	26.4%	4,433	1,599	26.3%
Spring ADT	5,222	1,773	25.3%	5,537	1,690	23.3%
Summer ADT	7,626	1,705	18.3%	7,783	1,653	17.6%
AADT	5,728	1,720	23.1%	5,759	1,640	22.2%

Results: Peace Bridge Automobiles







- Diurnal Plots (average concentration by hour)
- Higher on weekends and summer
- Weekdays – peak period is 11 am – 7 pm

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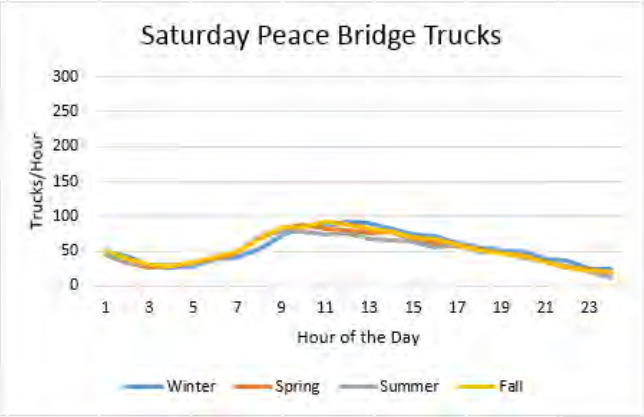
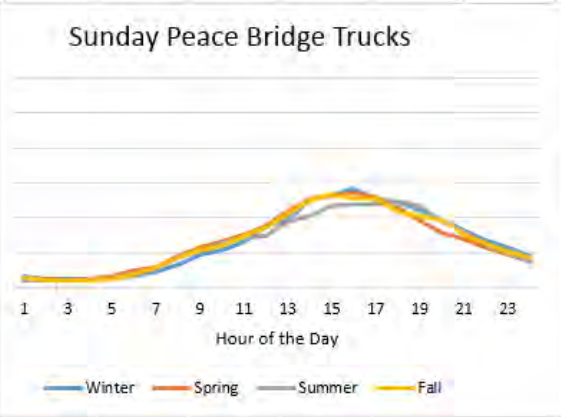
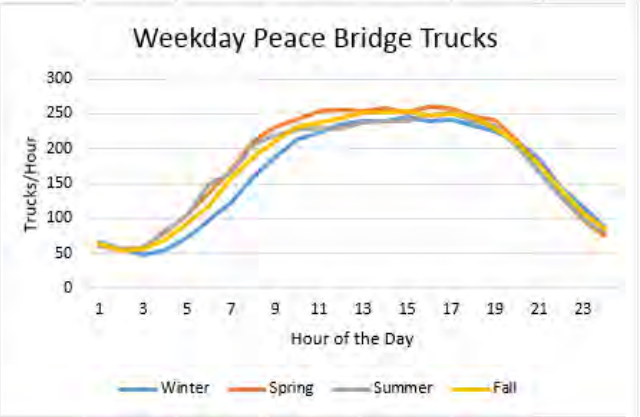
Results: Peace Bridge Trucks







- Lower on weekends
- Consistent throughout seasons
- Weekday – peak period is 9 am – 7 pm

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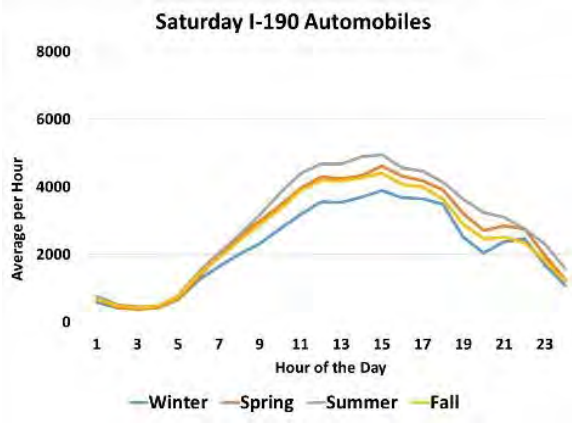
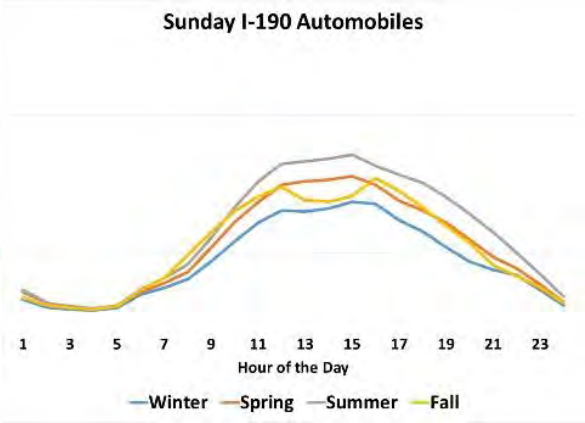
Results: I-190 Traffic

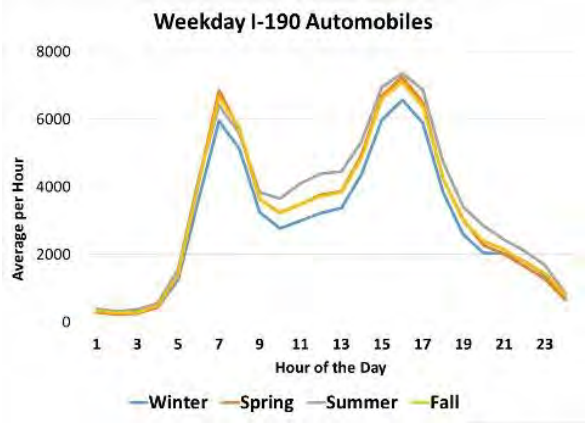
- Total AADT: 78,421 autos and trucks, north and southbound
- Truck traffic is slightly higher in the summer, lower in the winter
- Auto traffic is higher in the summer, lower in the winter

I-190 Traffic	Northbound Autos	Northbound Trucks	Northbound % Trucks	Southbound Autos	Southbound Trucks	Southbound % Trucks
Fall ADT	35,312	3,975	10.1%	34,808	3,992	10.3%
Winter ADT	31,621	3,506	10.0%	30,622	3,517	10.3%
Spring ADT	35,671	3,903	9.9%	36,166	4,008	10.0%
Summer ADT	39,201	4,203	9.7%	39,696	4,273	9.7%
AADT	35,349	3,888	9.9%	35,239	3,945	10.1%

Results: I-190 Autos







- Lower on weekends
- Higher in the summer, lower in the winter
- Weekday peak is 8 am and 4 pm

