Peace Project Water Use Plan

Williston Dust Control Monitoring

Implementation Year 6

Reference: GMSMON-18

BC Hydro Williston Reservoir Air Monitoring 2013 Annual Report

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BC HYDRO WILLISTON RESERVOIR REGIONAL AIR MONITORING 2013 ANNUAL REPORT

EXECUTIVE SUMMARY

Monitoring of regional particulate matter (PM) levels was carried out between 2011 and 2013 at multiple locations around the Williston Reservoir and to the north of the reservoir in the village of Ft. Ware. At Tsay Keh and Ft. Ware hourly mean levels of PM_{10} (particles ≤10 µm aerodynamic diameter) and $PM_{2.5}$ (particles ≤2.5 µm aerodynamic diameter) were measured using continuous samplers (TEOM 1405D), with the expectation of sampling for 365 days in a calendar year. At nine other locations designated by their associated beach names or other geographic moniker (Chowika, Davis South, Ingenika, Lafferty, Pete Toy, Rat Lake, Stromquist, Tsay Keh [village], and Van Somer) 24-hour mean levels of PM_{10} and $PM_{2.5}$ were measured using BGI PQ2000 filter-based samplers. These samplers ran for 24 hours on one-in-three day and one in-six day sampling schedules at different periods of the year with the expectation being that they were to measure PM between the period when the beaches became free of snow cover in the spring to the beginning of snow accumulation in the fall. One-in-three day sampling was carried out during the spring months (May through June) when there is the greatest potential for high winds and dust emission events. Following the end of June, to conserve resources, the sampling period was changed to one-in-six days. In addition to the PM measured at each of these locations, hourly mean meteorological data (i.e., wind speed, wind direction, temperature, relative humidity, and precipitation) were also acquired.

For 2013, the last year of operation by Nickling Environmental, both PM_{10} and $PM_{2.5}$ 24 hour mean concentrations were relatively low. $PM_{2.5}$ values ranged from near zero to a maximum of 17.9 and 34.9 µg m^{-3} at Tsay Keh and Fort Ware, respectively. PM_{10} values ranged from near zero to 39.3 µg m^{-3} at Tsay Keh and 1.7 µg m^{-3} to 59.5 µg m^{-3} at Fort Ware. At both sites, based on available data, the annual averages in 2013 for both $PM_{2.5}$ and PM_{10} were below 10 µg m^{-3}. There were no exceedances of either the $PM_{2.5}$ or PM_{10} 24-hour mean AQO at Tsay Keh during 2013, based on the TEOM data. Fort Ware recorded three exceedances of the 24-hour mean AQO, which were most likely related to construction activity near the monitoring site.

Over the three year period the annual mean PM_{10} at Tsay Keh ranged from 6.1 µg m^{-3} to 10.5 µg m^{-3} and the $PM_{2.5}$ from 3.4 µg m^{-3} to 4.2 µg m^{-3}. For Ft. Ware PM_{10} and $PM_{2.5}$ concentrations ranged from 6.2 µg m^{-3} to 11.6 µg m^{-3} and 2.7 µg m^{-3} to 6.3 µg m^{-3}, respectively.. These values are well within the allowable targets of Federal and Provincial standards for mean annual PM levels. For the 2011 to 2013 period the overall range of mean 24 hour PM_{10} at Tsay Keh was from near zero to 39.5 µg m^{-3} and for

$PM_{2.5}$ from near zero to 25.5 µg m^{-3}. In comparison the range of PM_{10} at Fort Ware was from near zero to 91.5 µg m^{-3} and for $PM_{2.5}$ from near zero to 34.9 µg m^{-3}.

Mean 24-hour values of PM_{10} and $PM_{2.5}$ in excess of 50 µg m^{-3} and 30 µg m^{-3}, respectively are deemed to be in exceedance of Federal and Provincial AQO. For the three years of available continuous monitor data from Tsay Keh and Ft. Ware, a combined total of 12 exceedances of the 24-hour PM_{10} and $PM_{2.5}$ AQO were observed. At Tsay Keh there were no exceedances of the $PM_{2.5}$ standard but three exceedances of the PM_{10} AQO. Over the three years there were three exceedances of the $PM_{2.5}$ standard and six of the PM_{10} at Ft. Ware.

Overall the PM measurements indicate that air quality in the Williston Reservoir Environment and in Ft. Ware is very good (i.e., low annual levels of PM) during the period 2011 to 2013, with only a few days in the available record that show levels of PM above Federal and Provincial Standards. In years prior to 2011 measurements of PM made during the tillage trials indicate that higher PM levels do occur. It would appear that, in the case of the Williston Reservoir, during years with low water levels during the period associated historically with observed dust emissions (i.e., spring) and lower than average precipitation that dust emissions are higher because of the larger areal extent of exposed beaches and their potentially higher emissivity due to the lower moisture levels. This observation clearly suggests that a strategy to best utilize tillage to control wind erosion and dust emission needs to be developed. This strategy needs to take into account water levels and exposed surface area, meteorology and beach emissivity with some understanding of which areas of the reservoir should be protected most or at least first. Developing such a strategy is a very difficult task based solely on field measurements where individual variables vary greatly from year to year and from place to place, but air quality and meteorological monitoring is a critical component for developing such a strategy.

ACKNOWLEDGEMENTS

We would like to express our gratitude to Mike Istchenko and Jill Guerra of Nickling Environmental Ltd and to Nadine Pierre and Emily Pooler of Chu Cho Enterprises Ltd. for their excellent contributions to this project that included the installation and maintenance of equipment, data collection and data reduction. Their dedication and contributions to the project, often under less than ideal field conditions, are gratefully acknowledged.

We Would also would like to extend our sincere appreciation Aaron Flett of BC Hydro for his valuable on-going input and support of the project and to Johnny Pierre (Field Superintendent, Chu Cho Enterprises Ltd), Dan Wiebe (General Manager, Chu Cho Enterprises Ltd) of Chu Cho Enterprises Ltd and Dennis Izony (Chief, Tsay Keh Dene) for their assistance with the ongoing operation of the project and for helping to resolve logistical problems that were encountered along the way. Our special and sincere thanks are extended to Harry Brownlow of BC Hydro for the numerous discussions and input that helped guide the research program.

We are also very grateful to Jordy McCauley (owner and operator) and the staff at Finlay River Outfitters, Fort Graham, BC for the excellent hospitality that was extended to our entire crew throughout the 2012-2013 field season.

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1.0 INTRODUCTION

The Williston Reservoir, located in northern British Columbia is the largest body of fresh water in the province with a surface area of 1775 km^2 and a shoreline of 1770 km. The reservoir was created in 1968 when BC Hydro constructed the Bennett Dam on the Peace River to generate hydroelectric power. The reservoir shorelines can be susceptible to entrainment and transport of sand by wind and a source of fine-grained particulate matter (dust), which can be a major environmental issue. Due to drawdown of water for hydroelectric power; the reservoir is typically at its lowest level (low pool) during the late winter and early spring months. During this time, up to approximately 10,000 ha of beach area can be exposed, high winds (>20 km/h) can result in large dust storms from the exposed beaches that impact visibility and air quality throughout the valley. These dust storms are significant; the village of Tsay Keh is located at the northern tip of the reservoir in nearly direct alignment with the dominant storms winds from the south and can be severely affected by dust entrained from beaches located downwind along the length of the reservoir.

Due to the environmental impacts associated with the reservoir dust storms, and the potential health risks to inhabitants residing near the reservoir, a 3-year field research project was initiated in the spring of 2008 to develop and test a large-scale dust control program. This project, with funding from BC Hydro and co-operation of the Tsay Keh Dene Band, was created to evaluate potential techniques to mitigate wind erosion on exposed beaches. After three years it was concluded that tillage would be an effective tool to reduce erosion and dust emissions on large areas of many exposed beaches along the Williston reservoir. It is noted that tillage is not effective on the deep sands where silt/clay rich clods cannot be brought to the surface. It is important to identify areas of deep sands and to develop, through further research, cost effective methods to stabilize these locations.

In order to monitor the effectiveness of tillage to control wind erosion and dust emissions on the beaches, a dust monitoring network was developed and installed around the reservoir during the spring of 2008. The primary objective of the network is:

To conduct regional dust monitoring at selected sites surrounding the Williston reservoir to evaluate the ambient air quality ($PM_{2.5}$ and PM_{10}) in the region and the effectiveness of the tillage operations in reducing regional dust concentrations.

The air quality monitoring network was initially established in 2008 to measure 24-hr average $PM_{2.5}$ and PM_{10} dust concentrations. Due to logistical issues associated with the deployment of a technically advanced system in remote, rugged conditions of the reservoir sites, the 2008 and 2009 networks were only operational during the months of May and June when water levels were relatively low and tillage trials operational. Due to ongoing concerns that dust storms can occur well into the fall, along with an increase in experience and infrastructure, it was decided that monitoring should be extended from spring to fall, during the time when the ground is free of snow or “from snow to snow”.

2.0 Regional Air Quality Monitoring Program 2011-2013

To evaluate the success of mitigation measures designed to decrease dust emissions from beaches on the Williston Reservoir, and to provide ongoing monitoring to quantify 24-hour and annual average levels of particulate matter (aerodynamic diameter ≤10 µm, PM_{10} and aerodynamic diameter ≤2.5 µm, $PM_{2.5}$) in the atmosphere in relation to provincial and federal air quality standards, a long term regional air quality monitoring program surrounding the reservoir was implemented during the fall of 2011 and spring of 2012.

The monitoring network has two major components:

1. Hourly measurement of PM_{10} and $PM_{2.5}$ and associated meteorology every day, seven days a week for the entire year in Tsay Keh and Fort Ware.
2. Measurement of 24-hour average PM_{10} and $PM_{2.5}$ concentrations and associated meteorology at key locations around the shoreline of the reservoir in the Finlay reach area to characterize regional particulate matter levels for the entire snow-free season.

In both cases, the measurements are taken to evaluate the air quality in this region based on the Federal and Provincial air quality guidelines and standards. In 2000, the Canadian Council of Ministers of the Environment (CCME) ratified new Canada Wide Standards (CWS) for airborne particulate matter based on a $PM_{2.5}$ concentration of 30 µg m-3 (24-hour average), based on the 98th percentile of annual measurements, and averaged over three consecutive years, which was implemented in 2010. The CWS was adopted by British Columbia in 2009. In 2009 a new, stricter $PM_{2.5}$ ambient air quality criteria of 25 µg m-3 also based on a 24-hour average derived from the 98th percentile of annual measurements was adopted by BC. The new provincial criteria for $PM_{2.5}$ is in addition to the existing provincial AQO of 50 µg m-3 (24-hour average) (Environment Canada, 2012: http://www.bcairquality.ca/regulatory/pm25-objective.html), both criteria must be met to be in compliance.

2.1 Continuous PM_{10} and $PM_{2.5}$ Monitoring in Tsay Keh and Fort Ware

An important part of the expanded sampling approach is the installation of permanent air quality monitoring stations in Tsay Keh and Fort Ware that continuously measure and record PM_{10} and $PM_{2.5}$ levels using the Thermo Scientific Ambient Particulate Monitor, TEOM 1405D. Standard meteorological data are also collected at these permanent sites, using the same instrumentation as the remote sites around the reservoir.

Each permanent site in Tsay Keh and Fort Ware utilize identical instrumentation to monitor ambient levels of PM_{10} and $PM_{2.5}$ and environmental conditions (temperature, relative humidity, atmospheric pressure, wind speed, wind direction, and precipitation). Both sites

FIGURE 2.1. THE STEEL BUILDING IN TSAY KEH THAT HOUSES THE TEOM, DATALOGGING INSTRUMENTS AND PROVIDES A PLATFORM FOR THE METEOROLOGICAL SENSORS AND THE TEOM INLET.

FIGURE 2.2. THE INTERIOR OF THE ENVIRONMENTAL ENCLOSURE SHOWING THE TEOM, DATALOGGING INSTRUMENTS, AND NETWORKING HARDWARE, TSAY KEH.

house the TEOM and datalogging hardware in climate-controlled custom steel building, complete with mains power and connectivity to the internet (Fig 2.1).

The TEOM 1405D (Fig 2.2) continuously measures PM_{10} and $PM_{2.5}$. It has US EPA, Federal equivalent designation status and has been utilized in monitoring networks to measure particulate matter mass concentrations continuously. TEOMs have been used exclusively by the Great Basin Unified Air Pollution Control District, Bishop, CA, to monitor dust emissions at Owens Lake, CA, which historically has had the highest dust levels associated with fugitive emissions in North America (Ono et al. 2006).

The TEOM uses a patented tapered element oscillating microbalance that uses micro weighing technology and provides mass measurements based on first principles. The instrument measures PM_{10} and $PM_{2.5}$ simultaneously. The 1405D provides a self-referencing, National Institute of Standards and Technology (NIST)-traceable true mass measurement. The PM measurement method is not subject to measurement uncertainties found in surrogate techniques such as beta attenuation, light scattering, or pressure drop. Specifications, given by the manufacturer of the TEOM 1405D are given in Table 2.1. Table 2.2 lists the specific model and manufacturer for the meteorological instruments used at Tsay Keh and Fort Ware as well as the remote sites surrounding the reservoir.

TABLE 2.1 TEOM 1405D SPECIFICATIONS.

Measurement Method	Tapered Element Oscillating Microbalance (TEOM) Technology
Measurement Ranges	0 to 1,000,000 µg/m^3 (1g/m^3)
Precision	±2.0µg/m^3 (one-hour average), ±1.0µg/m^3 (24-hour average)
Accuracy	For Mass Measurement: ±0.75%
Resolution	0.1µg/m^3
Flowrate	Main flow rate: Fine PM filter, 3.9L/min.; Coarse PM filter, 1.67L/min.
	Bypass flow rate: 12.0L/min.
Data Memory	Internal datalogging of user-specified variables; 5,00,000 record capacity
Input Output	Four averaged analog inputs (0 to 5VDC) with user-defined conversion to engineering units; 8 User-defined Analog Outputs (0-1 or 0-5VDC); 2 User-defined contact closure alarm circuits; Ethernet with embedded FTP server, US, RS-232, and RS-485; touch screen with user interface, and e-Port software to view and change system operation from PC
Data Output	Selectable from 10 sec. to 24 hour
Approvals	Designed to meet: CE EN 761326:1997 + A1:1998 + A2:2001 + A3:2003 and EN:61010-1; UL 61010-1:2004; CSA C22.2 No. 61010-1:2004; and FCC Part 15 Subpart B, Class B
Operating Limits: Temperature Range	Temperature of sampled air may vary between -40° and +60°C. TEOM sensor and control units must be weather protected within the range of 8° to 25°C.

TABLE 2.2. METEOROLOGICAL INSTRUMENTS DESCRIPTIONS.

Environmental Parameter	Instrument	Manufacturer, Make, Model
Temperature	Temperature Sensor	Rotronic Instrument Corp., HygroClip2, HC2-S3-L
Relative Humidity	Relative Humidity Sensor	Rotronic Instrument Corp., HygroClip2, HC2-S3-L
Atmospheric Pressure	Barometric Pressure Sensor	RM Young, 61302V
Wind Speed	Propeller-style anemometer	RM Young, RM Young Wind Monitor, 05103
Wind Direction	Wind vane	RM Young, RM Young Wind Monitor, 05103
Precipitation	Tipping bucket rain gauge	Texas Electronics, Tipping Bucket Rain Gauge, TE525M

The main design goals for the data acquisition program for the BC Hydro monitoring stations in Tsay Keh and Fort Ware were good reliability, ability to monitor the system remotely, save collected metrological and PM data on multiple platforms, and to provide internet access to the data in real time.

The backbone of the data acquisition system is a Campbell Scientific datalogger Model CR1000. The CR1000 datalogger is highly reliable, requires very little power to operate and is designed to operate over a wide temperature range. The dataloggers in Tsay Keh and Fort Ware are configured to run off of small 12 Volt batteries that are recharged daily by small solar panels in addition to the line power battery supply. This insures that metrological instruments will run and collect data even if line power is interrupted or completely off. The CFM100 memory module with high capacity CF memory card is interfaced to the datalogger and a Scientific NL200 network link device that provides a powerful network interface by means of a wired Ethernet network connection to the datalogger and peripherals. This system allows the CR1000 datalogger, as well as other serial devices, to communicate over a local area network or a dedicated Internet connection. This device then allows user to externally access the CR1000 datalogger and to check the status of all the devices connected to it.

In the configuration used, the 2GB CF card memory card has enough capacity to record and store data collected every 1 and 10 minute for a period of over five years. Stations at Tsay Keh and Fort Ware monitor ambient barometric pressure, temperature, relative humidity, wind speed, wind direction, and precipitation via appropriate sensors that are interfaced to the CR1000 datalogger. The CR1000 dataloggers read the meteorological sensors every second.

