



# Butte PM<sub>2.5</sub> Spatial Comparison Study



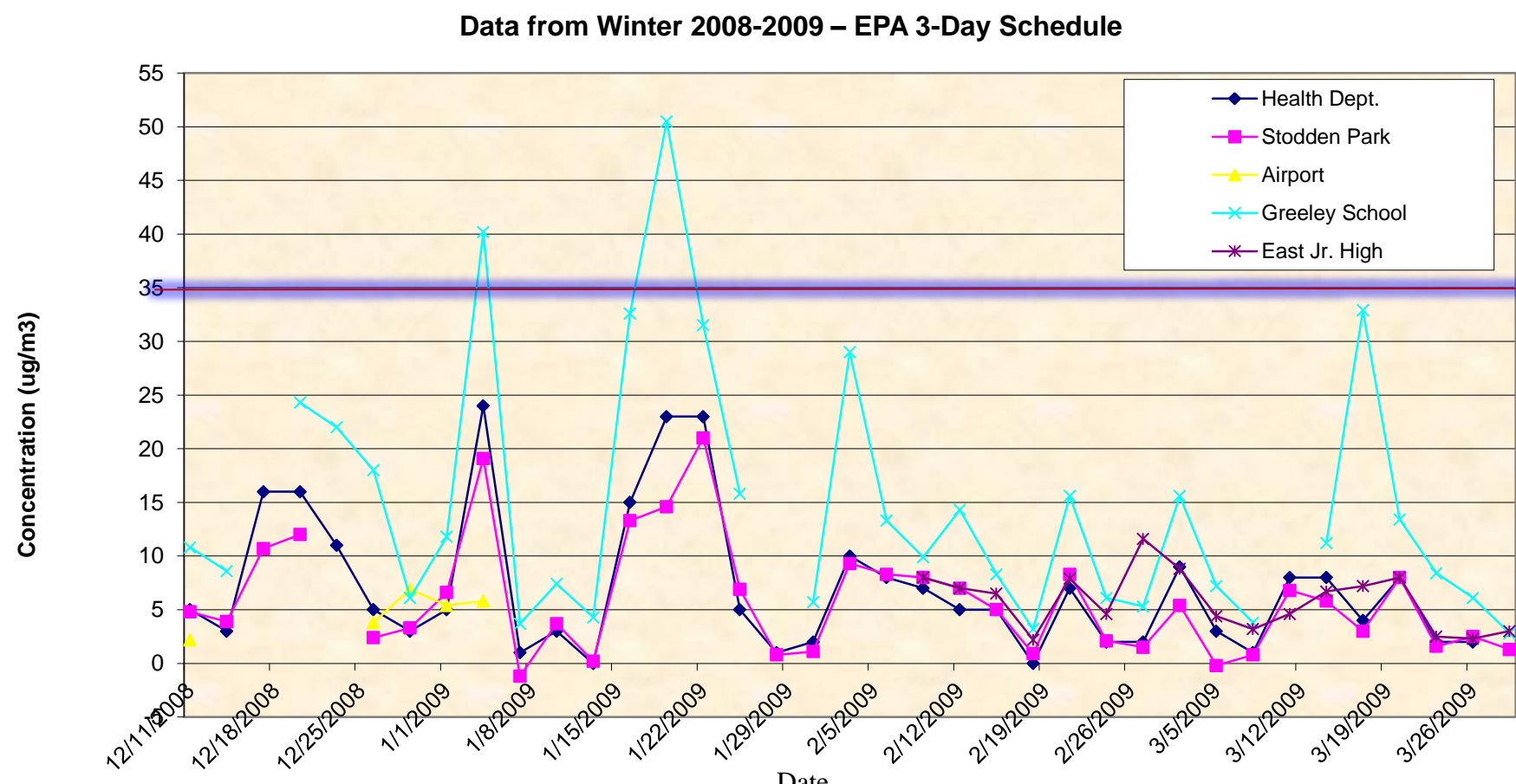
## DEQ Air Monitoring Section

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**Abstract:** The purpose of this study was to determine the degree to which PM<sub>2.5</sub> concentrations varied across the community of Butte, Montana. During the winters of 2012-2013 and 2013-2014, the Montana Department of Environmental Quality (Department), Air Monitoring Section (AMS) collected PM<sub>2.5</sub> data along with meteorological data utilizing portable, continuously operating PM<sub>2.5</sub> monitors at select, representative locations around the community. The PM<sub>2.5</sub> and meteorological data were compared to that produced by the permanent State and Local Air Monitoring Station (SLAMS) site located in the Butte Greeley School yard. The comparison of data indicated PM<sub>2.5</sub> concentrations exceeding the National Ambient Air Quality Standard (NAAQS) were only measured at Greeley School and at one other monitoring location approximately 600 yards south of the Greeley School site. PM<sub>2.5</sub> concentrations measured at other areas remained below the PM<sub>2.5</sub> NAAQS.

## Motivation

Over the years additional short term air monitoring for PM<sub>2.5</sub> has been conducted at various other locations around the city of Butte to determine whether the Greeley School site was indeed the area of highest concentration for PM<sub>2.5</sub>. Not only did the additional short term air monitoring indicate the Greeley School site was in the area of highest concentration, it also showed that in every other area where monitoring was conducted, away from Greeley School, there were significantly lower concentrations of PM<sub>2.5</sub>. The graph below displaying data from the winter of 2008-2009 illustrates this variation.



With these varying results as well as incomplete data sets for comparison, along with the very real possibility that Butte may become a nonattainment area for PM<sub>2.5</sub> because of the monitored exceedances (24-hr average greater than 35 µg/m<sup>3</sup>), the AMS proposed to do additional winter time monitoring in Butte to better understand the scope of the PM<sub>2.5</sub> problem being detected at Greeley School.

The collection of data concurrently at multiple locations around the Butte proper was determined to be beneficial for the Department as well as the Butte-Silver Bow Health Department in the following ways:

- Determine the spatial distribution of PM<sub>2.5</sub> concentrations; that is, determine if there is one localized area of elevated PM<sub>2.5</sub> or if the high PM<sub>2.5</sub> levels measured at Greeley School are representative of the Butte valley during the winter months.
- Identify patterns of air movement within the Butte area which could help determine where the PM<sub>2.5</sub> sources are in relation to the Greeley School site.
- Help develop a wood stove change-out plan if the data indicates the problem is localized.
- Collect data to help the local health department determine where resources should be directed as well as provide data for public education and outreach activities.
- Determine for communication with EPA whether Greeley School is representative of a "Microscale" spatial scale rather than a "Neighborhood" spatial scale as it is currently identified. Such a determination may allow additional time to correct a small scale problem before labeling the whole area as nonattainment.



## PM<sub>2.5</sub> Sources

Available data indicate that the major source of PM<sub>2.5</sub> in the Greeley School area is from wood smoke produced by residential wood burning appliances. This has been supported by a PM<sub>2.5</sub> Source Apportionment Research Study conducted by The University of Montana, Center for Environmental Health Sciences (UM-CEHS) during the winter of 2007-2008, another during the winter of 2012-2013.

## Equipment



To determine how the PM<sub>2.5</sub> concentrations compared across the Butte valley the AMS utilized MetOne, E-BAM®, portable beta-attenuation particulate monitors to measure PM<sub>2.5</sub> concentrations at select temporary locations in the Butte valley. Seven (7) E-BAMs were used during the 2012-2013 winter and ten (10) E-BAMs were used during the 2013-2014 winter. The additional E-BAMs were purchased in the spring of 2013 and were therefore not available the previous winter. During the 2012-2013 winter four (4) E-BAMs were equipped with MetOne wind speed and direction sensors, while two (2) of the sites utilized La Crosse Technology wireless weather stations. For the first winter, the Airport monitoring site did not have any wind speed or direction sensors, so the Airport met data was used, as reported by the National Weather Service. During the 2013-2014 winter all ten (10) E-BAMs were equipped with MetOne wind speed and direction sensors.