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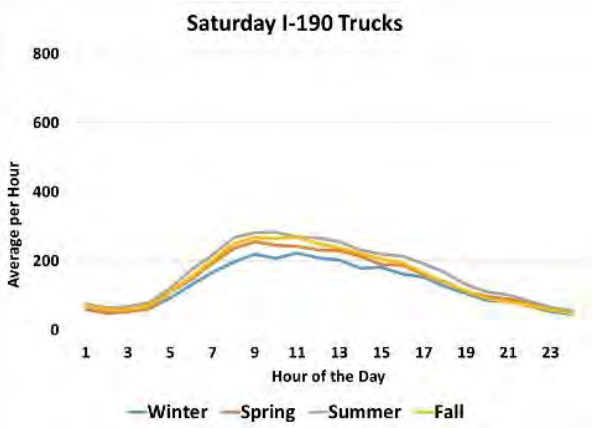
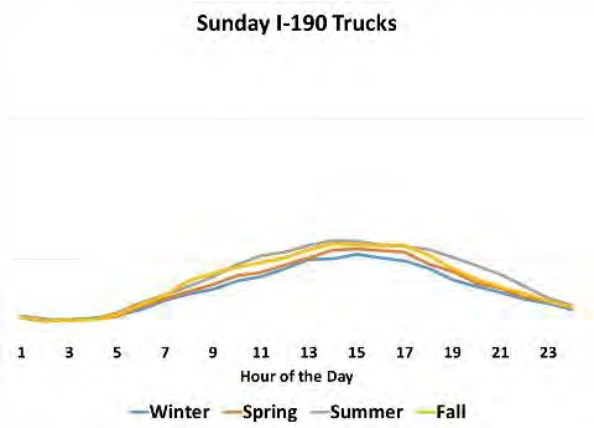
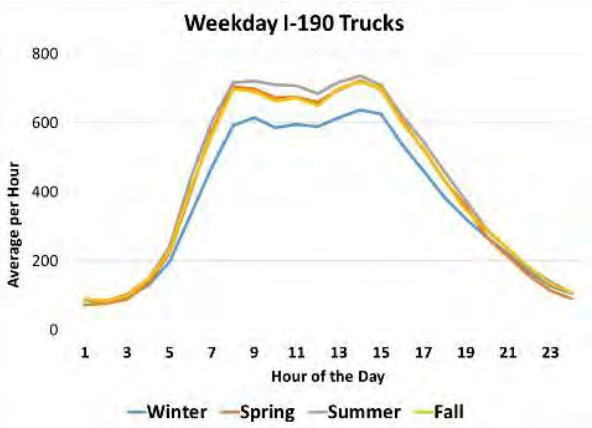
Results: I-190 Trucks







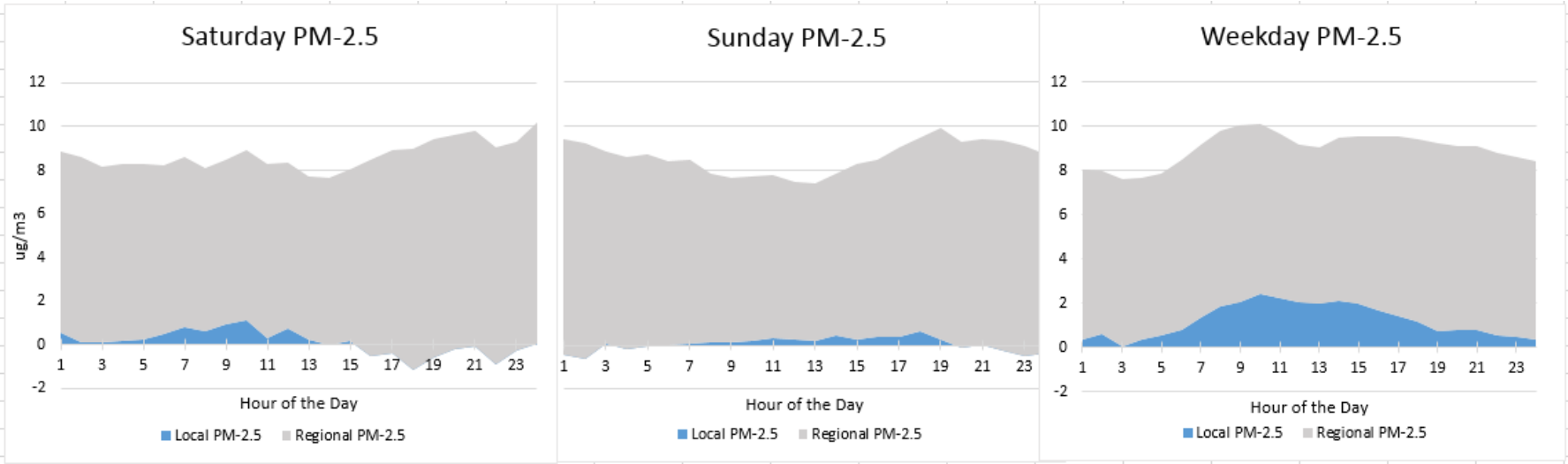
- Lower on weekends
- Relatively consistent throughout seasons
- Weekdays – peak period is 8 am – 6 pm

Results: $PM_{2.5}$

Both study sites (8.85 and 8.05 µg/m^3) are well below the Annual NAAQS for $PM_{2.5}$ (12 µg/m^3)

PM-2.5	Busti Ave µg/m3	PS198 µg/m3	Relative % Difference
All Data: 25th percentile	5.3	4.5	20%
All Data: Average	8.85	8.05	13.6%
All Data: 75th percentile	11.40	10.60	10.9%
Fall Average	8.58	8.47	5.6%
Winter Average	10.39	9.29	11.2%
Spring Average	8.17	6.64	24.1%
Summer Average	8.45	7.69	17.1%