In addition to the meteorological sensors, the CR1000 datalogger is interfaced with the TEOM via a serial port. The TEOM is polled for a new reading every 10 minutes and the data stored in table that also contains the meteorological data. The datalogger is also interfaced to a laptop computer via a serial port. The datalogger transmits the 1 s meteorological readings to the computer. The TEOM data are transmitted in a similar format but every 10 minutes. Figure 2.3 Illustrates in a schematic diagram how all the different components are interconnected. In addition to these metrological sensors and the TEOM the datalogger is also interfaced to a 3V DC power supply that serves as the indicator for mains power inside the monitoring shed. If external line power fails then this information is transmitted to the laptop computer, which then sends an e-mail warning of this development to the principals. Laptop computers are configured to shutoff once the battery power goes below 50% threshold. The CR1000 datalogger controls a specially designed and fabricated switching board (Arduino.cc) that is activated by the dataloggers 12 V excitation ports. If mains power is lost to the system the datalogger continues to run due to its external 12V power supply. When mains power is restored to the monitoring sheds the datalogger waits for a two minute period to insure power is permanently on and then turns on the Arduino board. The Arduino boards are programmed to interface with the network router and send the “wake on LAN” signal to the laptop. The laptop BIOS is configured to accept the “wake on LAN” signal, which then allows the datalogger to automatically restart the laptop computer after the power to the monitoring shed is restored. This automatic restart feature proved to be very useful since short term power disruptions appear to happen frequently in these locations.

The Laptop receives the one second data from the datalogger and then uses the custom developed LabVIEW program to process and display these data. Since the laptop computer has a much bigger memory capacity then the datalogger we chose to record the one second data on the laptop. It is also important to note that there is a third party application running on the laptop that connects to the atomic time server in Canada that automatically synchronizes the computer clock every hour in order to insure the computer clock remains accurate. To insure that data are not lost in a case of a hard drive failure, once per day backup scripts send the data on the laptop to a 64 GB flash drive connected to the its USB port. The one second data from the datalogger are saved to appropriately named files that have the correct date in the name of each file. New files are created every day one second after midnight. In a similar manner to the datalogger the LabView program running on the laptop collects data to its memory and then computes 10 minute, 1 hour, and 24 hour data averages and saves that processed data to an appropriately named data file (see Fig. 2.4). In addition to processing and recording the entire data set the laptop computer also acts as a web server for each station. The meteorological data are updated every 10 minutes and the PM data every hour so it is convenient for the laptops to serve as web page servers for each station since the webpage is automatically updated with new data every 10 minutes. Figure 3 shows the appearance of the basic display that is updated every 10 minutes.

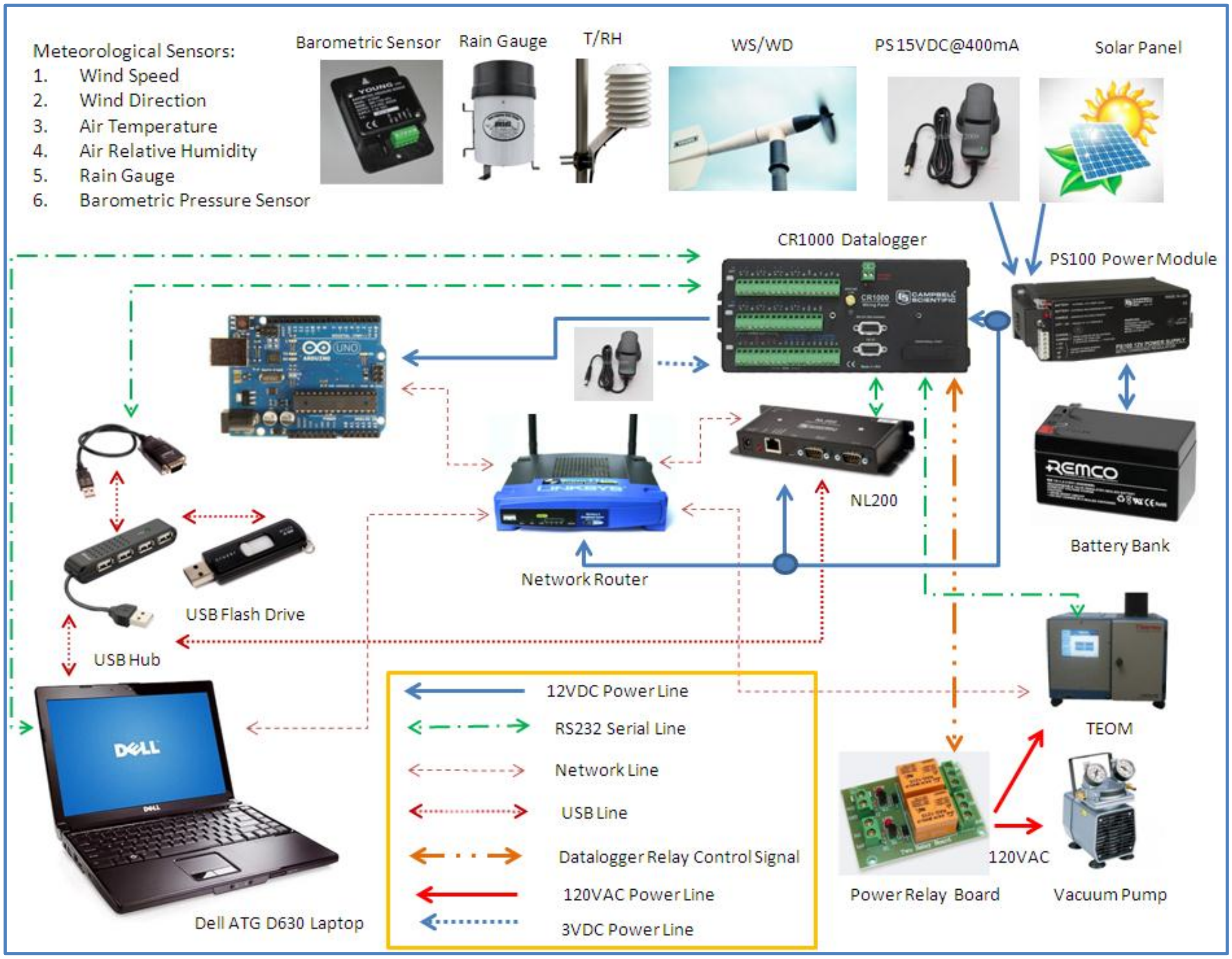


FIGURE 2.3. SCHEMATIC DIAGRAM OF THE INSTRUMENTATION AND DATALOGGING SYSTEMS AT TSAY KEH AND FORT WARE.

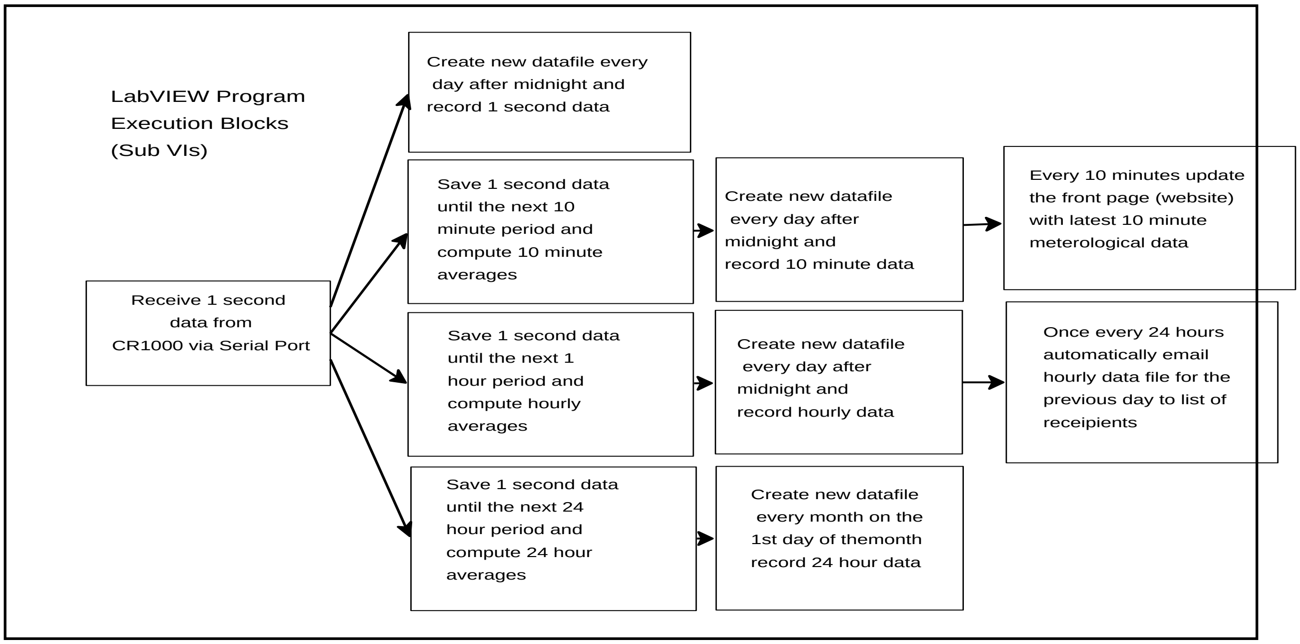


FIGURE 2.4. PROCESS OF DATA ACQUISITION AND STORAGE FOR THE TEOM STATIONS IN TSAY KEH AND FORT WARE.

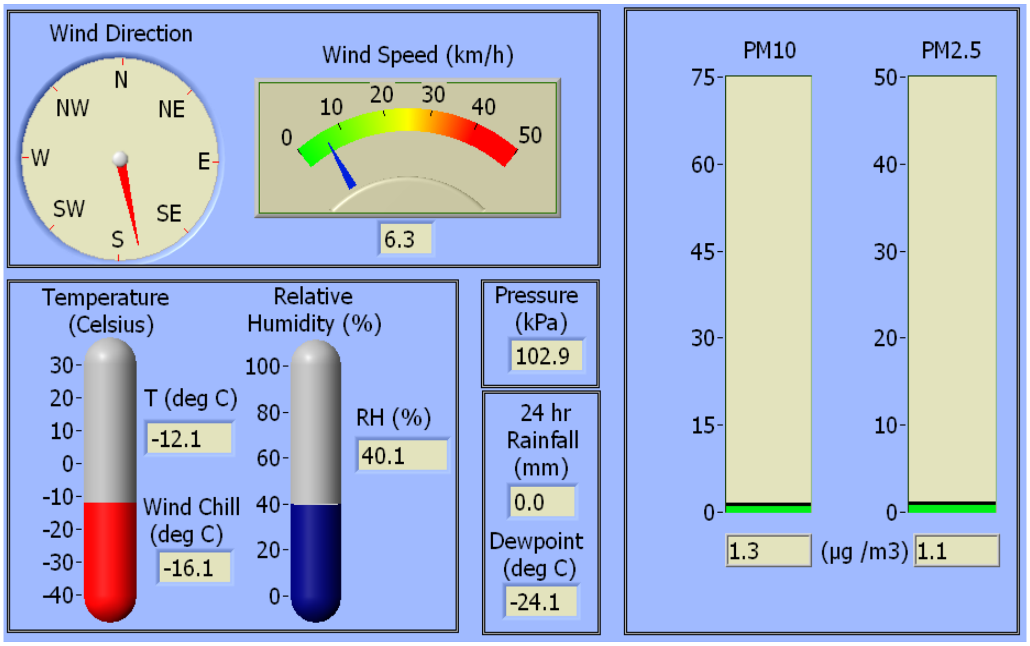
All data are transmitted daily at midnight via the internet to a server located in the Nickling Environmental office in Cambridge, ON. This provides additional back-up of all meteorological and PM data from Tsay Keh and Fort Ware.

Each computer also acts as a web server, this allows for meteorological and PM data to be uploaded for remote viewing. The meteorological data updates every 10 minutes and the PM data every hour. Figure 2.5 shows the display screen that updates every 10 minutes, these displays are located in the Tsay Keh Band Office and Fort Ware School lobby. These displays can be viewed online at the following websites:

Tsay Keh: http://willistondust.zapto.org/TK%20Data.html

Fort Ware: http://willistondust.zapto.org/FW%20Data.html

Tsay Keh, Feb 24, 2014



Fort Ware, Feb 24, 2014

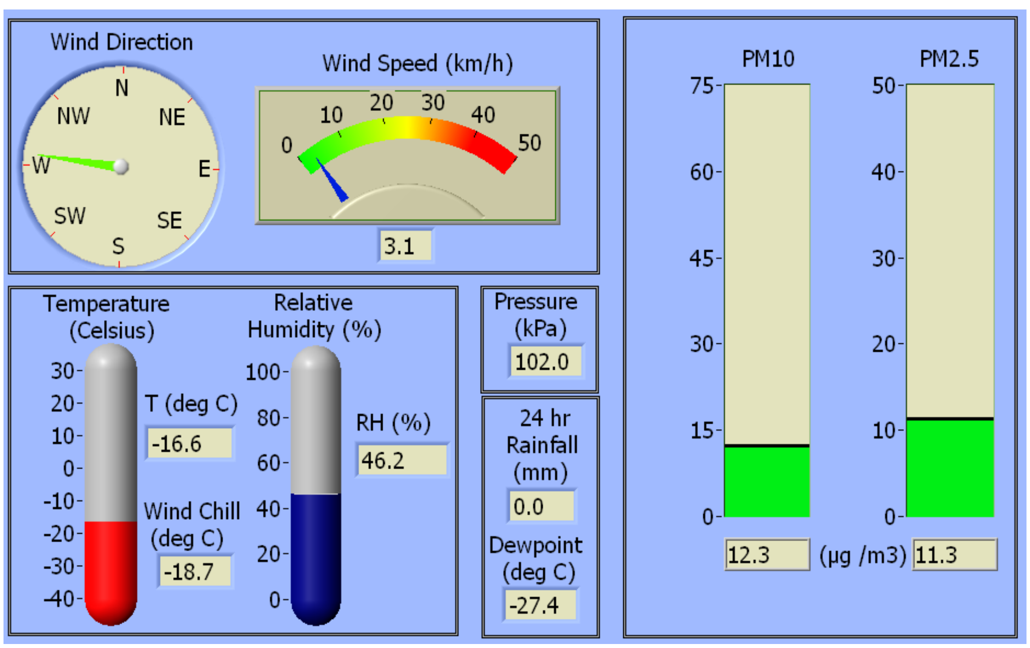


FIGURE 2.5. SCREENSHOT OF DISPLAYS IN THE TSAY KEH BAND OFFICE AND FORT WARE SCHOOL, 1230H, FEB 24, 2014. THE BARS DENOTING THE LEVELS OF THE PM_{10} AND $PM_{2.5}$ CHANGE FROM GREEN TO ORANGE TO RED AS CONCENTRATION APPROACH AND EXCEED THE 24 HOUR STANDARD

Future additions to the websites could be made to include graphs and tables showing long term trends and yearly comparisons of air quality, beach conditions and reservoir levels.

Due to problems associated with limited internet access to these websites in Tsay Keh; special changes had to be made for updating data records. To overcome this issue, in both Tsay Keh and Fort Ware, updates every 10 minutes are sent to an external web host that can be accessed within both villages. Although cumbersome, this approach allowed access to the display screen websites, it is hoped that upgrades to the internet in Tsay Keh will be undertaken soon to improve internet connection.

2.2 PM_{10} AND $PM_{2.5}$ MONITORING AT THE REGIONAL SITES

Prior to 2010, Partisol samplers, which required 120 V at 20 amperes, were used to collect PM_{10} and $PM_{2.5}$ at the regional sites. Although these samplers provided excellent data in previous years, the logistics of maintaining these instruments became increasingly difficult, particularly supplying fuel for the generators late in the season when water levels were high. After an in-depth review of potential alternatives, it was decided that BGI Ltd., Model PQ200 samplers would be used as an alternative to the Partisol samplers. The PQ200 is an U.S. EPA Federal Equivalent Reference instrument that is used internationally and has proven to be very reliable and robust (Figs. 2.6 and 2.7). One of the main considerations in selecting this instrument was the fact that it can run on 12 V power and has a relatively low power draw that can be supplied by two heavy duty batteries and solar panels that were previously available from the tillage trials project.

Unlike the Partisol samplers, the BGI PQ200 can only take one sample at a time per instrument (either $PM_{2.5}$ or PM_{10}) depending which size selective inlet is used, each instrument must be manually loaded with a filter prior to each 24-hr sample run. Two instruments are required for each site for the collection of PM_{10} and $PM_{2.5}$. The BGI is fully programmable using its onboard computer and the instrument can be set to take a sample for a specified duration (typically 24-hrs). In conclusion, the robust nature of the BGI, its simplicity, relatively low cost, and ability to run on 12 V opposed to 120 V made it an ideal sampler for the logistically difficult conditions around the Williston Reservoir.

The ambient air quality sampling network designed for the 2012 and 2013 field seasons was intended to operate from early spring when snow and ice first cleared (often mid to late May), until the first snowfall (typically late September to early October) following the filling of the reservoir to peak pool. In 2013 monitoring was halted in early October, the last day of sampling was October 7th.