\*The E-BAMs can not be used for regulatory purposes. However, co-location studies by the Department has found data comparable to Federal Equivalent and Federal Reference Methods for PM<sub>2.5</sub>.

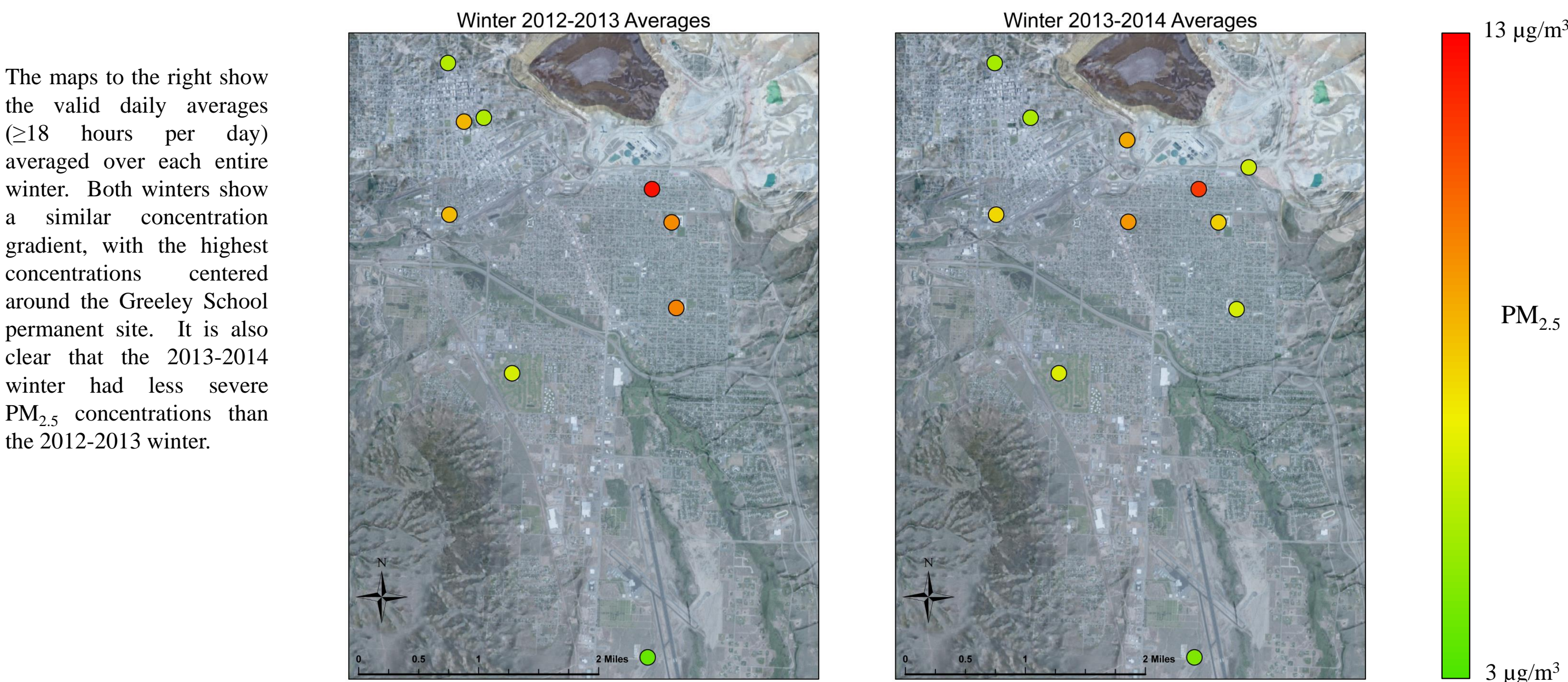
## Site Selection

Selection of the temporary monitoring sites was based first and foremost on locating particulate monitors as close as possible to where temporary monitoring had been conducted in previous years. This was felt to be important to verify if the variation in PM<sub>2.5</sub> concentrations measured during previous winters between those sites and Greeley School could still be measured and if they continued to be lower than Greeley School. Additional sites were then selected to provide additional PM<sub>2.5</sub> data in other residential areas away from Greeley School. The data gathered from all of the sites would also be used to determine if wood stove usage in those areas contributed to the PM<sub>2.5</sub> concentrations measured at Greeley School, or if perhaps there were other "pockets" of elevated PM<sub>2.5</sub> concentrations. Two of the additional temporary sites selected during the 2013-2014 were selected to help determine what, if any, contribution the Montana Resources Inc. open pit mine and associated crushers and concentrator facility contribute to the PM<sub>2.5</sub> concentrations at the Greeley School site. The third additional temporary site for the 2013-2014 winter was selected to gather more data from the residential area to the southwest of Greeley School where, due to a lack of particulate monitors the previous winter, we were unable to monitor. A monitor in this area seemed important after seeing the concentrations measured at another site approximately 0.3 miles to the south-southeast of Greeley School that saw exceedances of the 24-hr PM<sub>2.5</sub> NAAQS during the 2012-2013 winter.

During the 2012-2013 portion of the study one site was relocated. The temporary site located at the High School was found to be very close to a building with two wood stoves and therefore may not have been representative of the neighborhood. During the 2013-2014 portion, two sites were relocated. The temporary site at the Original Mine was moved due to security reasons and the Whittier site was moved to accommodate a property owner's wishes.