Results: $PM_{2.5}$



- Local is Busti $PM_{2.5}$ minus PS198 $PM_{2.5}$
- Regional is PS198

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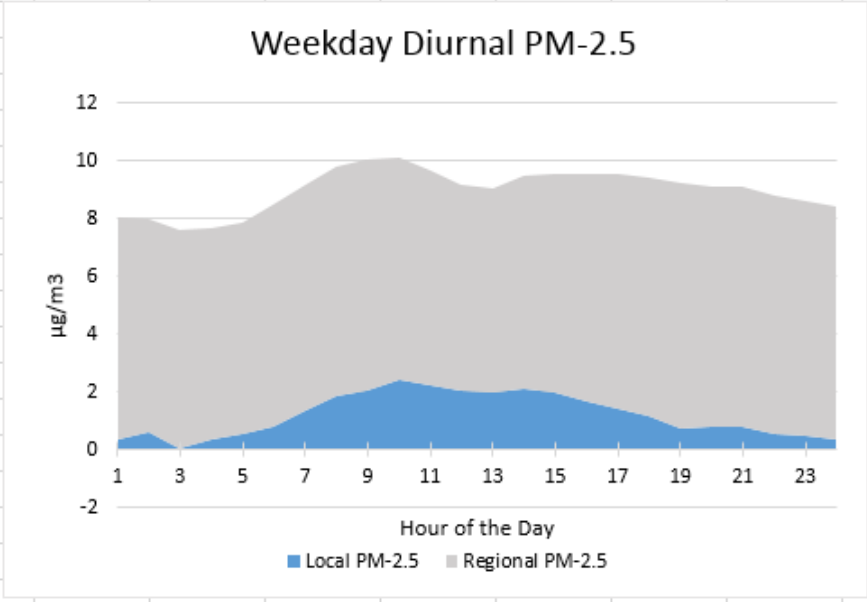
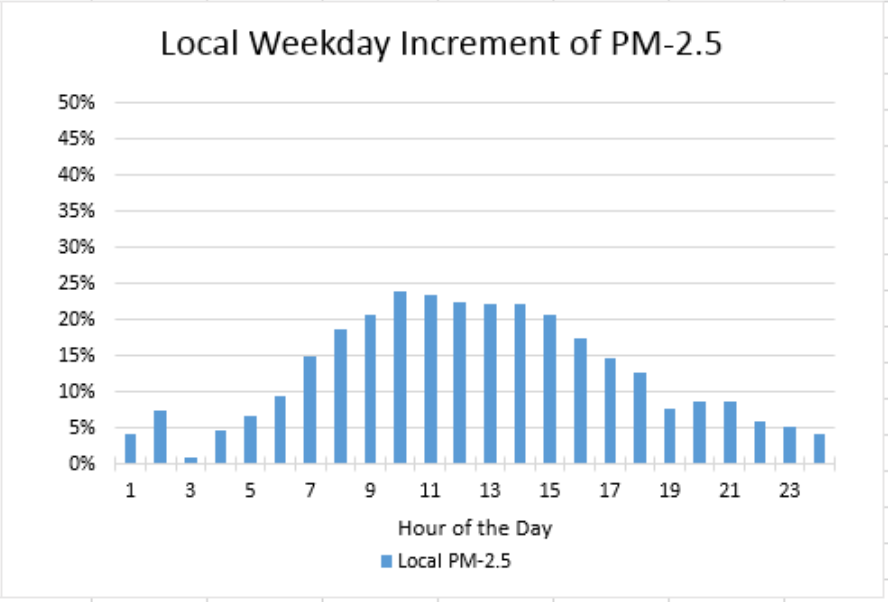
Results: $PM_{2.5}$





Weekdays: contribution of local source $PM_{2.5}$ is 1% to 24% of the total $PM_{2.5}$

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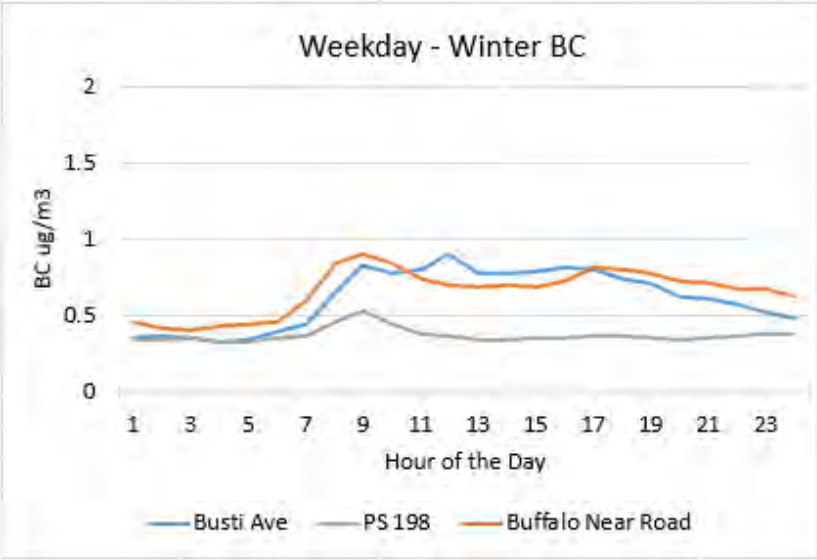
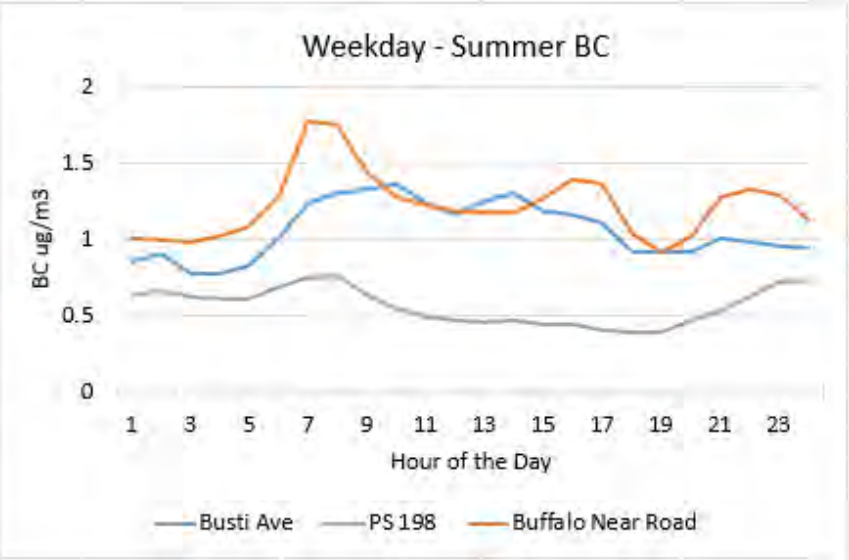
Results: Black Carbon

BC has a stronger gradient and is a good indicator of mobile source emissions

Black Carbon	Busti Ave µg/m3	PS198 µg/m3	Relative % Difference
All Data: 25th percentile	0.37	0.24	51.9%
All Data: Average	0.79	0.49	52.0%
All Data: 75th percentile	1.06	0.63	57.9%
Fall Average	0.71	0.55	32.4%
Winter Average	0.58	0.37	54.3%
Spring Average	0.90	0.43	70.8%
Summer Average	0.94	0.59	47.2%

Results: Black Carbon





- All sites are effected by daily pattern of vehicle emissions
- BC is higher in the summer than winter
- Near-road site has stronger traffic influence

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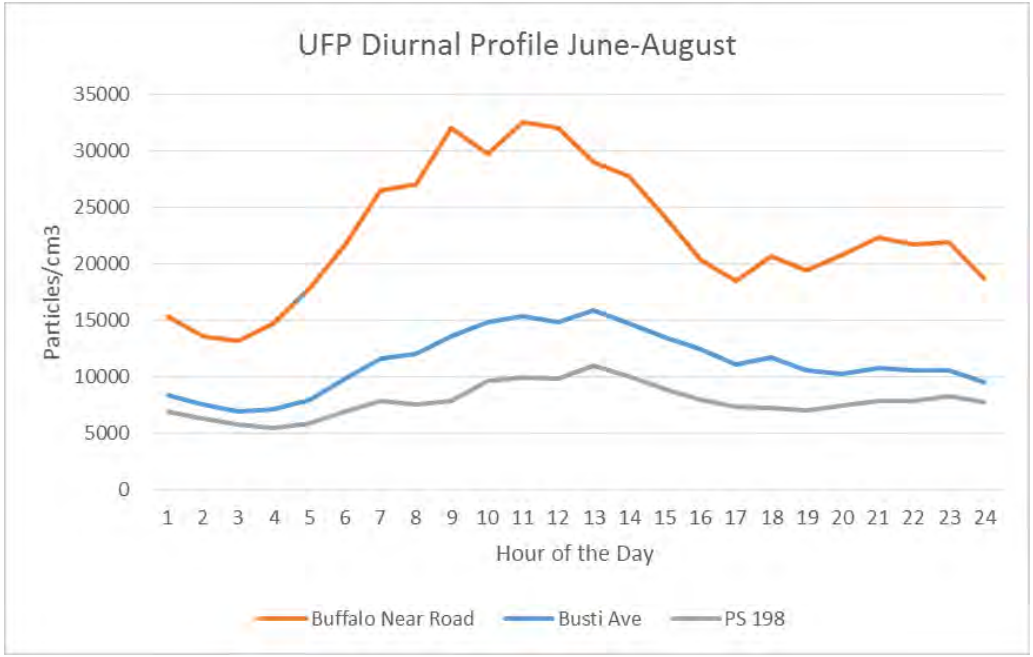
Results: Ultrafine Particles