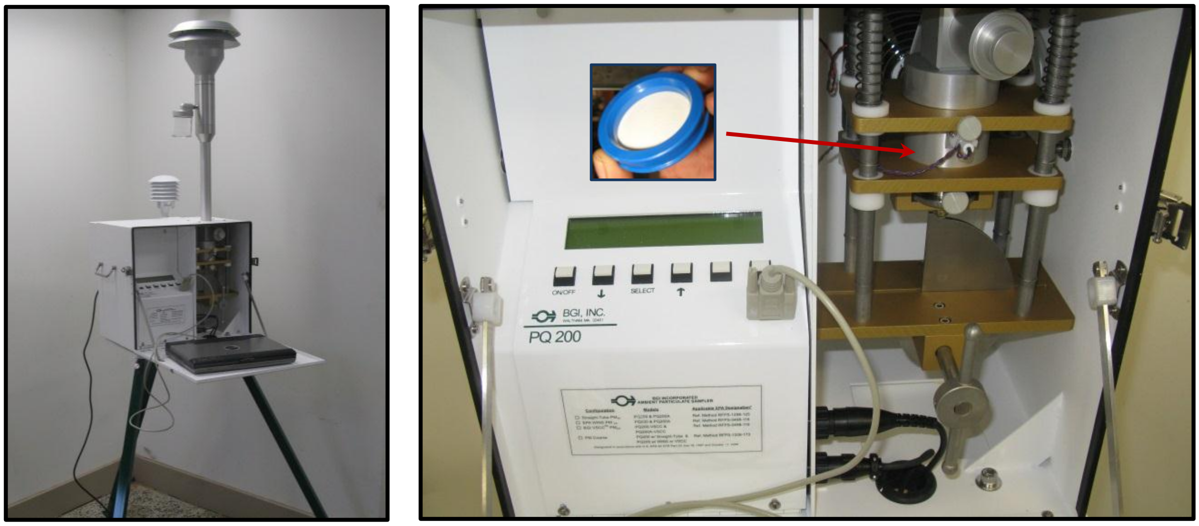


FIGURE 2.6. (LEFT) BGI, MODEL PQ200 PM SAMPLER ON TRIPOD MOUNT, (RIGHT) CLOSE UP OF THE PROGRAMMABLE CONTROLLER UNIT (ON LEFT) AND THE INSTRUMENT FILTER CHAMBER (ON RIGHT) AS WELL AS A CLOSE UP OFA FILTER RING HOLDER AND A 47 MM FILTER.

FIGURE 2.7. DEPLOYMENT OF THE BGI PQ200 PM_{10} AND $PM_{2.5}$ SAMPLERS AND ASSOCIATED METEOROLOGICAL INSTRUMENTATION AT CHOWIKA BEACH.

2.3 Instrument Deployment

PM_{10} and $PM_{2.5}$ samplers were deployed at nine sites on the northern reach of the Williston Reservoir that were selected to be representative of the regional air quality (Fig 2.3). Detailed co-ordinates for the sites are given in Table 2.3. Brief descriptions and photographs of each sampling site are given in Table 2.4. In Tsay Keh, the PM_{10} and $PM_{2.5}$ BGI instruments are co-located on the same site as the TEOM monitoring shed. Power for the datalogger and meteorological instruments are supplied by two 12 V batteries connected in parallel and housed in a weatherproof container. The batteries are charged by a large solar panel previously used in the tillage trials.

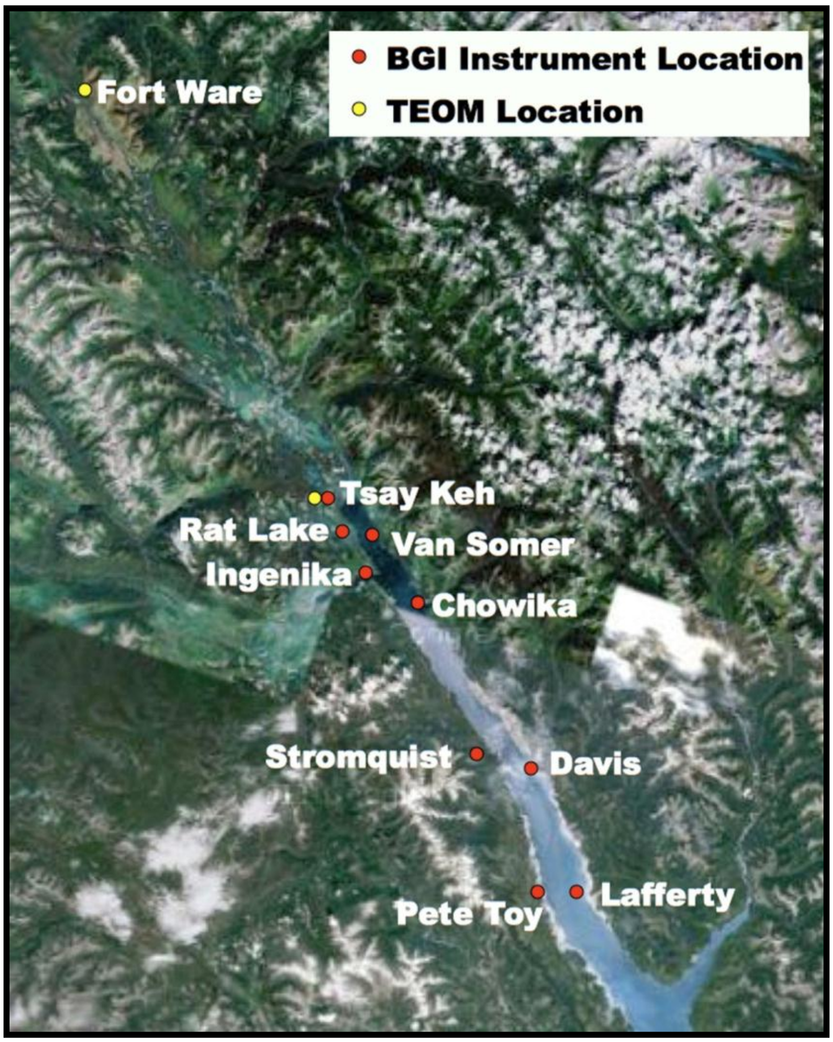


FIGURE 2.3. MAP SHOWING THE LOCATION OF THE REGIONAL AIR QUALITY MONITORS (BGI REPRESENTED BY RED CIRCLES, TEOM BY YELLOW CIRCLE) AROUND THE RESERVOIR.

TABLE 2.3. GPS CO-ORDINATES FOR BGI AND TEOM MONITORING SITES

Site	Latitude	Longitude
Lafferty	56° 20.588'	124° 21.231'
Davis South	56° 30.828'	124° 28.144'
Chowika	56° 44.629'	124° 46.113'
Van Somer	56° 50.242'	124° 53.131'
Tsay Keh	56° 53.497'	124° 57.832'
Fort Ware	57° 25.383'	125° 37.766'
Rat Lake	56° 49.616'	124° 55.697'
Ingenika	56° 47.201'	124° 52.527'
Stromquist	56° 34.036'	124° 37.696'
Pete Toy	56° 29.699'	124° 33.262'

TABLE 2.3. SITE DESCRIPTIONS FOR THE BGI LOCATIONS.

<table>
<tr><td>(A) Pete Toy
</td><td>Pete Toy is located on an exposed beach adjacent to Ole Creek. The beach is comprised of mobile sand and there is no vegetation, stumps or logs on the beach to impede wind flow and sand transport at the site. The samplers are subject to regional dust emissions from adjacent beaches as well as emissions from surrounding beaches.</td></tr>
<tr><td>(B) Stromquist
</td><td>The Stromquist instruments swere located on a grass covered storm beach above a steep, expose cobble covered point that is subject to northerly and southerly winds. The samplers are located on a sandy beach that is a source for sand and dust transport during storm events. The site is exposed to regional dust emissions from upwind sources (north and south) sources and is strongly affected by south easterly flows. A small amount of vegetation and dead tree stumps are present but have minimal effect on regional wind flow and dust transport.</td></tr>
<tr><td>(C) Ingenika
</td><td>This site is located on a point that is exposed to southerly winds and to a lesser extent northerly winds that transport dust from the beaches on the west side of the reservoir. This site is a good indicator of regional dust within the reservoir.</td></tr>
</table>

(D) Rat Lake 	The samplers are located on top of an exposed bluff adjacent to a narrow beach along the western edge of the reservoir. The surface of the site is comprised of crusted sand with a sparse vegetation cover. No measurable amount of dust appears to be generated by the surface at this site. This site is a very good indicator of regional dust conditions as plumes pass by from the south. This site is exposed to southerly winds and is protected from northerly winds by vegetation.
(E) Tsay Keh 	The BGI samplers at this site are located on top of the TEOM sampling shed in Tsay Keh adjacent to the school and community center. This site provides a designed co-location sampling site with the TEOM. The site surface is covered with grasses and low shrubs. There is a nearby beach with a very long fetch which is free of vegetation and comprised of mobile sediment. The location is subject to all winds and dust from the south during storm events. Van Somer beach is an important source to the south.
(F) Fort Ware 	The sampling shed at Fort Ware is located on a river terrace approximately 75 m west of the school and approximately 150 m east and 10 m above the roadway entering into the village. This instrument shed only houses a TEOM and the associated meteorological instruments. As a result of the expansion of the school and ongoing issues with road dust, this site will likely need to be moved to a new location that better represents the regional air quality.

(G) Van Somer 	Located on Van Somer beach, this site is comprised of highly erodible sandy silt. This location is often one of the worst emitting beaches in the valley. Intense dust emissions can often be seen from across the reservoir in Tsay Keh. During extended low pool years, this beach may have extensive vegetation, limiting dust transport. The BGI is well exposed to both northerly and southerly winds.
(H) Chowika 	The samplers at this site are exposed to both southerly and northerly winds. The surface at Chowika is comprised of large gravel cobbles with an abundance of large woody debris and as a result is not a source for localized transport of sand and dust. This site is an excellent indicator of regional dust transport from both the north and south.
(I) Davis South 	This site is characterized by over 320 degrees of exposure to southerly and northerly winds on a beach that is comprised of mixed gravel, sands and clays. The surface is covered with woody debris and a small amount of plant matter that may grow if given time before water inundation. This beach is a known dust emitter resulting from the diverse range of sediments that are present. Fine-grained, mobile sands, located south of Davis creek are a major factor for the ejection high dust from the extensive beach complex.

(J) Lafferty 	This site has excellent north/south exposure and captures dust as it blows past other beaches. Lafferty itself (in the vicinity of the sampler) is not a strong emitter of dust; however the adjacent beaches (Collins to the North and Ospika to the South) are considered major emitting beaches. The surface surrounding the sampler at Lafferty is primarily coarse sand and gravel. There is also a significant amount of woody debris present at this site.

2.4 Sampling Protocols

Regional Sites

As previously discussed, the BGI samplers, unlike Partisol samplers can only be loaded with one sample filter at a time, requiring filters to be manually exchanged for each sampling day. All sites need to be visited and filters installed prior to the beginning of a given sampling period, which typically begins at midnight. There were major logistical issues associated with sampling, as monitoring crews were housed at Fort Graham, on the eastern side of the reservoir near Davis Beach. To complete the sampling schedule, long days of driving were required, particularly for the samplers on the western side of the reservoir. To limit driver exhaustion, each of the two crews alternated changing filters on the east and west side. Each crew drove >20,000 km over the duration of the field season on poorly maintained roads and often in inclement weather.

After consulting the EPA standard particulate sampling schedule, considering the logistics involved in the timing of filter changes and evaluating safety concerns, it was decided the remote samplers would operate on a one-in-three day sampling period commencing on May 25th, 2013. The one-in-three day schedule ensures that each day of the week is represented over time. This sampling protocol is often used in air quality studies to reduce the operating costs (costs associated with personnel, filters, laboratory analyses, etc.). The sampling days were synchronized with the Provincial Air Quality Monitoring days, which also follow the EPA schedule previously mentioned. Once reservoir water level reached high pool, inundating most of the emissive particles and tillage operations could no longer be completed on the majority of beaches, sampling reverted to a one in six day schedule on June 27th, 2013. This change reduced the personal required to maintain the network, the costs, and distances required to be driven.

During the study period, the following data were collected at each remote site during the 24-hr sampling periods: 1) 24-hr average PM_{10} and $PM_{2.5}$, 2) wind speed, 3) wind direction, 4) temperature,

5) atmospheric pressure, and 6) precipitation. The instruments used to collect this information are listed in Table 2.2. All data at the remote sites are collected by a Campbell CR1000 datalogger.

PM_{10} and $PM_{2.5}$ were measured with two BGI, PQ200 samplers. To ensure that remote sites are comparable to the Tsay Keh station, two additional PQ200 samplers (one configured for PM_{10} and the other for $PM_{2.5}$) were co-located with the TEOM in Tsay Keh. This ensures that measurements are comparable, as each instrument (PQ200, TEOM 1405D) uses different methods of measuring particulate mass.

The operation and maintenance of the remote sites around the reservoir was carried out by two crews of two individuals, each consisting of a Nickling Environmental employee and a Tsay Keh Band member, both of whom had been trained in the correct sampling protocol. The two crews were split based on location of the monitoring sites, one crew serviced all sites on the eastern side of the reservoir and the other crew maintained all sites on the western side of the reservoir, along with the Tsay Keh site.

Upon arrival at each monitoring site a visual inspection was carried out to ensure there was no physical damage to instruments (due to wildlife, falling debris, etc.). If no obvious signs of damage were present after visual inspection, the CR1000 datalogger was connected to a laptop and the instrument output was observed to ensure all instruments were functioning and recording properly. Once these visual checks were completed and data appeared to be normal, the meteorological data were downloaded and appended to a data table. Following this, the BGI instrument was opened and the used filter cassette from the last 24-hr sampling period was carefully removed and placed inside its transport container and the filter ID was logged on the chain of custody form. Prior to a new filter being inserted into the PQ200, a leak test and flow audit of the system was performed to ensure the instrument was working correctly. Any issues associated with the meteorological or PQ200 instruments were recorded in a log book. If the BGI unit was operating correctly, a new filter was removed from its transport container and placed into the filter assembly of the instrument. The PQ200 was then programmed by the operator to begin sampling at midnight on the next sampling date. The BGI door was then closed and the crew would move on to the next remote site, providing no issues were unresolved. In the rare case when an issue could not be resolved (e.g. instrumentation malfunction or breakage, technical consultation required, spare parts needed, etc.) the crew would leave the site without inserting new filters, proceed to the remaining remote sites and return the next day to solve the problem. One of the rare instances where this was required was during a leak check at one of the remote sites, a leak was isolated to a part of the instrument, a spare was collected from Collins Camp and the crew returned to the site the next day to replace the part and complete the leak check. In general, once the system was up and running there were few issues and the instruments ran without problems.

The dust monitoring crew trailer which was installed at the end of the 2013 field season will be more efficient, less costly and safer for the 2014 field crews to access the remote sites as Tsay Keh is more central to the sites compared with Fort Graham. Serious consideration should be given to returning to a daily sampling program, during the main dust season at least. Although ideal, daily sampling would require the purchase of additional instruments and two new crew members at a minimum.

TEOM SITES

Particle sampling with the TEOM was automatically carried out at 10 minute intervals and then averaged over 1 hour and 24 hour periods. Meteorological data at these sites were collected each second and averaged over 10 minutes, 1 hour and 24 hour periods to match the TEOM data averaging intervals. The TEOMs require ongoing, scheduled maintenance at regular time periods. The micro filters must be changed on a regular basis. The timing of these changes is based on the filter loadings, which depends on the concentration of the particulate matter in the air being sampled. The filter loadings can range from 0 to 150%. However, filters should be changed before the filter loading reaches 100% to maintain sampler efficiency. The length of time between filter changes is not standard and varies with the atmospheric PM concentrations. As a result the TEOMs must be monitored regularly. Following every filter change a leak test of the entire system was undertaken to ensure that there were no flow losses that would affect subsequent calculations of PM concentrations. In addition to the leak test a flow audit was also carried out when filters were exchanged and at a minimum, once a month if atmospheric dust concentrations and filter loadings were low. During inspection, flow problems and instrument failures were identified and corrective measures performed as soon as possible, to limit instrument downtime. A total system audit and calibration was also performed less frequently, at least once a year, although severe weather conditions result in these measures being performed more frequently.

3.0 Regional Dust Monitoring Results

3.1 Wind Flow at Tsay Keh and Fort Ware

The entrainment and transport of sand and finer grained particulate matter is a complex function of the surface characteristics and wind field for a given site. Sand sized particles are generally transported relatively short distances during a given storm but aid in the ejection of fine grained particulates through bombardment and abrasion processes. In contrast, finer particulates (dust: PM <70 µm) can be transported and diffused downwind great distances depending on the particle size and the turbulent characteristics of the wind flow.