## Data



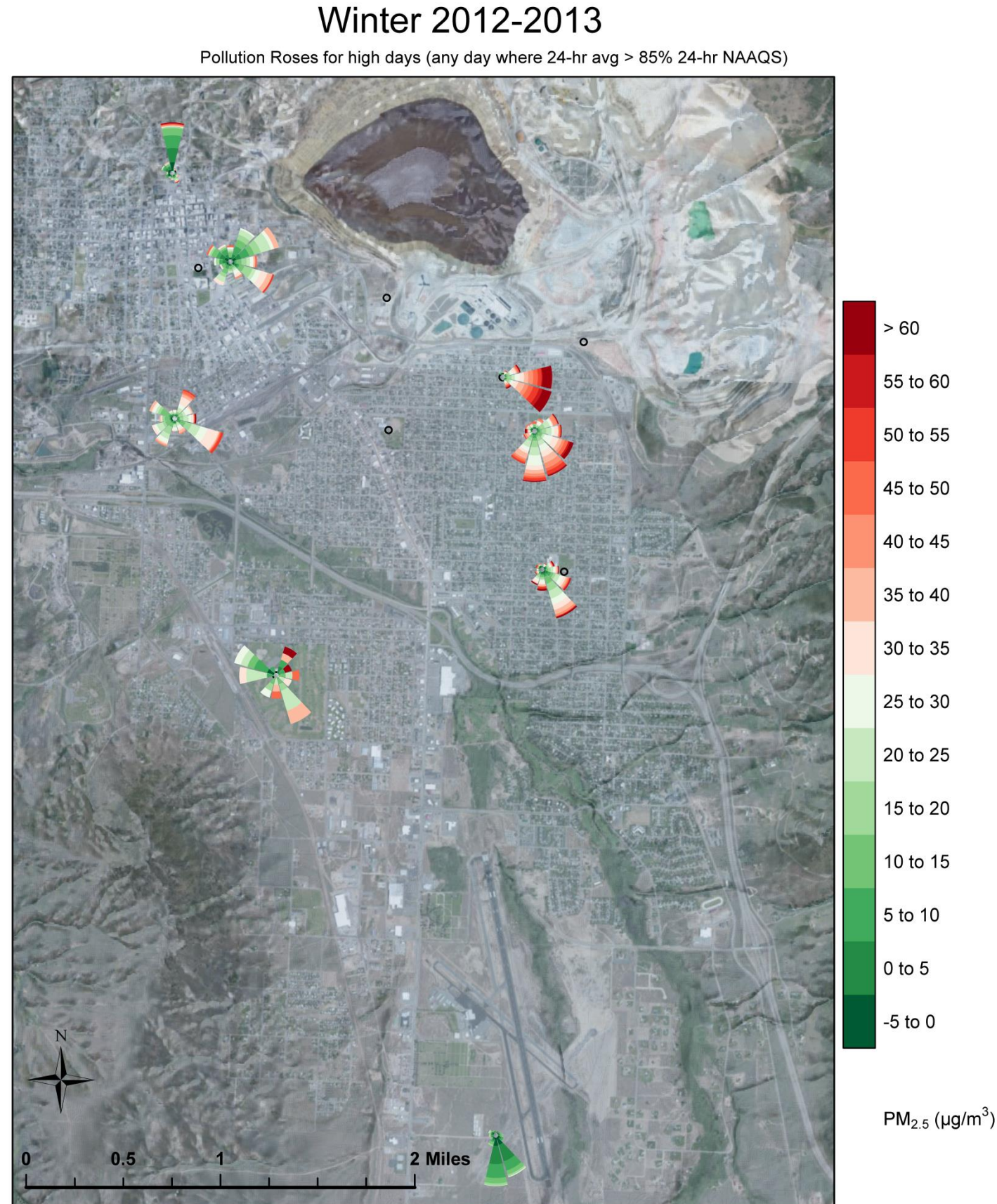
## High Days

Because the Greeley School SLAMS site is at risk of breaking the 24-hr PM<sub>2.5</sub> NAAQS of 35 µg/m<sup>3</sup>, 19 days were identified over both winters in which any site's 24-hr PM<sub>2.5</sub> concentration exceeded 85% of the NAAQS (or 29.75 µg/m<sup>3</sup>). This was done to better understand the distribution of PM<sub>2.5</sub> concentrations throughout town on days with elevated concentrations at or near the 24-hr NAAQS. The tables below show the 24-hr concentrations on those 19 days, where the red text indicates NAAQS exceedances, and orange text indicates concentrations exceeding 85% of the NAAQS, and green text are lower concentrations. Any blanks arise from invalid data or the site not in operation. For example, 2/6/14 was a particularly cold day and none of the E-BAMs were able to get their pumps running again at midnight when the filter tape was scheduled to shuffle ahead.