- UFP is much higher in the winter
- UFP has a strong gradient and is a good indicator of mobile source emissions

Ultrafine Particle Number	Busti Ave #/cm3	PS198 #/cm3	Relative % Difference
All Data: 25th percentile	7,788	4,234	53.6%
All Data: Average	11,844	7,666	42.8%
All Data: 75th percentile	19,469	9,600	41.8%
Fall Average	10,702	7,473	39.6%
Winter Average	23,636	NA	NA
Spring Average	19,549	NA	NA
Summer Average	12,232	7,736	43.9%

Results: UFP Summer Site Comparison



The time of day plot shows that UFP is considerably higher at the Near Road site than at Busti Avenue and PS 198

The Near Road site is much closer to vehicle emissions than Busti Ave

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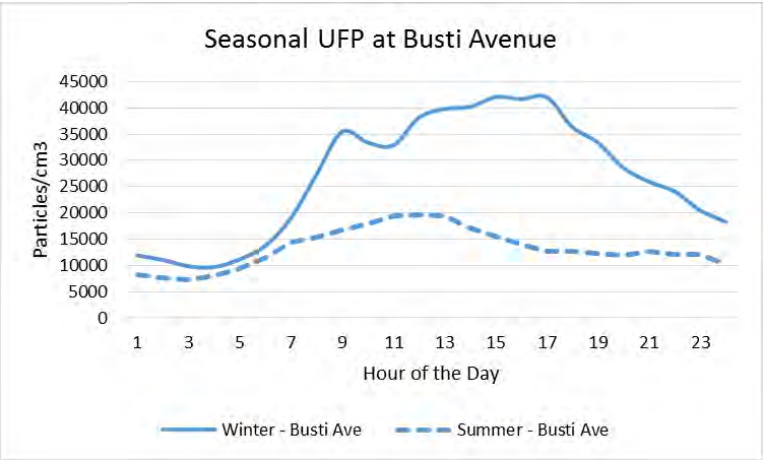

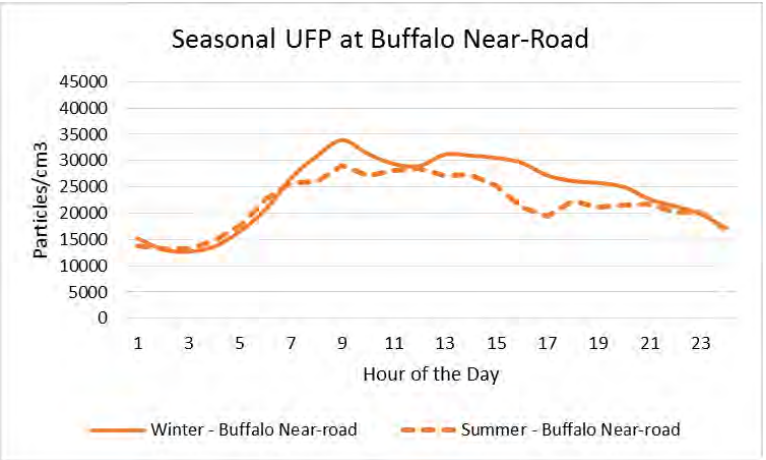

Results: Seasonal UFP

- Trucks are large contributor to UFP and daily volumes are relatively consistent throughout the year
- UFP in the summer at Busti Ave is about ½ of winter values
- UFP at Buffalo near-road in the summer is similar to winter
- UFP does not decrease significantly in 20 yards but it does in 40 yards to 200 yards

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Results: UFP from the 2006 HEI/Harvard study

Table 23. Ten-Minute Average UFP Counts at Fixed Sampling Sites by Season[a]

	Summer 2005			Winter 2006		
Site	*N*	Mean	SD	*N*	Mean	SD
GLC	1067	6,232	4060	1682	12,033	13,241
Chapel	1067	14,528	8222	1618	20,922	18,195
School	1203	6,512	3705	1673	13,031	7,585

[a] Values are particles/cm^3.

DEC Study 2015		**DEC Study 2014-15**	
Summer Average		Winter Average	
Busti Ave	12,232	Busti Ave	23,636
PS 198	7,736	PS 198	Not Installed

- Due to UFP instrument's lower particle size cut we would expect to find UFP 25-50% higher in the DEC study
- UFP in the DEC study were about 12% higher in the winter and lower in the summer. This is not conclusive but suggests that UFP have decreased

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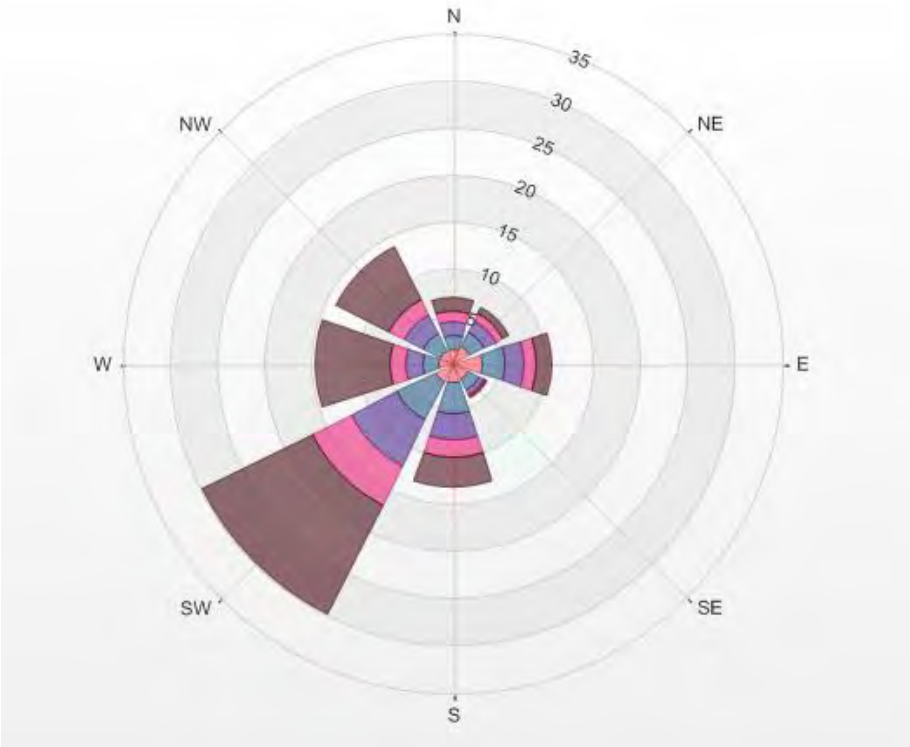
Results: Meteorology