As in previous years, wind flow at the Williston Reservoir was very consistent and dominated by northerly and southerly wind flows throughout most of the year. This pattern in large part results from topographic steering of the dominantly western flows that are redirected along the valley of the Peace River and the Rocky Mountain Trench.

Figures 3.1 and 3.2 show monthly wind characteristics for the 2013 study period recorded at Tsay Keh and Fort Ware. At Tsay Keh, there was a strong north and south alignment of winds for almost all months of the year. The strongest and most consistent winds were the northerly flows in January, May and December and southerly flows in February. Relatively strong, but somewhat more variable southerly winds also dominated from March through June. However, during this period a relatively strong NNE to N component was also apparent. These strong southerly and northerly winds, coupled with the low water level in the reservoir exposing thousands of hectares of erodible sediments, are the primary reasons for the high dust storm potential at Williston during the spring and early summer months.

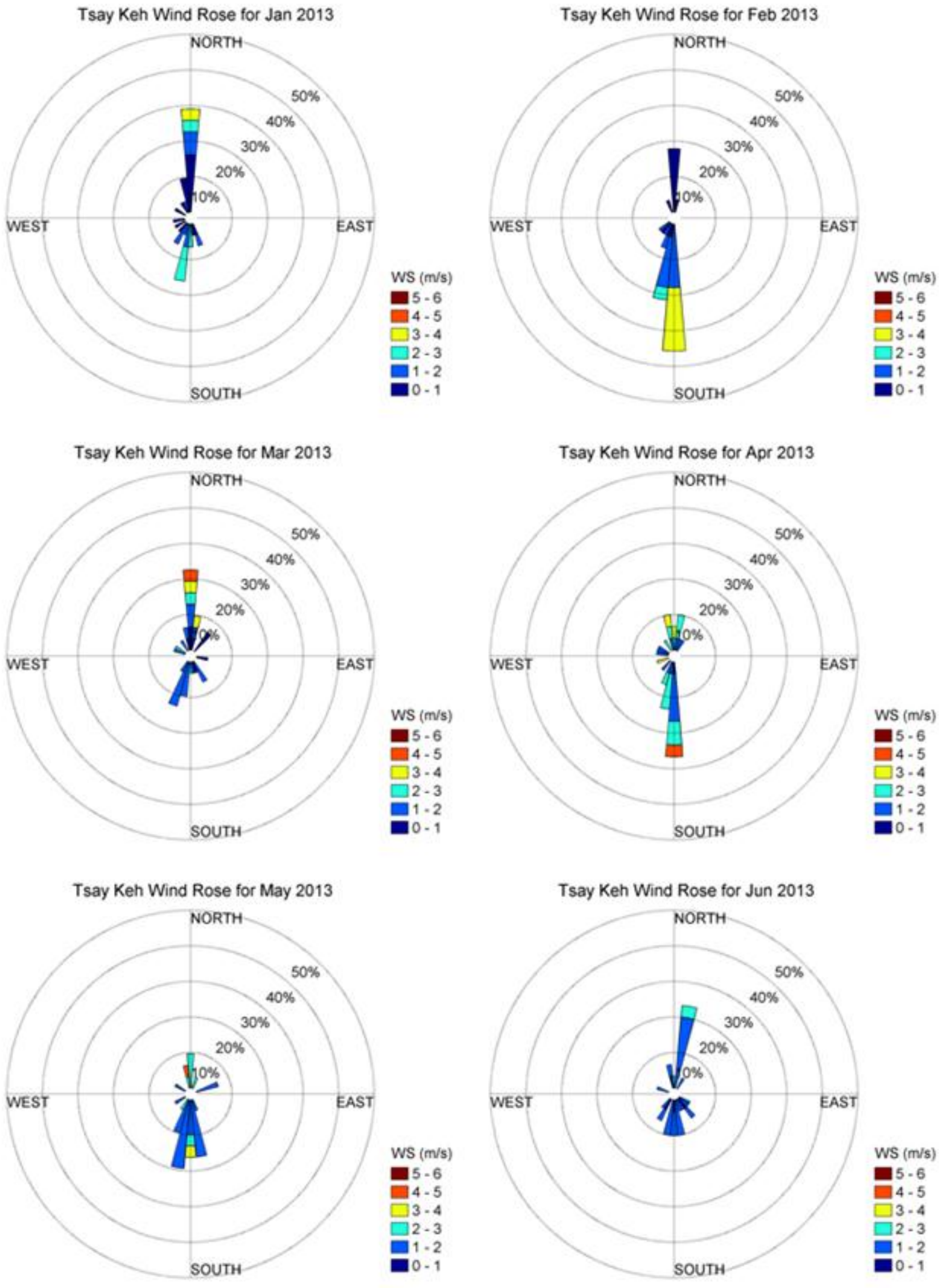


FIGURE 3.1A. MONTHLY WIND ROSES FOR TSAY KEH.

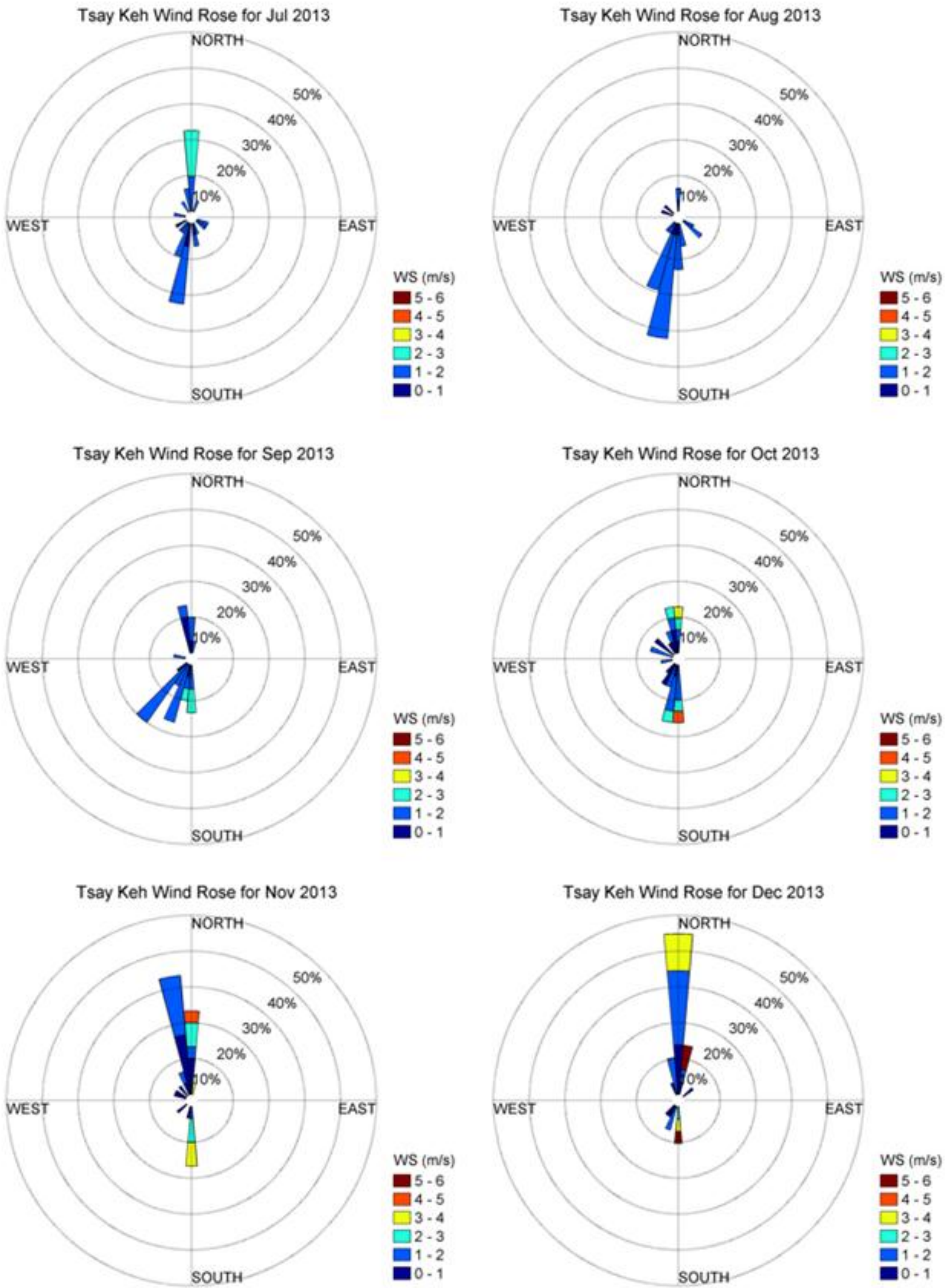


FIGURE 3.1B. MONTHLY WIND ROSES FOR TSAY KEH.

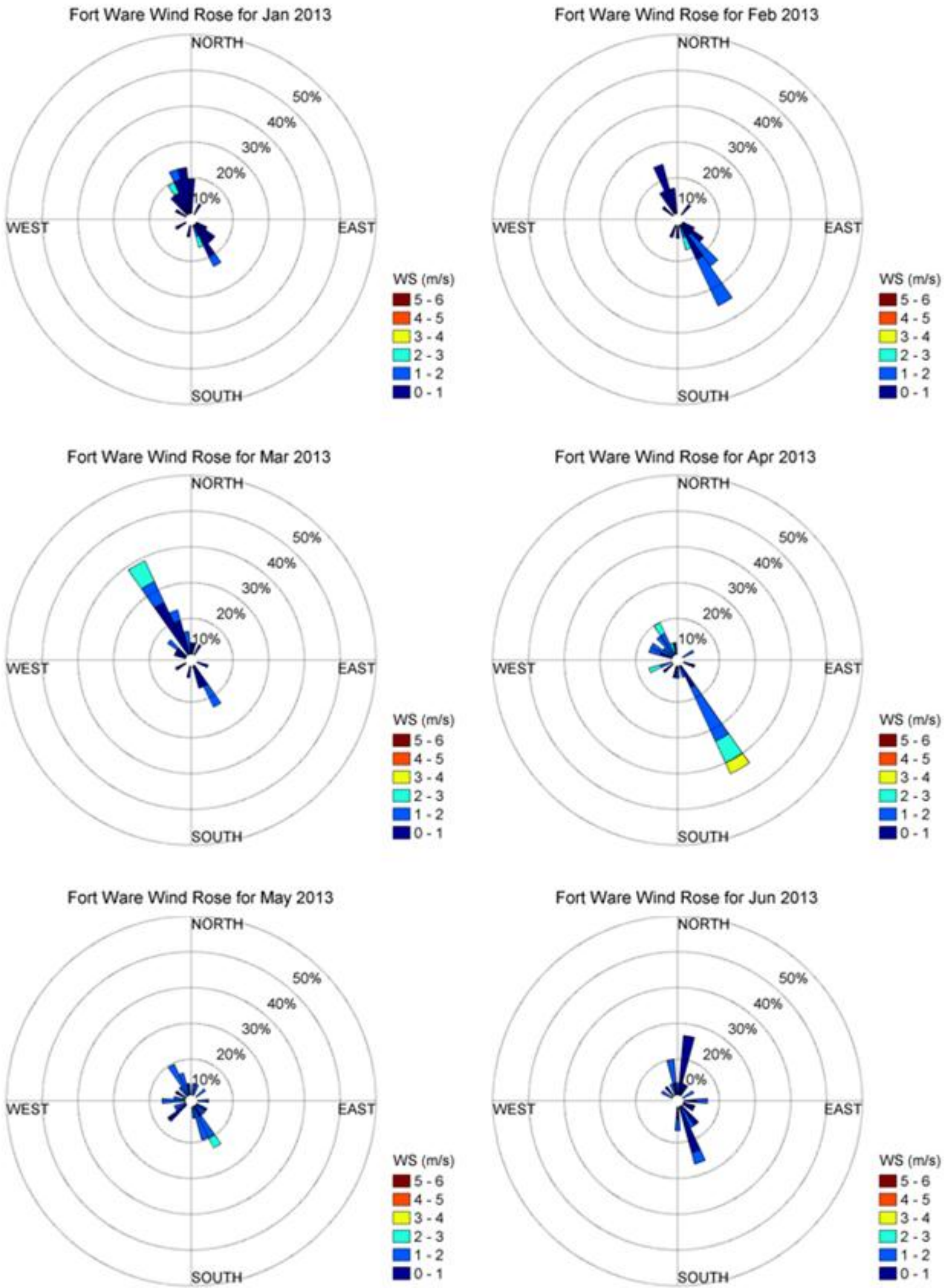


FIGURE 3.2A. MONTHLY WIND ROSES FOR FORT WARE.

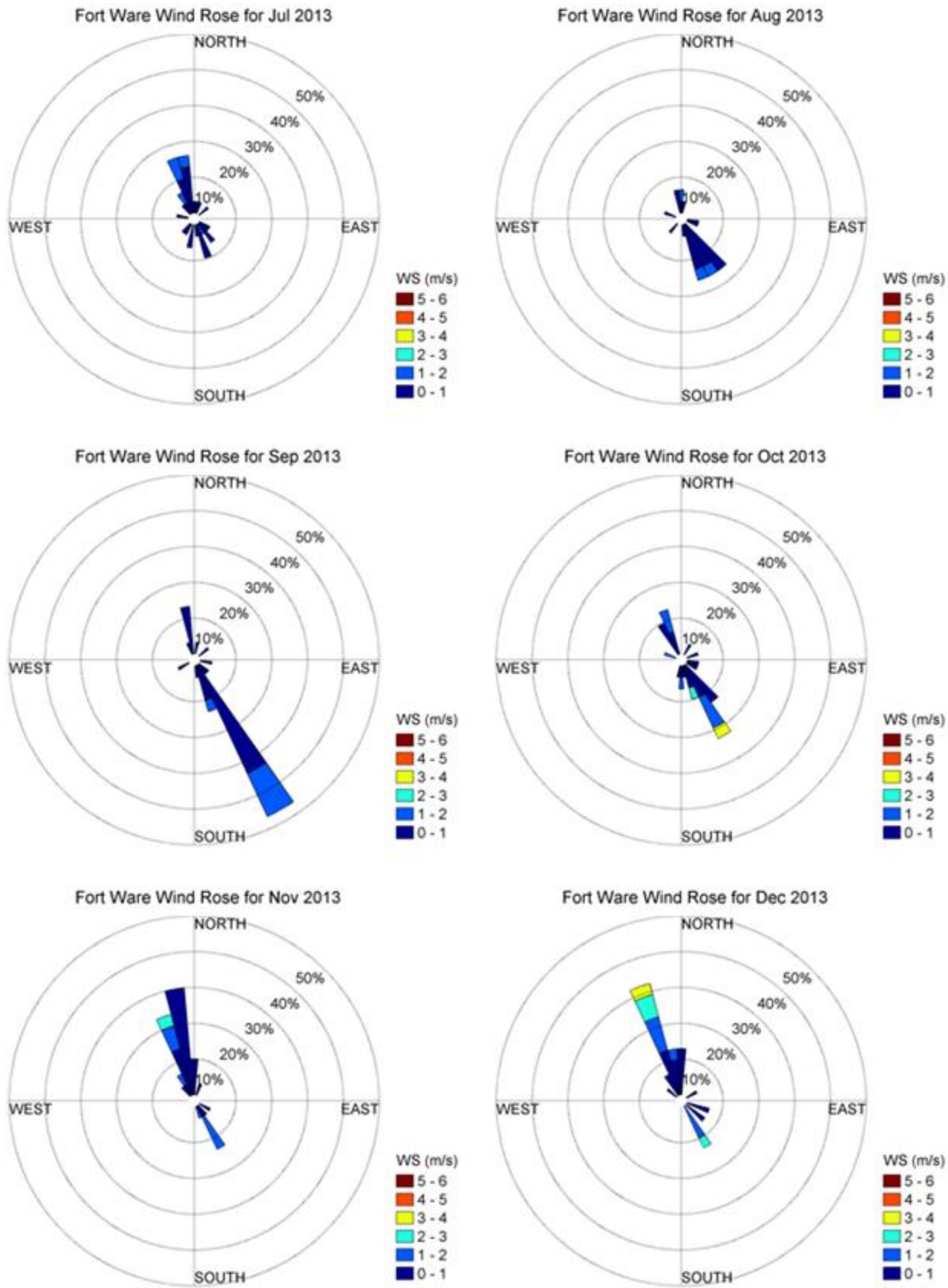


FIGURE 3.2B. MONTHLY WIND ROSES FOR FORT WARE

Wind flow at Fort Ware was also quite consistent, but the dominant directions were NNW and SSE flows rather than the more northerly and southerly flows observed at Tsay Keh. The NNW and SSE pattern reflects the localized topographic steering in Fort Ware where the valley is relatively narrow. Winds at Fort Ware also tended to be somewhat more consistent in 2013 in contrast to 2012. A notable difference between Fort Ware and Tsay Keh is that southerly wind speeds were generally higher in Tsay Keh, which can be attributed to the long open fetch of the reservoir to the south of the village.