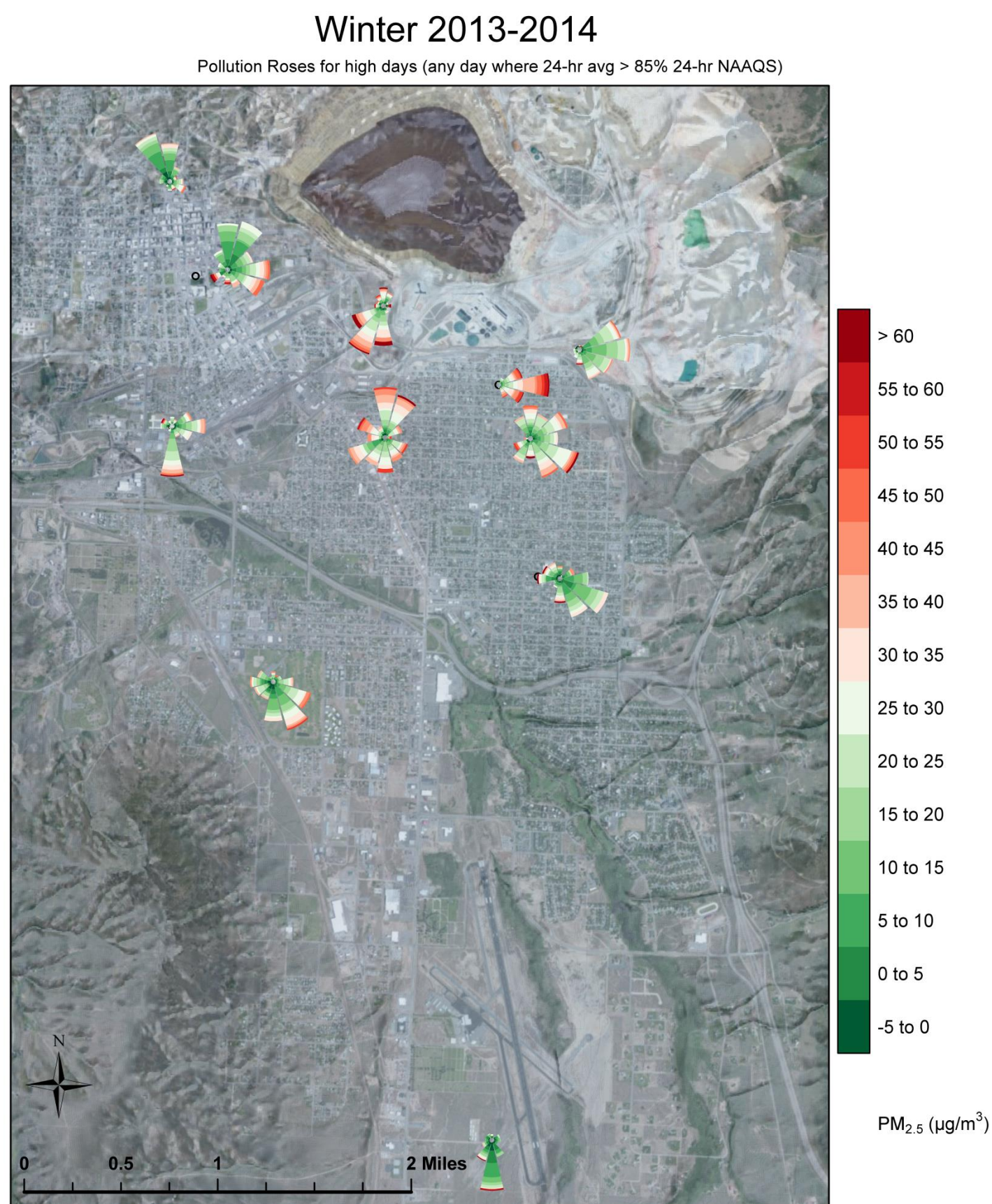
	10/08/2012*	11/28/2012	01/03/2013	01/04/2013	01/05/2013	01/16/2013	01/17/2013	01/19/2013	01/20/2013	01/21/2013	01/22/2013	01/23/2013
Greeley School	30.6	30.0	30.6	39.6	32.2	33.8	49.2	47.2	49.6	54.1	58.3	33.1
East Junior High	26.8	21.0	20.3	27.5	27.6	24.2	37.8	33.9	32.1	39.4	38.7	25.5
Whittier Elementary		20.3	17.2	27.0	22.4	19.9	29.1	30.6	24.0	25.6	29.3	23.0
Health Department	27.2	21.0	21.8	23.5	20.7	25.3	29.0	23.0	22.5	22.5	28.5	24.6
Stodden Park	26.0		14.7	19.4	15.5	15.3	21.5	17.3	15.0	15.6	22.5	18.6
Housing Authority				18.5	14.5	13.8	22.5	14.0	13.6	13.2	18.0	18.4
Original Mine	32.3	10.7				3.8	14.6	3.5	5.8	6.2	13.5	8.5
Airport		7.2	4.1	6.3	5.4	5.7	5.8	7.2	5.3	7.2	6.0	8.8
High School	28.7	27.4										
*This date was affected by late season wildfires, which is evident from the uniform concentration distribution.												
						11/26/2013	11/28/2013	11/29/2013	01/07/2014	02/06/2014	02/26/2014	02/27/2014
Greeley School						34.9	34.9	29.8	34.7	30.9	32.5	31.6
East Junior High						18.8	18.8	18.6	28.8		22.8	23.8
MR West						20.0	20.9	23.1	29.3		31.8	34.9
Clark Park						26.4	26.5	27.9	26.2		34.2	28.2
Whittier Elementary						11.4	10.0	12.7	20.7		15.5	17.0
Health Department						17.4	18.0	18.9	26.0		21.5	24.9
MR East							19.3	12.2	23.5		18.5	20.1
Stodden Park						15.8	13.1	14.1	20.8		18.2	16.6
Housing Authority						9.2	11.3	9.6	23.9		19.5	25.5
Original Mine						8.0	11.5	7.0	11.5		13.8	18.4
Airport						3.8	4.9	3.8	10.4		7.4	12.3