- This plot shows the frequency of wind direction (blowing from) for the Busti Ave site
- The predominant wind direction (30%) is from the southwest
- Wind direction is fairly consistent year round



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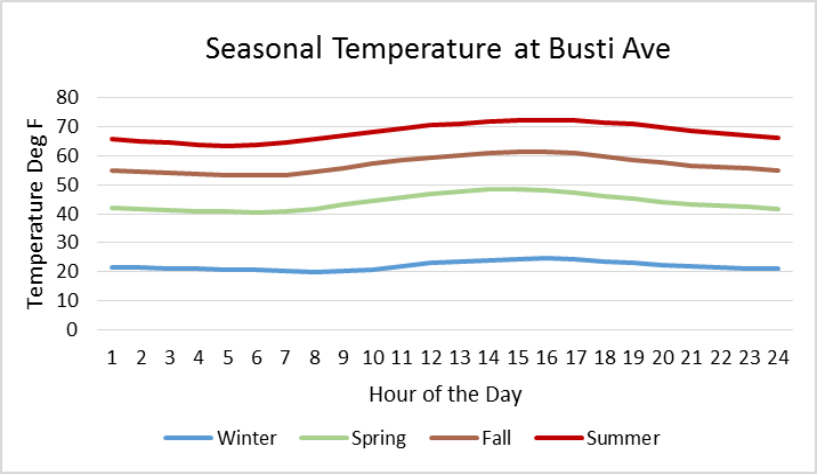
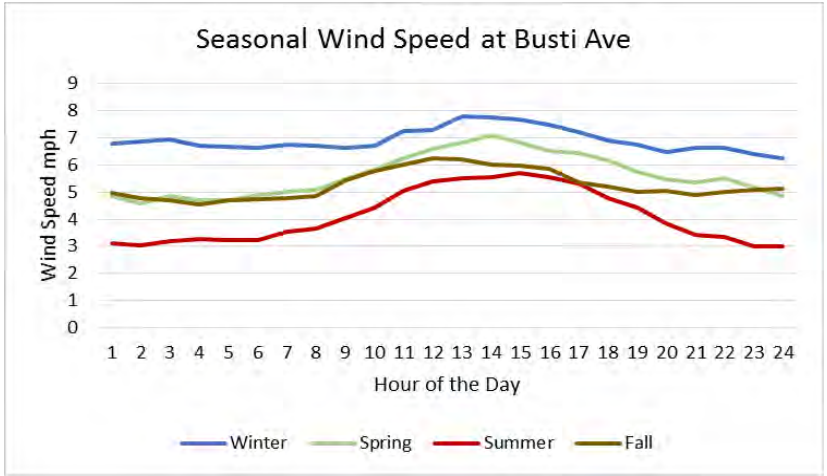
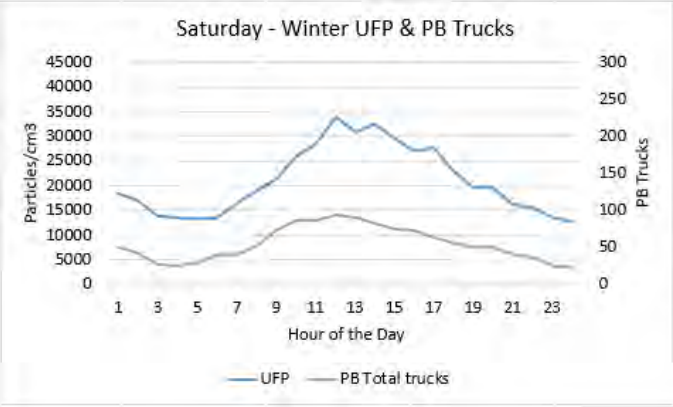
Results: Temperature and Wind Speed by Season

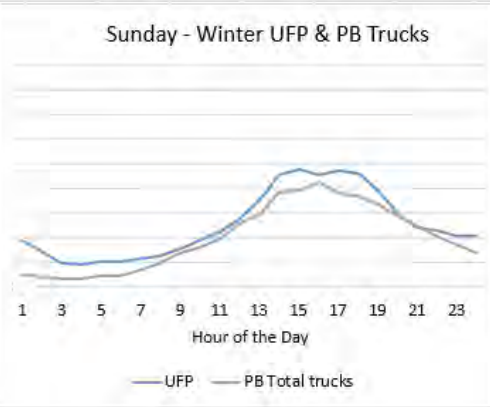


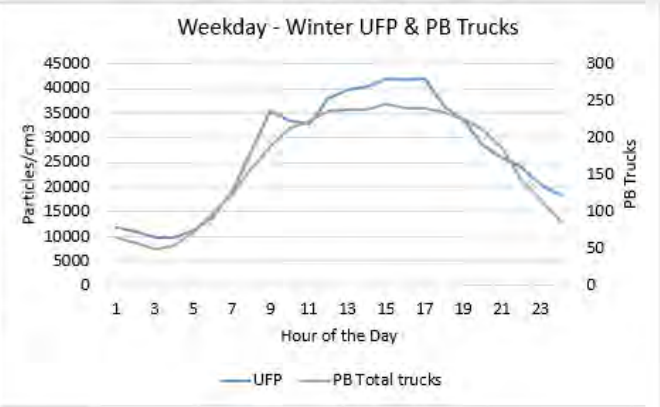


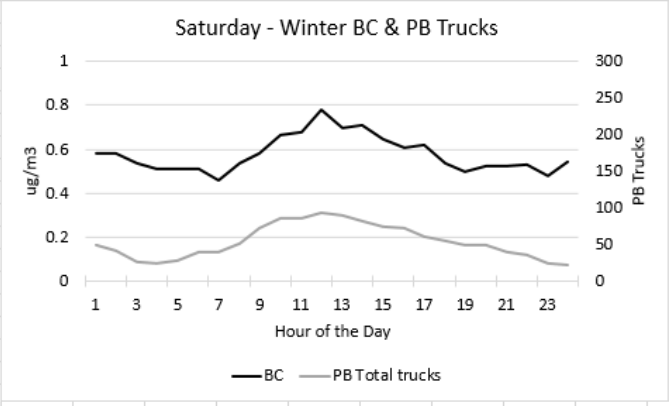
- Higher temperatures and humidity allow some UFP to become gases and some UFP to become larger particles
- High wind speed disperses BC and UFP more quickly