3.2 PM CONCENTRATIONS AT TSAY KEH AND FORT WARE

Thermo Scientific Ambient Particulate Monitors (Model TEOM 1405D) were first deployed during the late Fall of 2011 and the Spring of 2012 at both Tsay Keh and Fort Ware. The instruments were installed in climate controlled, prefabricated, weather proof sheds to continuously monitor average 24-hr $PM_{2.5}$ and PM_{10} throughout the year (Figs. 2.1 and 2.2). Two BGI PQ200 samplers were co-located with the TEOM in Tsay Keh as a cross reference for the Regional BGIs. It should be noted that both the BBGI PQ200 and The TEOM 140D are USA EPA approved equivalent methods (FEM) for the measurement of $PM_{2.5}$ and PM_{10} and are accepted samplers in Canada.

Figures 3.3 and 3.4 present PM_{10} and $PM_{2.5}$ concentration time series for the TEOM samplers in Tsay Keh and Fort Ware along with the associated meteorological data for the 2013 "dust season" (May 25 – Oct 7, 2013). As well, Figs. 3.5 and 3.6 show PM data plotted for the entire year. Tabular data associated with these plots are provided in Appendices I and II, respectively. As a result of mechanical and electronic breakdowns, which required servicing of the TEOMs and travel logistics, there were time intervals wherein no PM data were collected by the Tsay Keh and Fort Ware TEOMS. In Appendices I and I this is indicated by "NaN". As well, during some periods, particularly during winter months, the quantity of particulate matter in the atmosphere was very low and below the detection limit of the TEOMs. In the Appendices and associated tables this is indicated by the presence of the asterisk symbol (*).

As can be noted in Figs. 3.3 and 3.4, both PM_{10} and $PM_{2.5}$ concentrations were relatively low during 2013 with $PM_{2.5}$ values ranging from near zero to a maximum of 17.9 and 39.3 µg m^{-3} at Tsay Keh and Fort Ware, respectively (Table 3.1). As would be expected, PM_{10} values were higher, ranging from near zero to 39.3 µg m^{-3} at Tsay Keh and 0.1 to 59.5 µg m^{-3} at Fort Ware (Table 3.1). At both sites, the annual averages for both $PM_{2.5}$ and PM_{10} were below 10 µg m^{-3}.

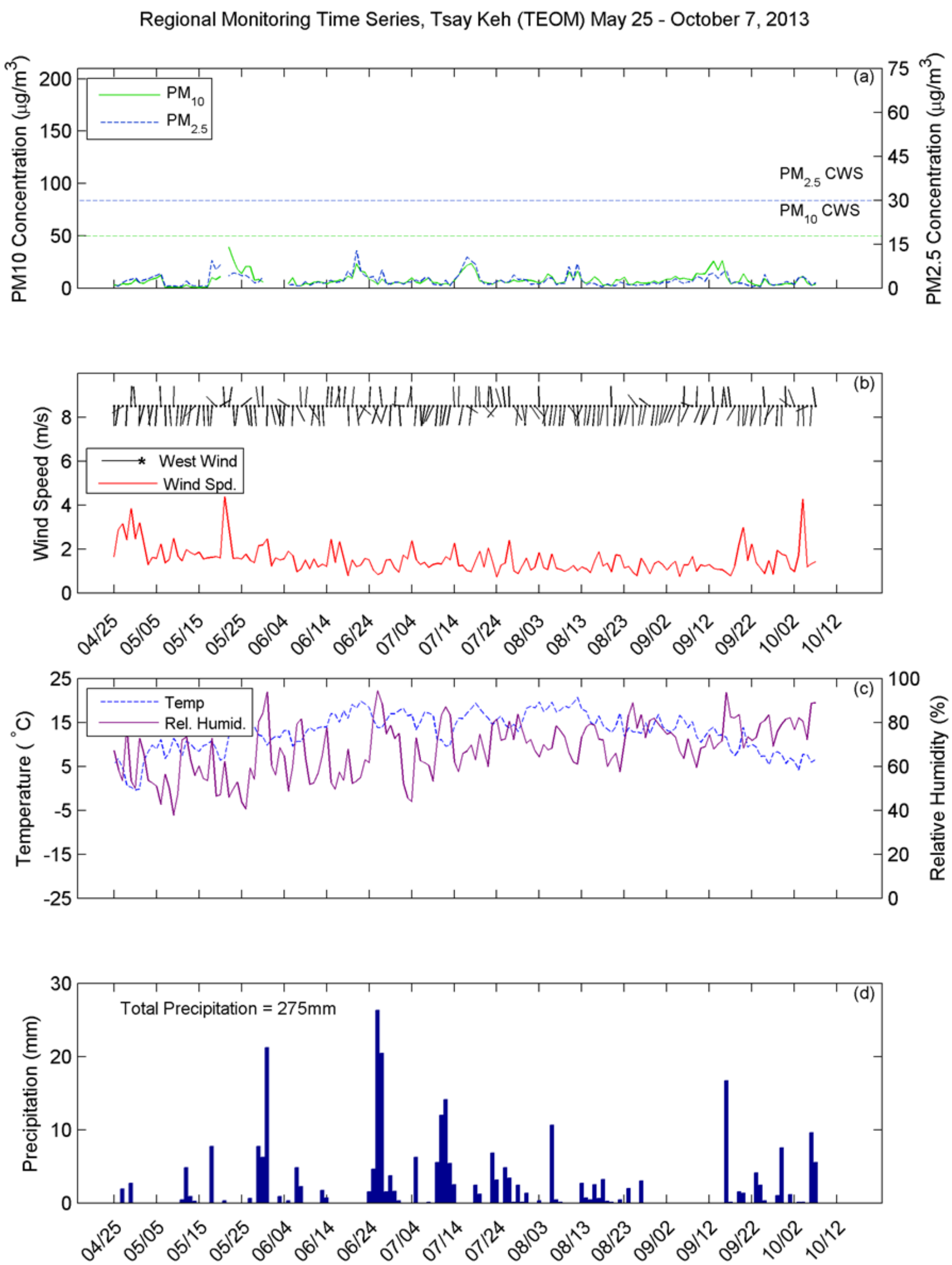


FIGURE 3.3. TIME SERIES OF 24-HR AVERAGE TEOM PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR TSAY KEH DURING THE 2013 DUST MONITORING SEASON (REGIONAL BGI INSTRUMENTS ALSO OPERATIONAL DURING THIS TIME PERIOD).

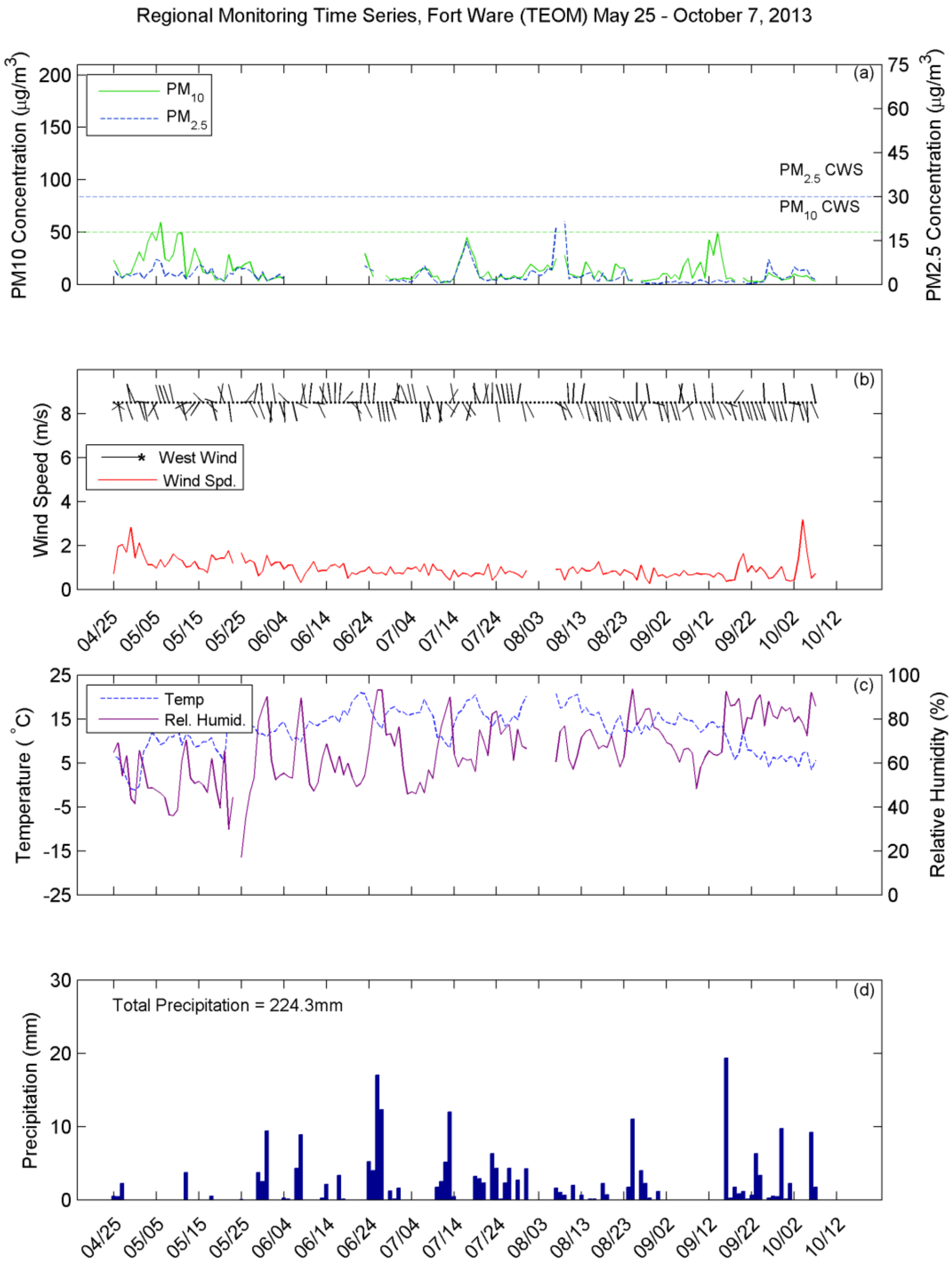


FIGURE 3.4, TIME SERIES OF 24-HR AVERAGE TEOM PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR FORT WAREDURING THE 2013 DUST SEASON (REGIONAL BGI INSTRUMENTS ALSO OPERATIONAL DURING THIS TIME PERIOD).

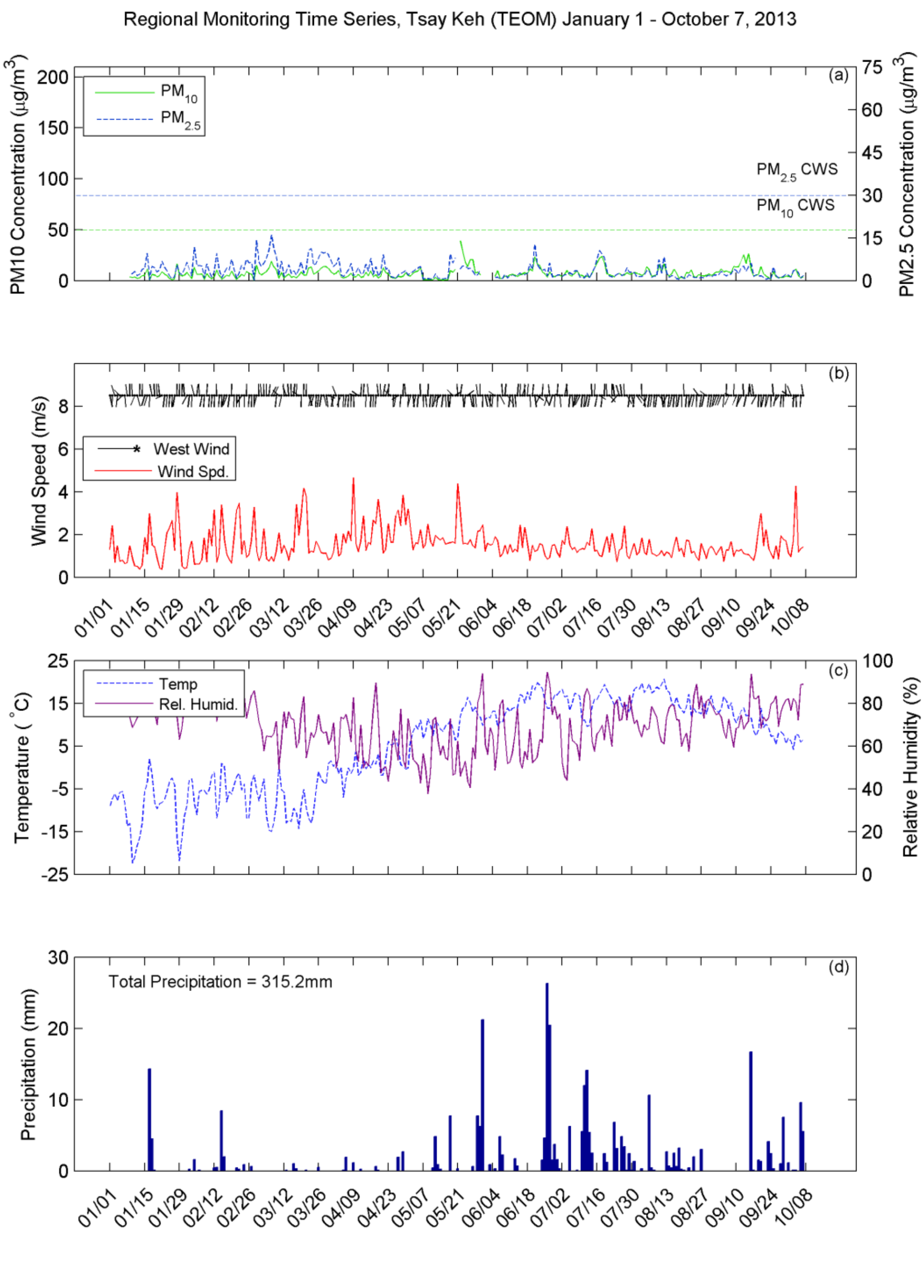


FIGURE 3.5A. TIME SERIES OF 24-HR AVERAGE TEOM PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR TSAY KEH DURING FOR THE FULL SAMPLING SEASON (JANUARY 2013 TO OCTOBER 2013) (CONTINUED ON NEXT PAGE)

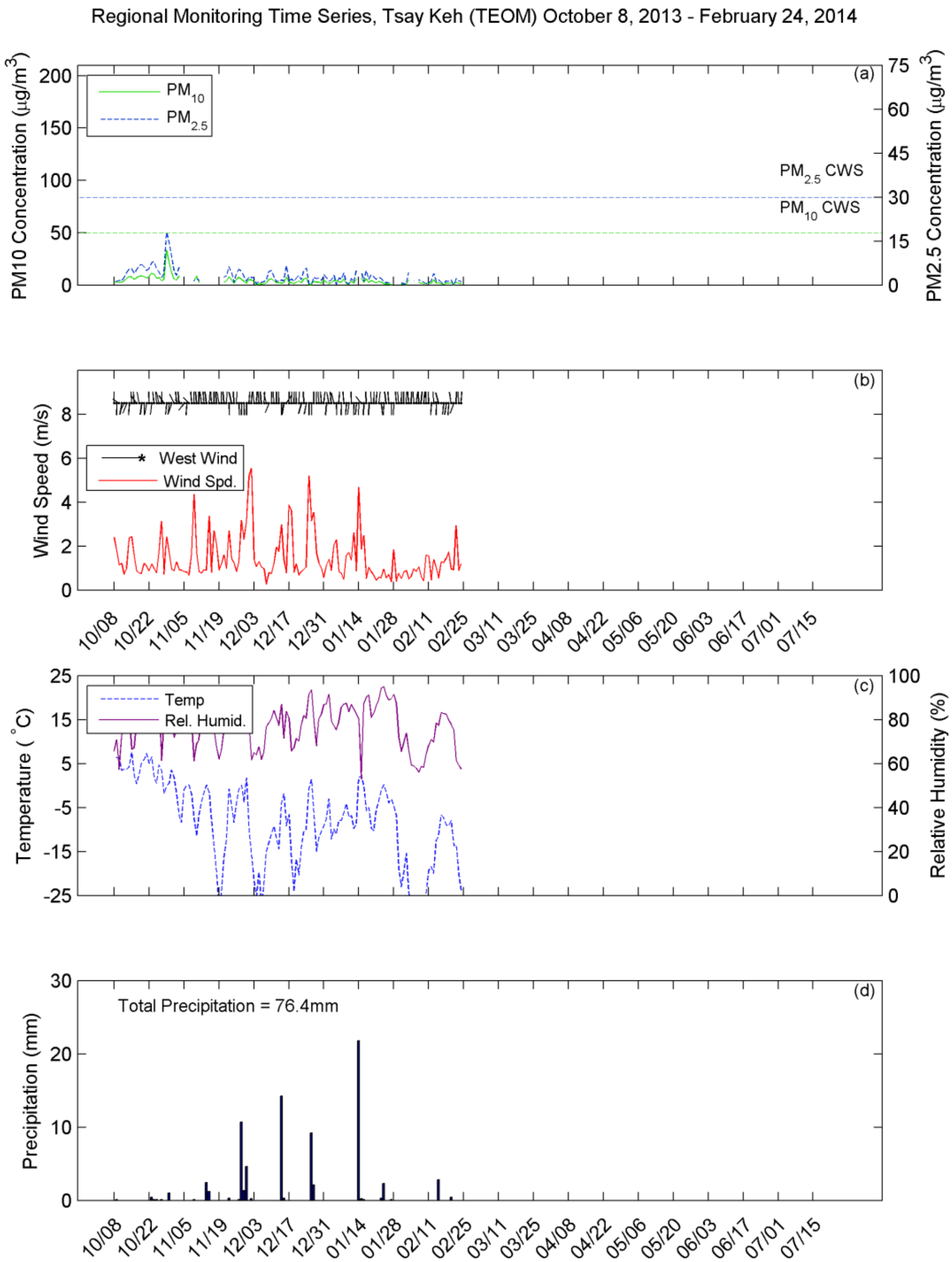


FIGURE 3.5B. TIME SERIES OF 24-HR AVERAGE TEOM PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR TSAY KEH DURING FOR THE FULL SAMPLING SEASON (OCTOBER 2013 TO FEBRUARY 2014)