## Results



The maps displayed here show pollution roses over top of the site locations, representing the high days identified earlier. Each petal represents which direction the wind was coming from, with the length of each petal proportional to the relative number of hours the wind originated from that sector. The colors differentiate the relative frequency of the hourly PM<sub>2.5</sub> concentrations from that sector. These maps were made to help visualize the air and PM<sub>2.5</sub> movement throughout Butte on days that the PM<sub>2.5</sub> concentrations approach or exceeded the 24-hr NAAQS. Both maps suggest that the elevated PM<sub>2.5</sub> concentrations are in the vicinity of the neighborhood surrounding Greeley School (likely to the east and south).



During the two winters of this study only two sites measured exceedances of the PM<sub>2.5</sub> 24-hr NAAQS, Greeley School and East Jr. High School. The PM<sub>2.5</sub> sampling data collected during the winter months of 2012-2013 at the seven temporary sites and Greeley School showed that the highest 24-hr concentrations of PM<sub>2.5</sub> were measured at the Greeley School site with the East Jr. High School site measuring the next highest 24-hr concentrations. During the 2013-2014 winter months the data showed that the MR West site had the single highest 24-hr PM<sub>2.5</sub> concentration, however it did not exceed the 24-hr PM<sub>2.5</sub> NAAQS. In fact, no exceedances of the PM<sub>2.5</sub> 24-hr NAAQS were measured during the 2013-2014 winter at any of the monitoring sites, including Greeley School. Overall during the 2013-2014 winter monitoring data showed that, on average, the highest concentrations of PM<sub>2.5</sub> were measured at the Butte Greeley School Air Monitoring Site with the Clark Park site having the next highest average 24-hr PM<sub>2.5</sub> concentrations.

## Conclusion

Concurrent air monitoring for PM<sub>2.5</sub> at various locations around the Butte valley indicated that elevated PM<sub>2.5</sub> concentrations approaching or in some cases exceeding the PM<sub>2.5</sub> 24-hr NAAQS did not extend across the Butte valley but were only found in a relatively small area of the valley near the Butte Greeley School SLAMS site. Variation in weather patterns as well as use of wood burning appliances lead to a great amount of variation in PM<sub>2.5</sub> concentrations. Wind data at Greeley School suggested that light winds (<5mph) coming from between ENE and SSE led to higher concentrations at the Greeley School site. Monitoring at Clark Park indicated that PM<sub>2.5</sub> concentrations there are elevated at times however wind data at Greeley School indicated that air movement from the Clark Park area towards Greeley School did not appreciably increase PM<sub>2.5</sub> concentrations at Greeley School. With the exception of the areas around Greeley School, East Jr. High, and Clark Park, PM<sub>2.5</sub> data from the other temporary monitoring sites in this study indicated that airborne concentrations of fine particulate were well below the PM<sub>2.5</sub> 24-hr NAAQS. Wind data showed that when air movement was from the direction of the mine PM<sub>2.5</sub> concentrations trended lower, indicating little or no contribution of PM<sub>2.5</sub> from the mine and its associated activities.

These findings showed that efforts to lower fine particulate concentrations and improve winter time air quality in Butte should be concentrated in the city blocks immediately to the east and south of Greeley School. It also appeared that additional monitoring in the East Jr. High and Clark Park areas may be warranted to determine if corrective efforts are improving air quality throughout the affected neighborhoods.

## Acknowledgements

We would like to especially thank Paul Riley with the Butte-Silver Bow Health Department for his help in coordinating and obtaining permission to locate samplers at the temporary monitoring sites. We would also like to thank the Butte School District and the Butte Housing Authority for allowing us to locate samplers on their properties for two winters as well as Montana Resources Inc. for allowing us to locate monitors on their property during the second year of this study.