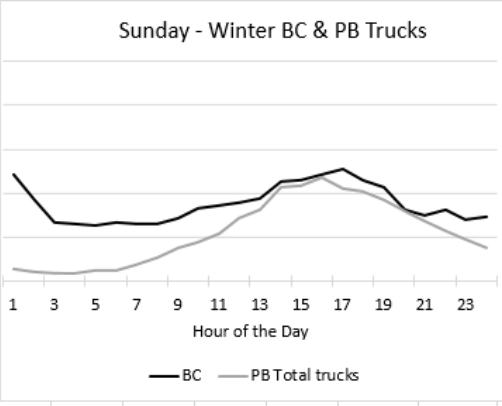
Results: Mobile Source Indicators and Truck Traffic

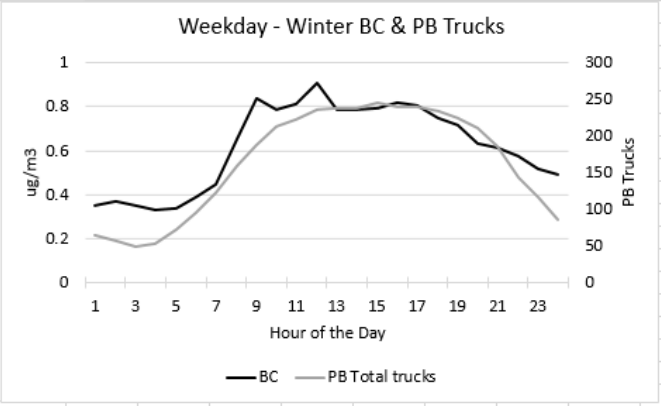




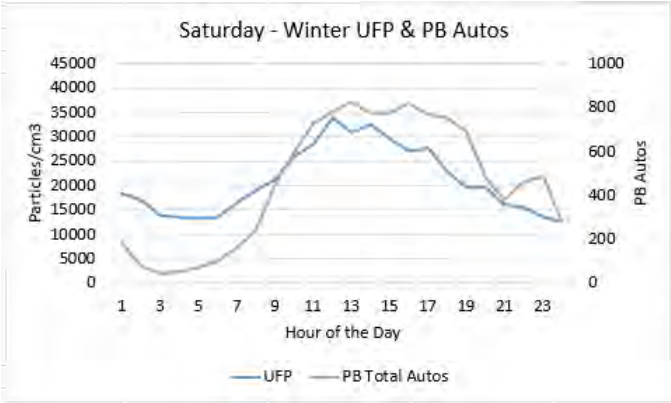


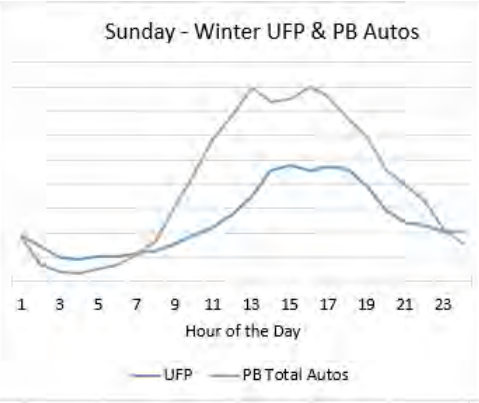


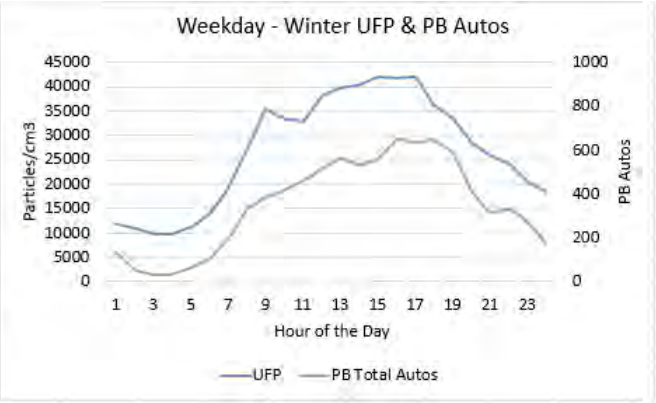


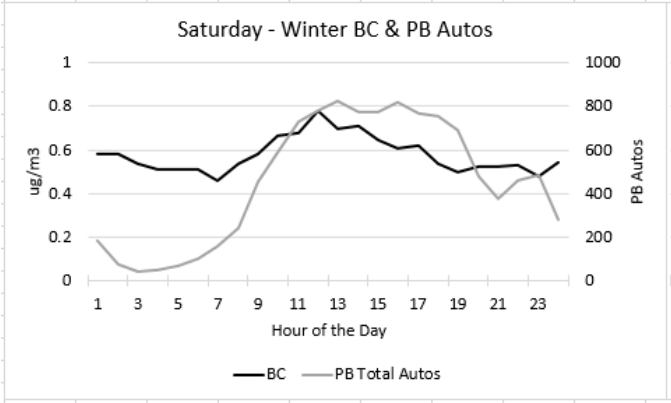


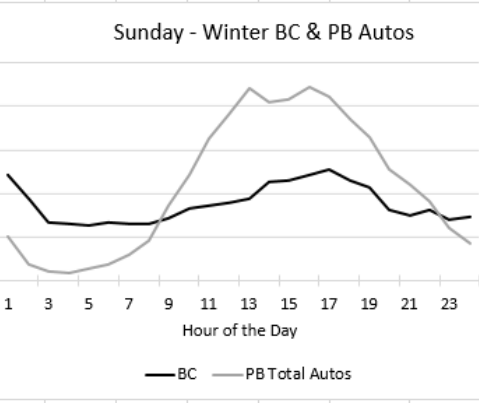
Results: Mobile Source Indicators and Auto Traffic