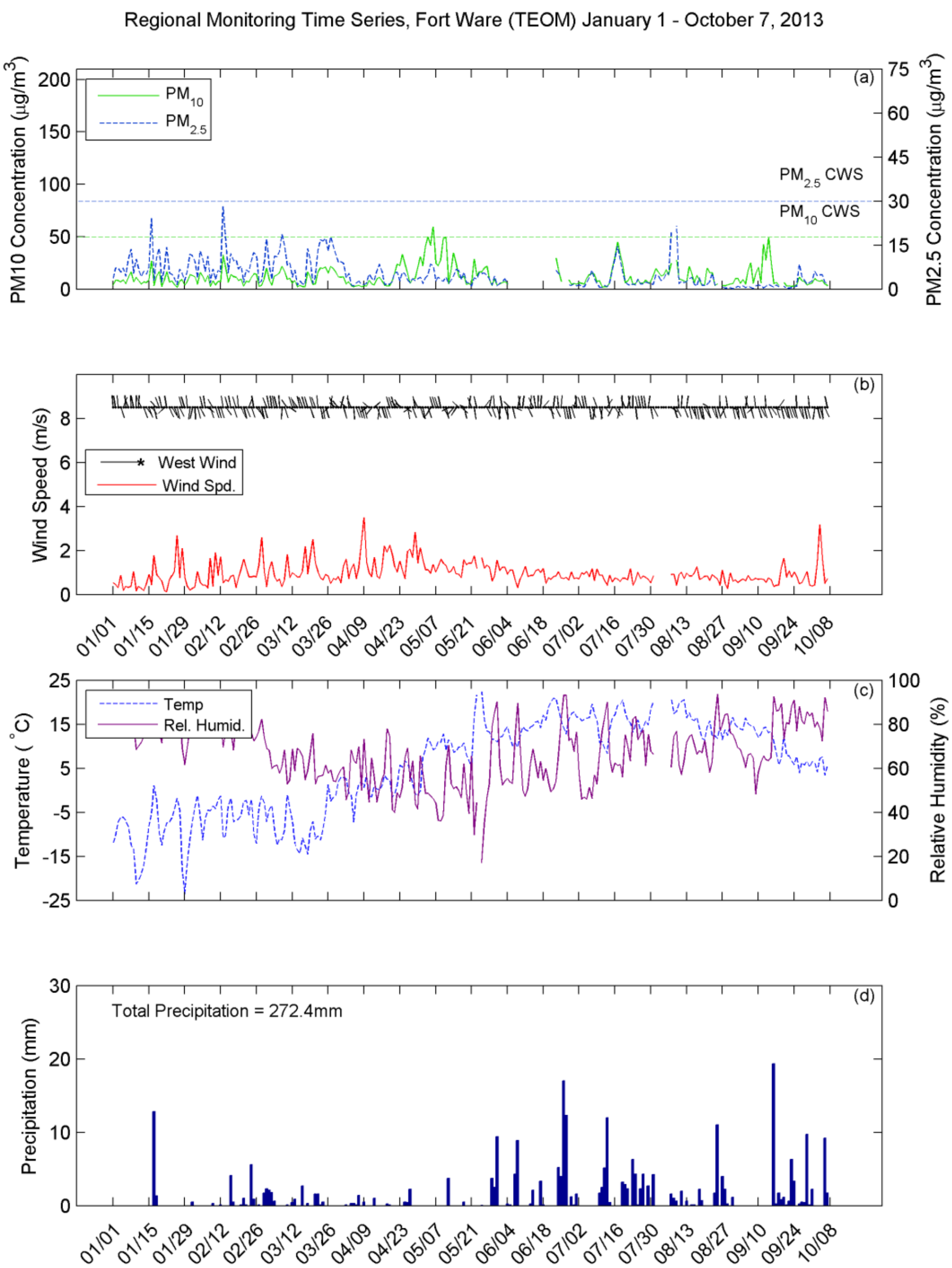


FIGURE 3.6A. TIME SERIES OF 24-HR AVERAGE TEOM PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR FORT WARE DURING FOR THE FULL SAMPLING SEASON (JANUARY 2013 TO OCTOBER 2013)(CONTINUED ON NEXT PAGE).

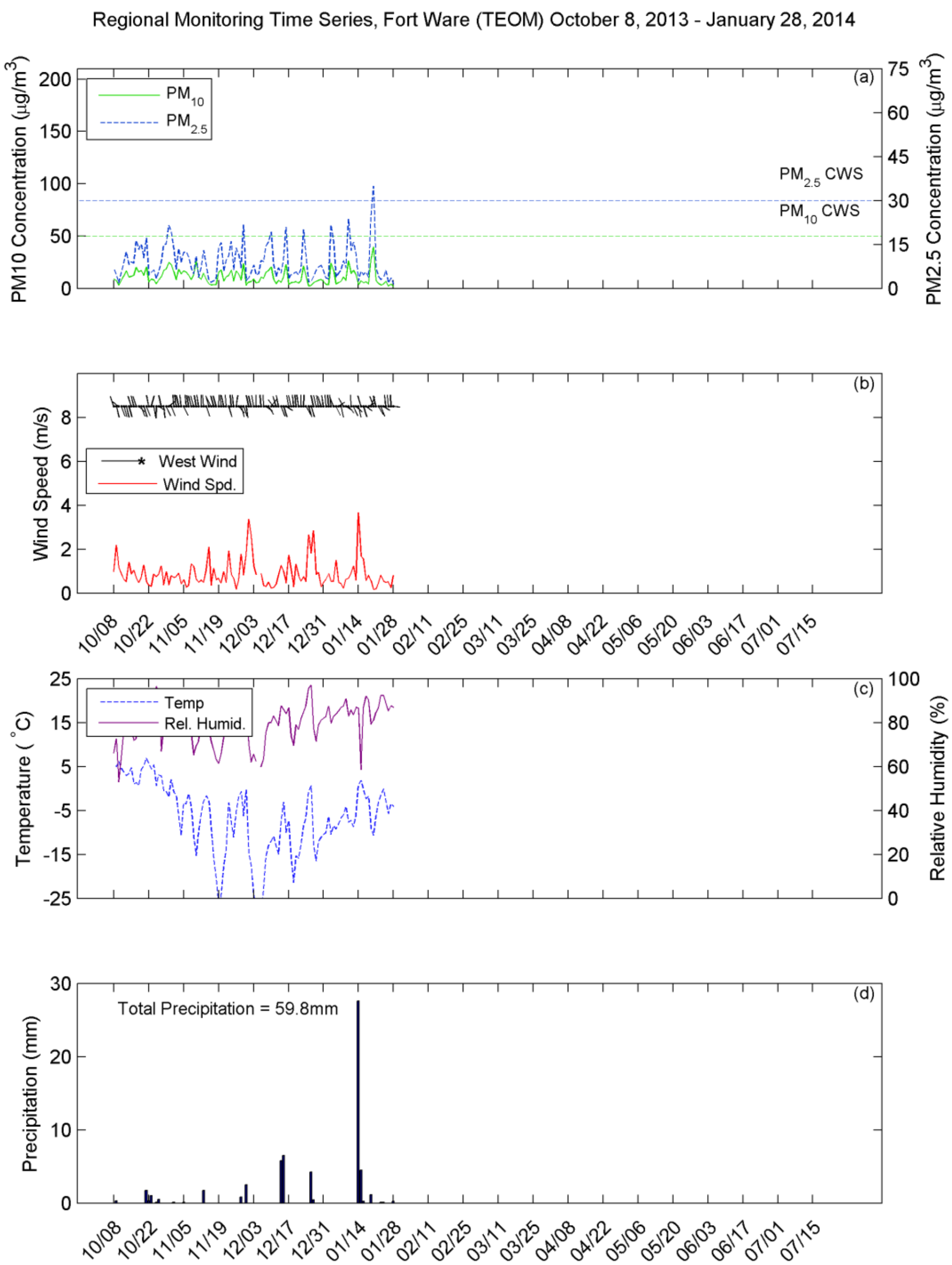


FIGURE 3.6B. TIME SERIES OF 24-HR AVERAGE TEOM PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR FT. WARE DURING FOR THE FULL SAMPLING SEASON (OCTOBER 2013 TO JANUARY 2014)

The Canada Wide Standard (CWS) for airborne particulate matter is based on a $PM_{2.5}$ concentration of 30 µg m^{-3} (24 hour averaging time) based on the 98^{th} percentile of annual measurements, averaged over three consecutive years. Despite the fact that the present monitoring study has been operating for approximately 3 years, the data record is not continuous, and has large gaps at each site in all years as a result of power outages, breakdown of telecommunications (Tsay Keh in particular) and instrument malfunctions and necessary service repairs. As well, the largest gaps in the data record were most often in the winter months which would skew and artificially raise the numerical value of 98^{th} percentile value of the $PM_{2.5}$ concentrations. In that three years of continuous TEOM data are not available at this point for Tsay Keh or Fort Ware, the numerical value of the CWS is used here as an approximation for the level of exceedances of $PM_{2.5}$ at these sites. Exceedance of PM_{10} for the two sites is based on the British Columbia's existing AQO of 50 µg m^{-3} (24-hour average). Table 3.2 presents the dates and levels of PM_{10} and $PM_{2.5}$ exceedances at the TEOM sampling sites during the 2013 sampling period.

TABLE 3.1. COMPARISON OF MAXIMUM, MINIMUM AND STANDARD DEVIATIONS OF THE 24-HR PM_{10} AND $PM_{2.5}$ TEOM CONCENTRATIONS FOR 2012 AND 2013.

Parameter	Tsay Keh		Fort Ware	
	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
	(µm^{-3})			
Max 2013	17.9	39.3	34.9	59.5
Min 2013	*	*	0.2	1.7
Std. Dev 2013	2.8	5.2	5.1	9.1
Max 2012	25.5	37.9	36.4	91.8
Min 2012	0.1	*	0.1	0.2
Std. Dev 2012	3.1	6.0	5.5	11.6

* below detectable limit

TABLE 3.2 EXCEEDANCES OF THE NUMERICAL VALUE OF THE CWS FOR THE TEOMS AT TSAY KEH AND FORT WARE DURING THE 2013 SAMPLING YEAR.

	Tsay Keh		Fort Ware		
Date	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	
	µgm^{-3}				
20-Jan-13			28.1		
6-May-13				59.5	
Total Exceedances					**Total**
	0	0	1	1	2

As can be seen in Figs. 3.5, 3.6 and Table 3.2, $PM_{2.5}$ and PM_{10} concentrations were low at both Tsay Keh and Fort Ware during 2013. At Tsay Keh, $PM_{2.5}$ ranged from Below the Detectable Limit (BDL) to 17.9 μgm^{-3} in 2013, as compared to 0.1 to 25.5 $\mu\ m^{-3}$ in 2012. The $PM_{2.5}$ concentrations for both locations in 2013 ranged from 0.1 to 39.3 μgm^{-3} as compared to a similar range of BDL to 37.9 μgm^{-3} in 2012.

Surprisingly, there were no exceedances of either $PM_{2.5}$ or PM_{10} at Tsay Keh during 2013 based on the TEOM data (Table 3.1 and Figs. 3.3 and 3.5). These results are very similar to those found in 2012 (Table 3.1). In comparison, Fort Ware had one exceedance each of $PM_{2.5}$ and PM_{10}, both of which were just above the associated standards. During mid-May Ft. Ware had four additional PM_{10} measurements that were just marginally below the BC AQ, three of which were at or only marginally above the CWS and BC AQO. All three exceedances were associated with northerly winds but with velocities well below the entrainment threshold velocity of either sand or dust (Nickling et al. 2012). Comparative dust concentrations at Tsay Keh were also very low and associated with very low speed winds from the north. Exceedances on July 9 and 24 were associated with southerly winds that also resulted in fairly high dust concentrations at Tsay Keh. It would appear that all three of the exceedances in Ft. Ware were likely due to ongoing construction activity at the new Health Care Facility and Band Office located west of the TEOM site. As well, the main, gravel access road to the Health Care Centre and the village is located between the TEOM and the construction site. As a result, it is likely that these exceedances are associated with dust being generated from the road and the construction site. From an anecdotal perspective, localized dust plumes were visible at the construction sites when the TEOM site was visited for regular maintenance during this period. Although it is not a major issue, it may be advisable to consider moving this site further from the roadway east of the school.

The low $PM_{2.5}$ and PM_{10} concentration found in the villages and at the regional sites in 2013, as well as in 2011 and 2012, can be attributed to several factors. Based on several years of observations, it appears that the major factor that results in low concentrations in the spring and early summer is the water level elevation in the early spring and the maximum pool level in a given year. An early high water level with a rapid rise to a full pool such as occurred in 2012 and 2013(Fig. 3.7) appears to lead to low PM values. In years such as these the fact that pool levels during the early spring were quite high meant that even in the early spring a large proportion of the surface area that is potentially susceptible to erosion was already covered by water from the previous year, thus decreasing the potential for dust storms and high levels of PM.

A second factor that may have resulted in lower atmospheric loadings, at least during the 2013 dust season was the relatively high precipitation levels during the spring and early summer of that year. Higher precipitation levels in 2013 and more frequent precipitation events (see Appendix III), tended to keep the beach surfaces damp, suppressing dust entrainment.

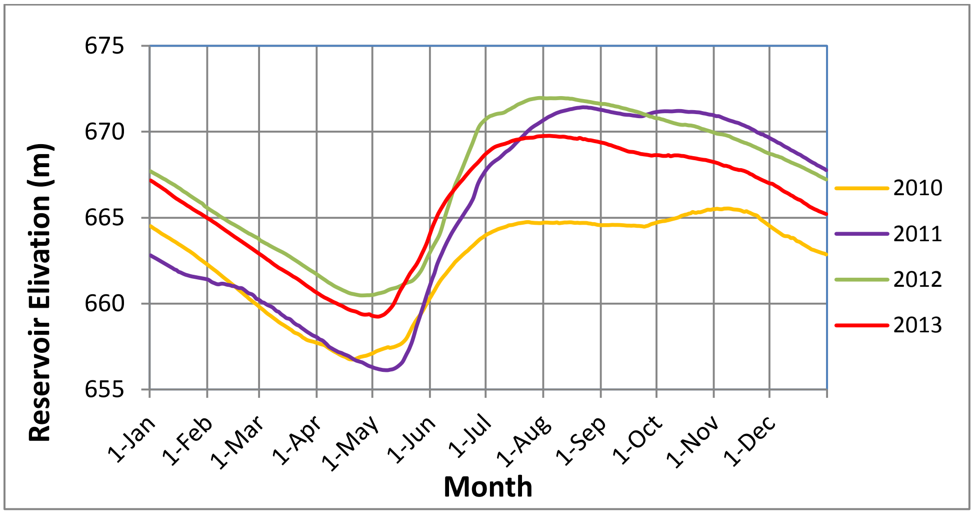


FIGURE 3.7. CHANGE IN DAILY WATER LEVELS OF THE WILLISTON RESERVOIR FOR 2010 TO 2013.

Figure 3.8 shows the comparison of the BGI derived $PM_{2.5}$ and PM_{10} concentrations between Tsay Keh and Fort Ware. The red regression line represents the average relationship for $PM_{2.5}$ and PM_{10} between the two sites. As can be noted, atmospheric dust loadings at Tsay Keh tend to have a greater proportion of $PM_{2.5}$ than at Fort Ware whereas Fort Ware tends to have a greater proportion of PM_{10}.

These observations suggest that in most cases the source(s) of PM are different for the two sites. The dominance of coarse PM at Fort Ware suggests that the sources are likely more localized with the heavier PM_{10} particles remaining in suspension over shorter distances. As noted above the most likely sources of the atmospheric particulates are the nearby construction sites and the main gravel roadway through the village. In contrast the generally finer material found at Tsay Keh is likely derived from longer distance transport of PM derived from beaches downwind of the village. The colour of material collected on TEOM filters provides some indication of the source of aerosols in a given area and time. In Fig. 3.9 filters removed from the TEOM during different times of the year are shown (N.B. depending on the loading filters may be changed up to once a month). The TEOM filters images in Fig 3.9 show a clear difference between the characters of particulate matter in the atmosphere during different seasons of the year. Figure 3.9B is a filter from the spring dust season and is characterized by a heavy loading of light grey-brown coloured particulates that is associated with mineral dust. As can be seen, the adjacent filter (Fig 3.9C) is less heavily loaded but still brown in colour reflecting the collection of mineral dust during the summer months. In contrast the filters from the fall and winter months are dark grey (Fig 3.9D) and black (Fig 3.9A) in colour, which reflect the collection of wood smoke particles, typically $PM_{2.5}$, when wood is being burned in the village for home heating. The colour of these filters suggests that wood

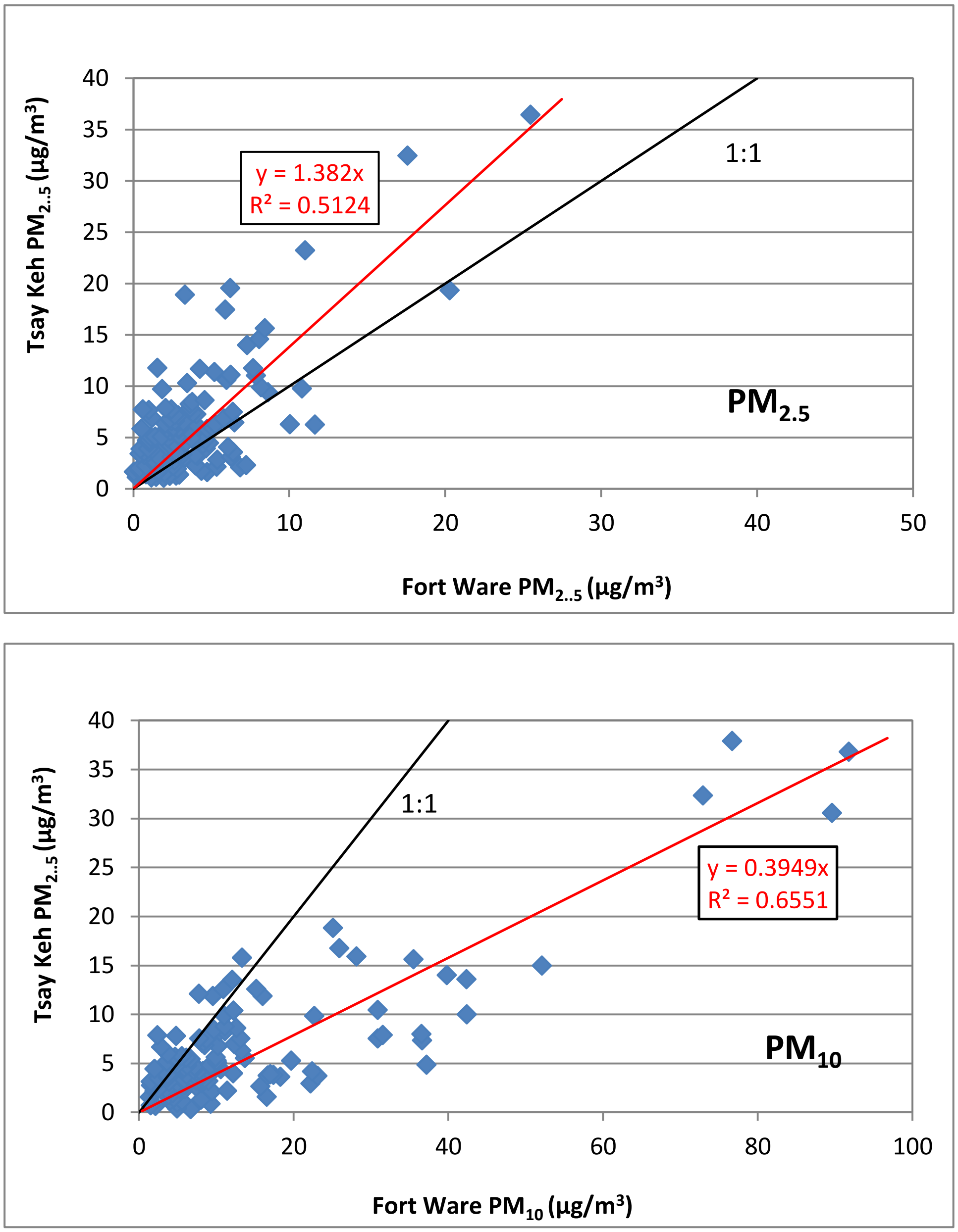
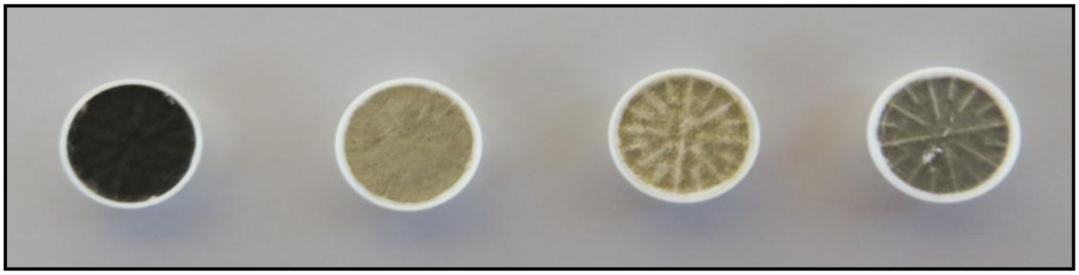


FIGURE 3.8. COMPARISON OF 24-HR AVERAGE PM_{10} AND $PM_{2.5}$ CONCENTRATIONS AT TSAY KEH AND FORT WARE.



(A) DEC - FEB (B) MAR – MAY (C) JUN – AUG (D) SEP - DEC

FIGURE 3.9 FILTERS FROM THE TSAY KEY TEOM THAT WERE COLLECTING $PM_{2.5}$ FOR DIFFERENT PARTS OF THE YEAR (DECEMBER 2012 TO DECEMBER 2013) SHOWING THE DISTINCT COLOUR VARIATION DUE TO THE NATURE OF THE PM COLLECTED.

smoke in the village is a major component of fine aerosols in the atmosphere during the winter months and should be considered a major pollutant.

It has been widely reported in the scientific and government literature that frequent exposure to wood smoke can pose a serious health hazard that can affect both the lungs and heart because of the particle size and the presence of volatile chemicals (e.g., BC Air Quality, 2013, http://www.bcairquality.ca/topics/wood-burning-appliances.html;EPA, 2007, http://www.epa.gov/burnwise/pdfs/woodsmokehealth_effects_jan07.pdf).

Results of this monitoring study suggests that a review of the role of wood smoke contributions to local PM in the village should be considered with an important goal of reviewing the efficiency of the types of stoves and fireplaces in Tsay Keh homes, which influence the quantity and composition of PM created during combustion.

4.0 PM CONCENTRATIONS AT THE BGI REGIONAL SITES

Average 24-hr $PM_{2.5}$ and PM_{10} concentrations, as well as associated meteorological data for the 2013 snow free season measured using paired BGI PQ200 samplers located around the Williston Reservoir (Fig. 2.7) are given in Appendix II. These data represent samples collected using a one-in-three day sampling schedule from May 25 to June 27, 2013 and one-in-six day schedule from June 27 to October 7, 2013. Time series plots showing PM and meteorological data for each of the nine sampling sites are presented in Figs. 4.1A to I. In addition, Table 4.1 provides a summary of 24-Hr average $PM_{2.5}$ and PM_{10} concentrations for the sampling days at each of the nine sites.

As can be noted in the time series and tabular data for the regional BGI samplers, both the PM_{10} and $PM_{2.5}$ dust concentrations were generally very low during the 2013 sampling period and are similar but generally lower than those recorded at these sites in 2012 and in particular, during 2011 (Nickling et al., 2011).

Average maximum 24-hr PM_{10} BGI concentrations at the sites in 2013 ranged from a low of below the detectable limit at Stromquist to a high of 102.2 µg m^{-3} at Pete Toy. $PM_{2.5}$ concentrations at the sites ranged from below the detectable limit at almost all sites to a maximum of 12.8 µg m^{-3} at Davis. In comparison PM_{10} concentrations at Tsay Keh ranged from 2.9 to 40.7 µg m^{-3}, which is very comparable to the 2012 range of 0.8 to 42.4 µg m^{-3}. On a seasonal basis, the highest average PM_{10} concentrations were measured at Rat Lake, Stromquist and Pete Toy with the lowest average PM_{10} values measured at Chowika and Davis. This pattern is similar to that observed in both 2011 and 2012, but with generally lower average concentrations.

In general, higher concentrations were associated with southerly wind flows. Minimum average 24-hr PM_{10} values were very low, particularly during the late fall and winter months of 2013, which again is a pattern that was observed in both 2011 and 2012.

A striking feature of the 2013 Regional Air Monitoring data are the very low levels of $PM_{2.5,}$ which were typically well below 10 µg m^{-3} at all sites on most days (Fig. 4.1A-I and Table 4.1). Average PM_{10} concentrations measured in 2013 were very similar, but somewhat lower than those measured in 2011 and 2012 by 3.0% and 1.8%, as can be seen in Table (4.2), which compares concentration between the three sampling years. In contrast the average $PM_{2.5}$ for the nine sites was more similar in 2013, 2012 and 2011 than was observed for 2010. In these three years the mean values were considerably lower than those measured in 2010 (Table 4.2). The lower concentrations in these three years are likely associated with the higher water levels and higher precipitation in during the spring and summer. In contrast 2010 had considerably lower water levels (Fig 3.7) and somewhat less precipitation and as a result, much higher $PM_{2.5}$ and PM_{10} levels (Nickling et al. 2010)

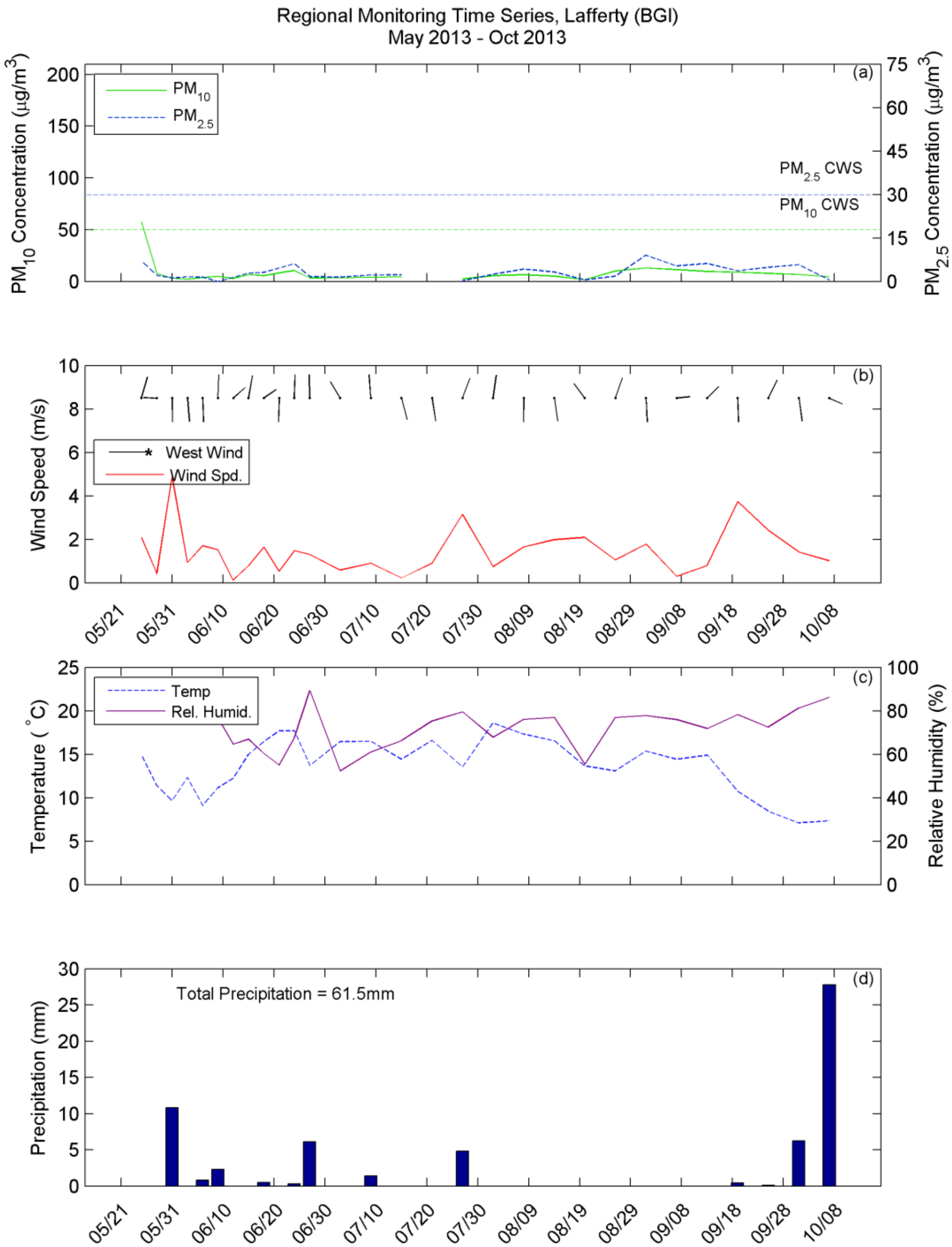


FIGURE 4.1A. TIME SERIES OF 24-HR AVERAGE BGI PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR LAFFERTY.