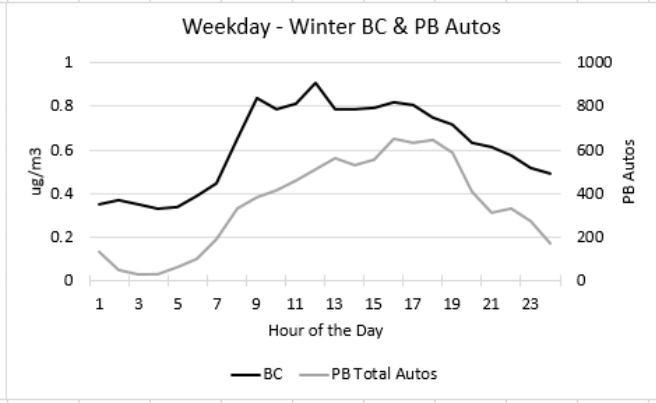












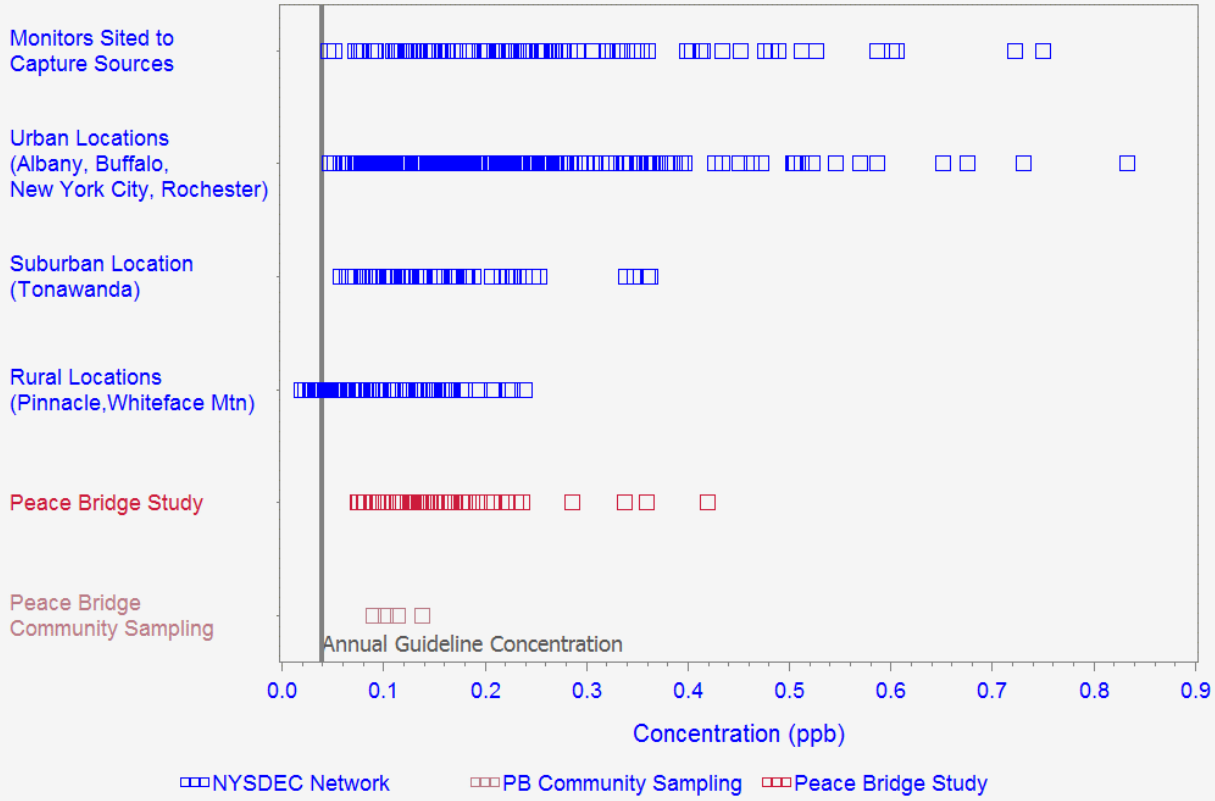
Results: VOCs & Carbonyls

- Air samples analyzed for the presence of 43 VOCs and 11 carbonyls
- 12-month average compared to DEC's Annual Guideline Concentrations (AGCs)
- Four vehicle-related VOCs and carbonyls
  - Were found above AGC
  - Below DEC's target risk level
  - Similar to concentrations found in other cities in the State

Results: Community Samples VOCs

- Community collected samples at times and in locations where concentrations were expected to be elevated
- Four air samples collected on two different dates
  - May 24 and September 15, 2015
  - Both mid-afternoon
- 1-hour concentrations compared to DEC's Short-term Guideline Concentrations (SGCs)
- All results below SGCs and similar to 24-hour results obtained in this Study

Benzene



- Benzene primarily from mobile sources
- Concentrations in PB neighborhood are similar to urban and suburban areas of the State

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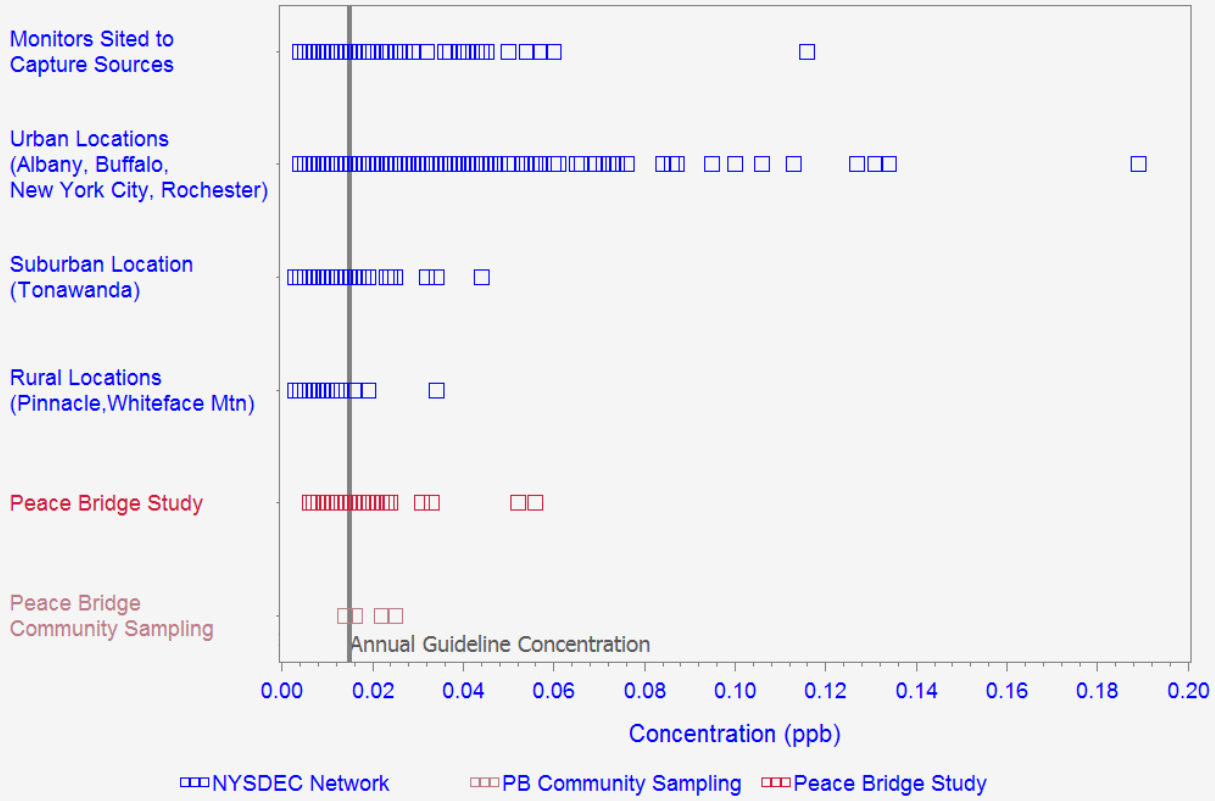
1,3-Butadiene



- 1,3-Butadiene primarily from mobile sources
- Concentrations in PB neighborhood are similar to suburban areas of the State

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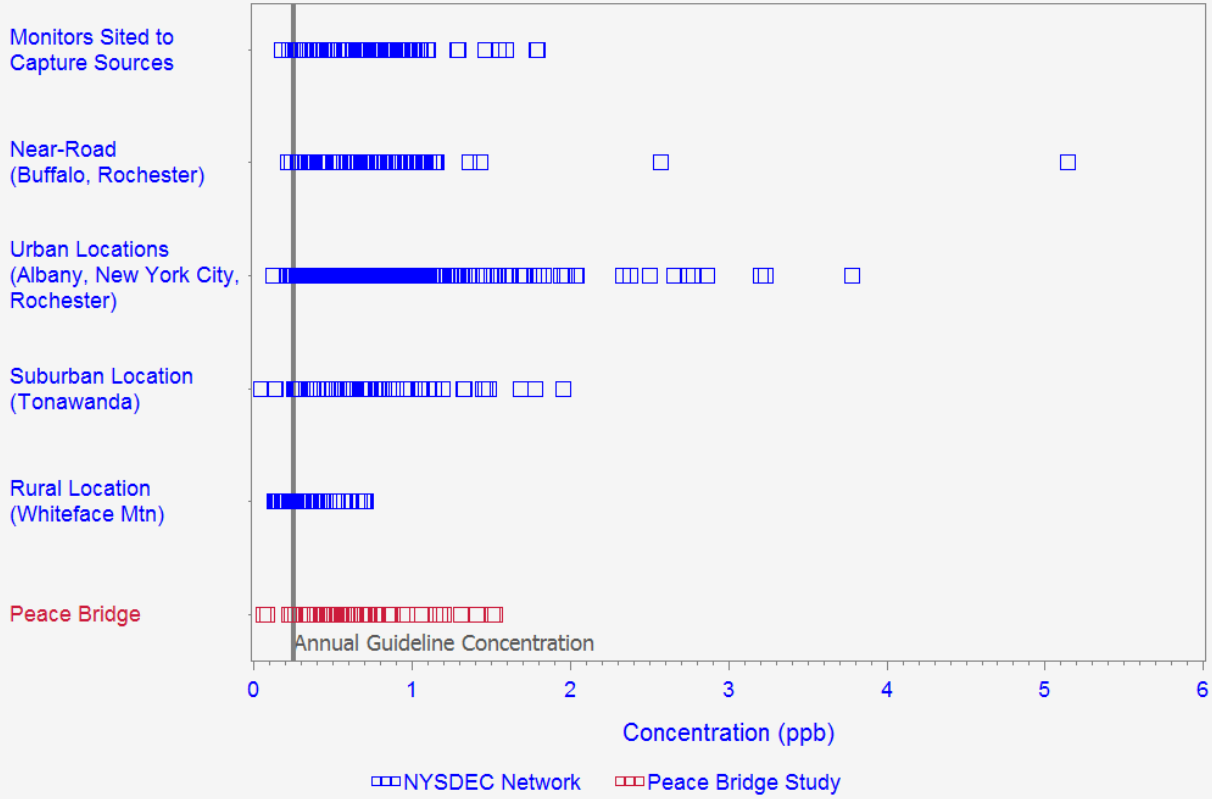
Acetaldehyde



- Concentrations are similar to other areas of the State

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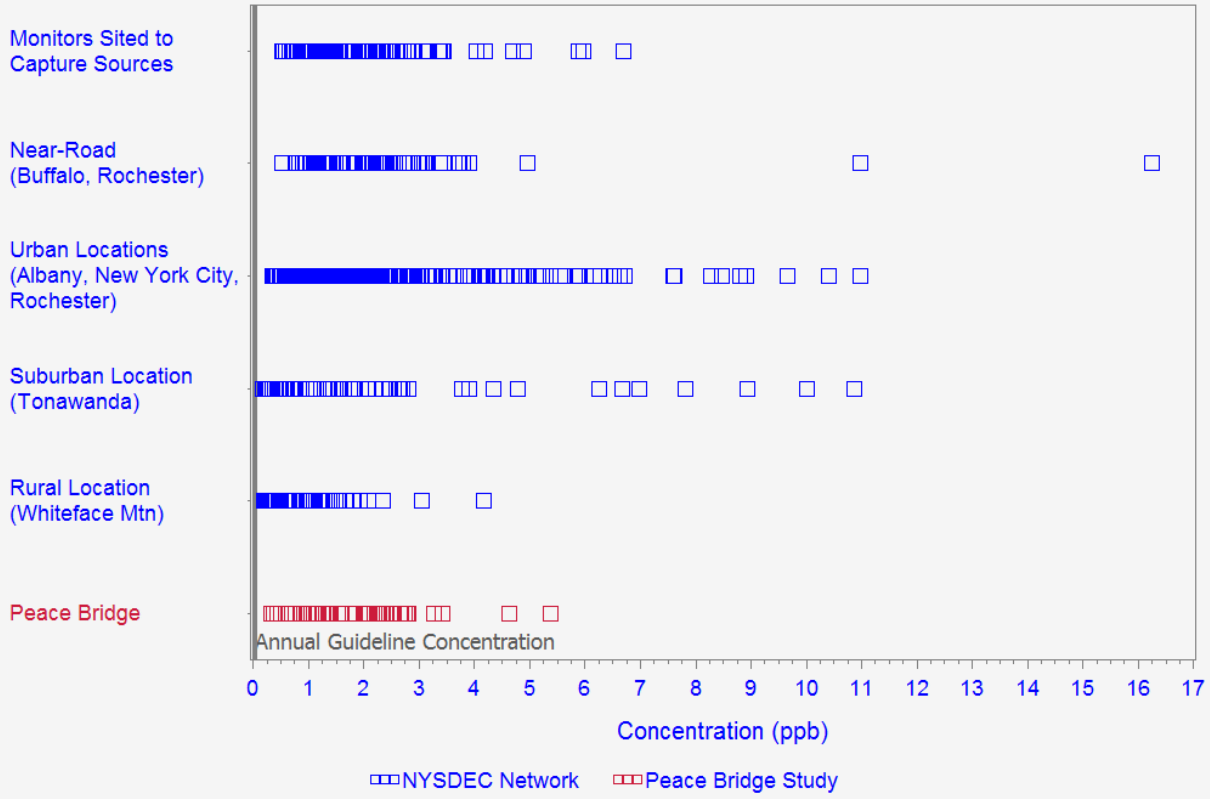
Formaldehyde



- Concentrations are similar to other areas of the State

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Conclusions: Mobile Source Emissions UFP & BC

The study has improved our understanding of the behavior of mobile source indicator pollutants

- BC at Busti Avenue is similar to the Near-road site and is higher than PS198
  - BC is emitted and it's concentration decreases due to dispersion
- UFP is higher at the Near Road Site because the monitor is much closer to roadway
  - UFP are emitted and quickly undergo dispersion and transformations

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Conclusions: Mobile Source Emissions Air Toxics

- Vehicle related VOCs and carbonyls found at levels similar to other similar sized cities in the State
- All concentrations found were below DEC's target risk level

Future UFP Monitoring and Data

- The Buffalo Near Road site as expected has higher UFP and will successfully represent the worst case near-road emissions for the Buffalo-Niagara region
- The EPA near-road monitoring stations are expected to be a component of the revised PM NAAQS
- The study data are available for EPA and other researchers for use in health assessments

Thank You

- Dirk Felton
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