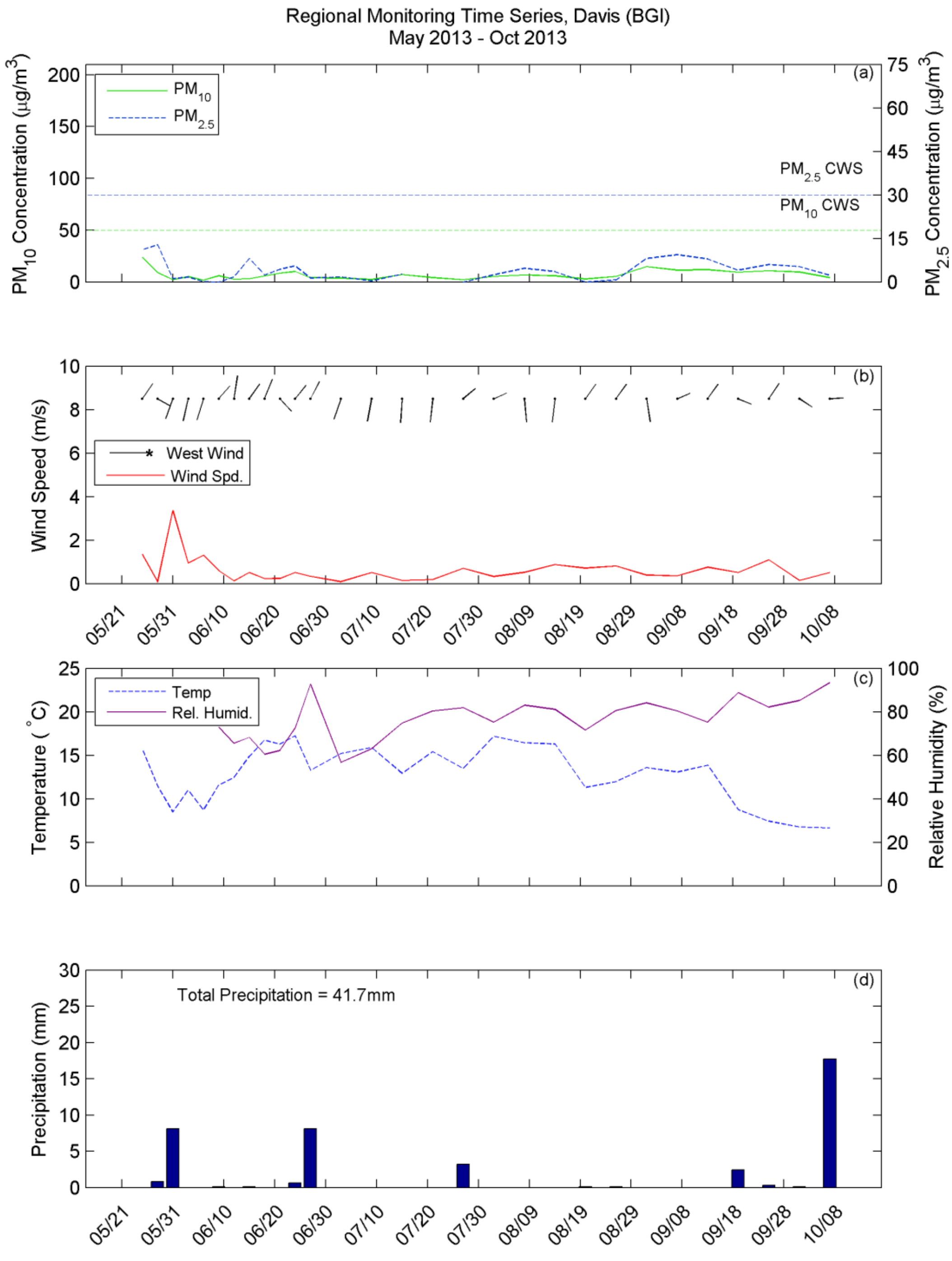


FIGURE 4.1B. TIME SERIES OF 24-HR AVERAGE BGI PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR DAVIS.SOUTH

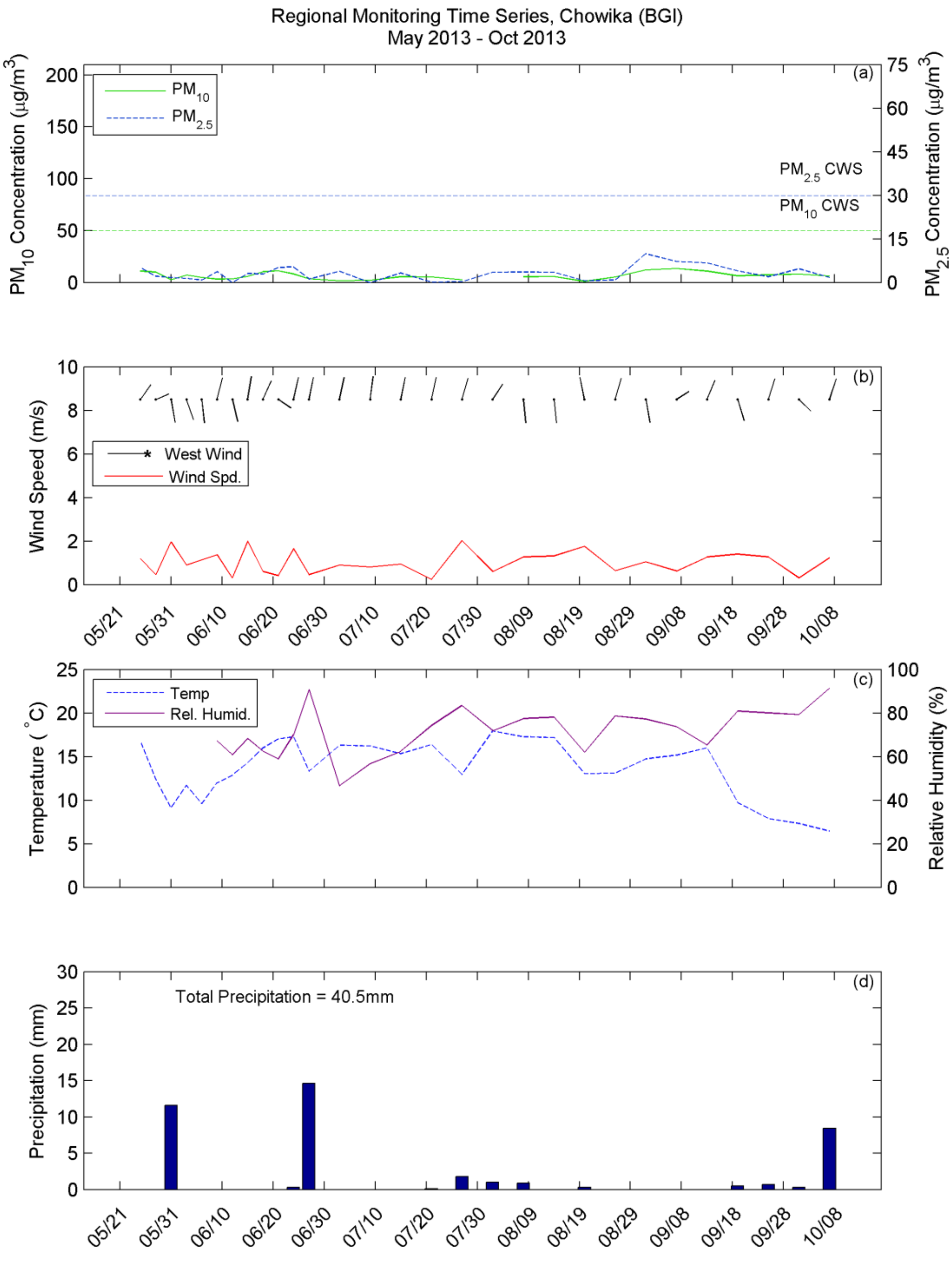


FIGURE 4.1C. TIME SERIES OF 24-HR AVERAGE BGI PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR CHOWIKA.

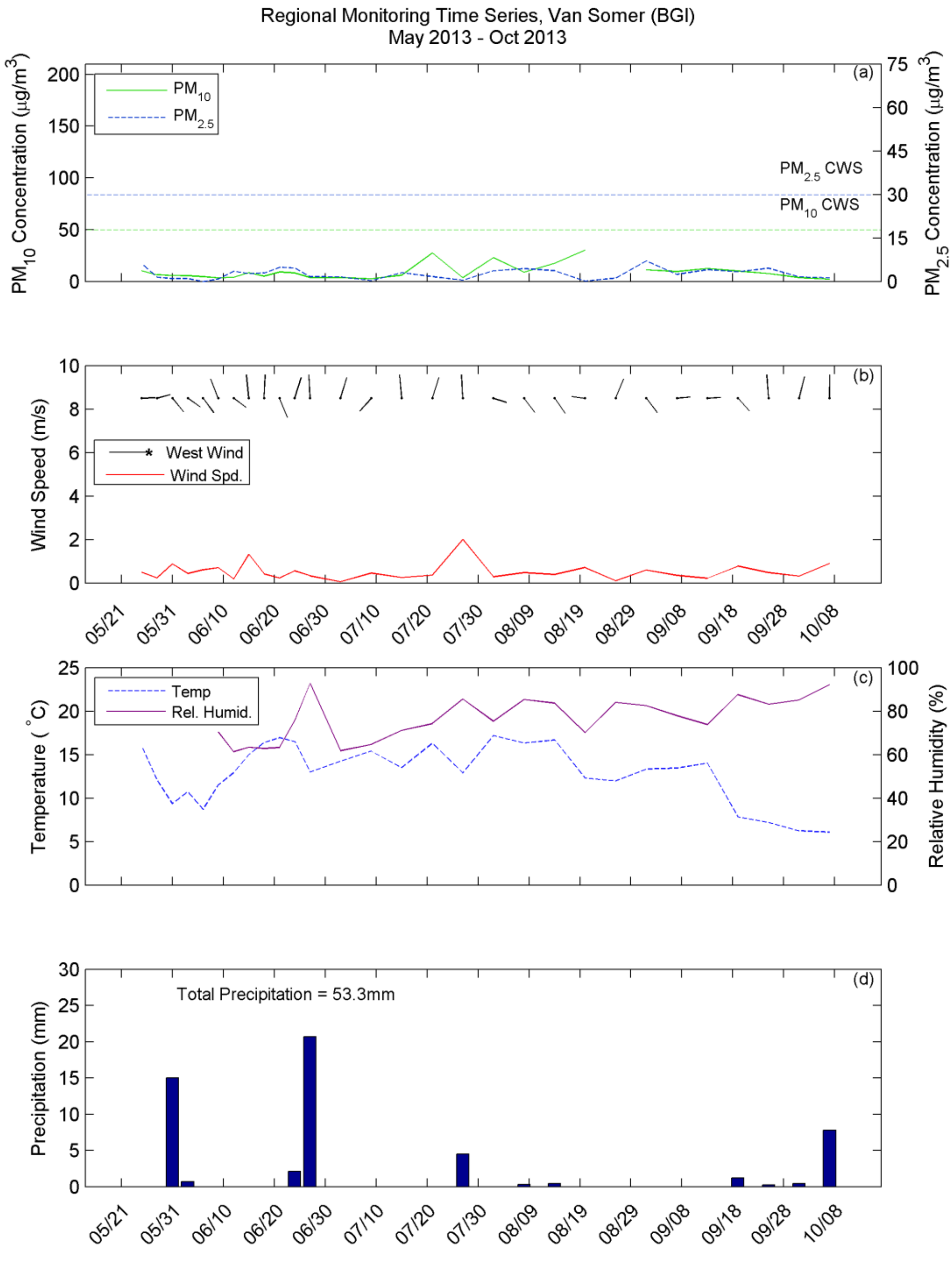


FIGURE 4.1D. TIME SERIES OF 24-HR AVERAGE BGI PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR VAN SOMER.

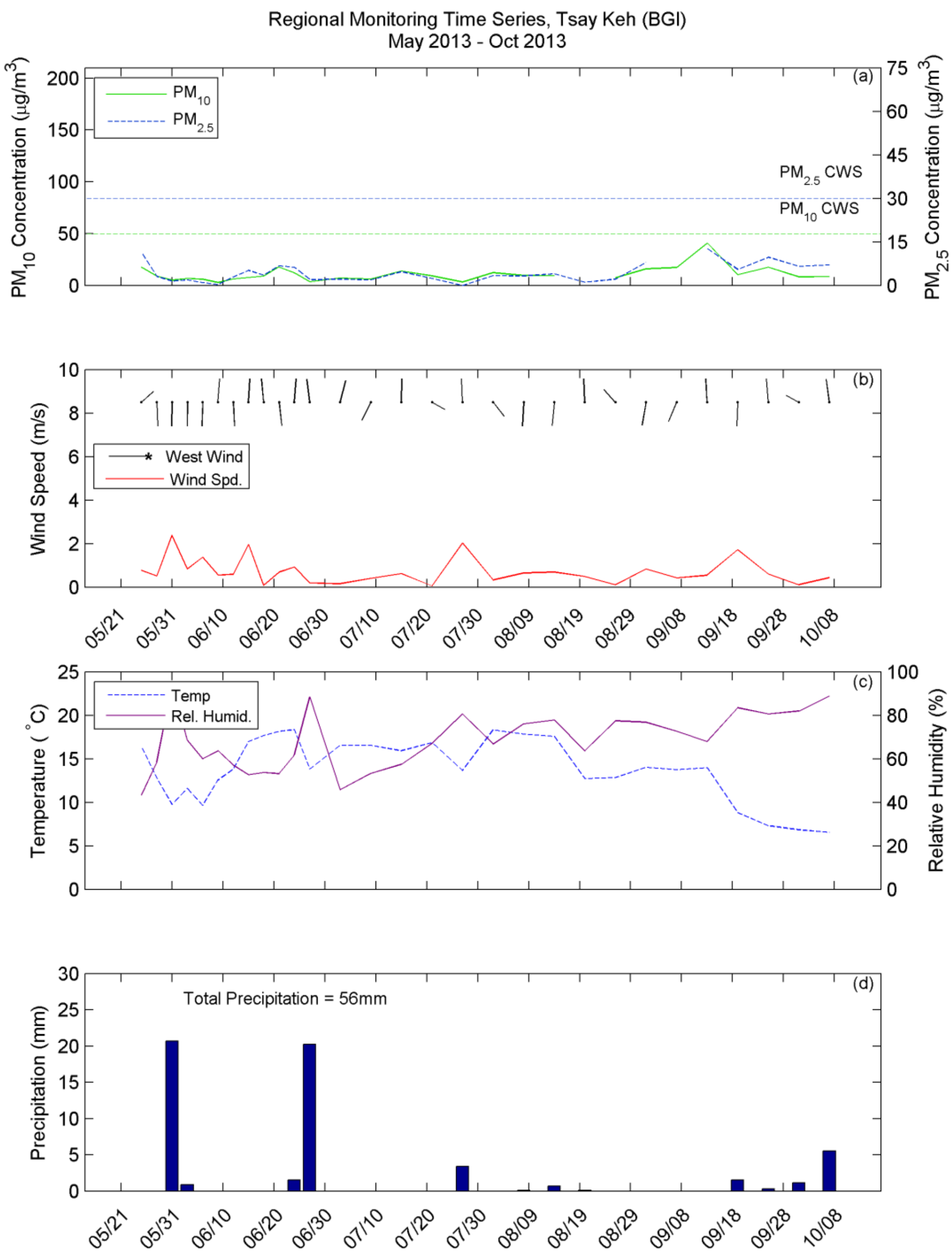


FIGURE 4.1E. TIME SERIES OF 24-HR AVERAGE BGI PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR TSAY KEH.

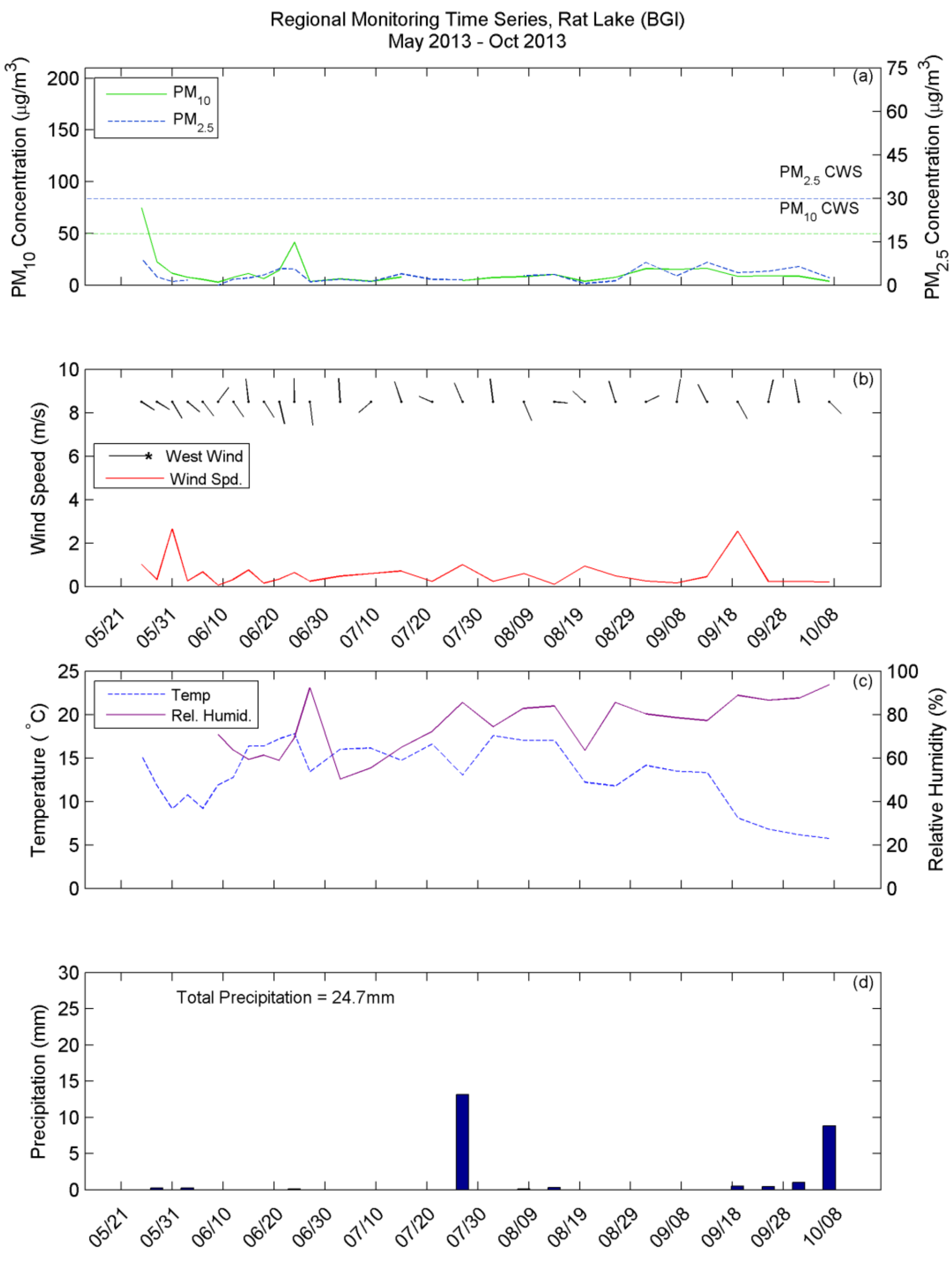


FIGURE 4.1F. TIME SERIES OF 24-HR AVERAGE BGI PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR RAT LAKE.

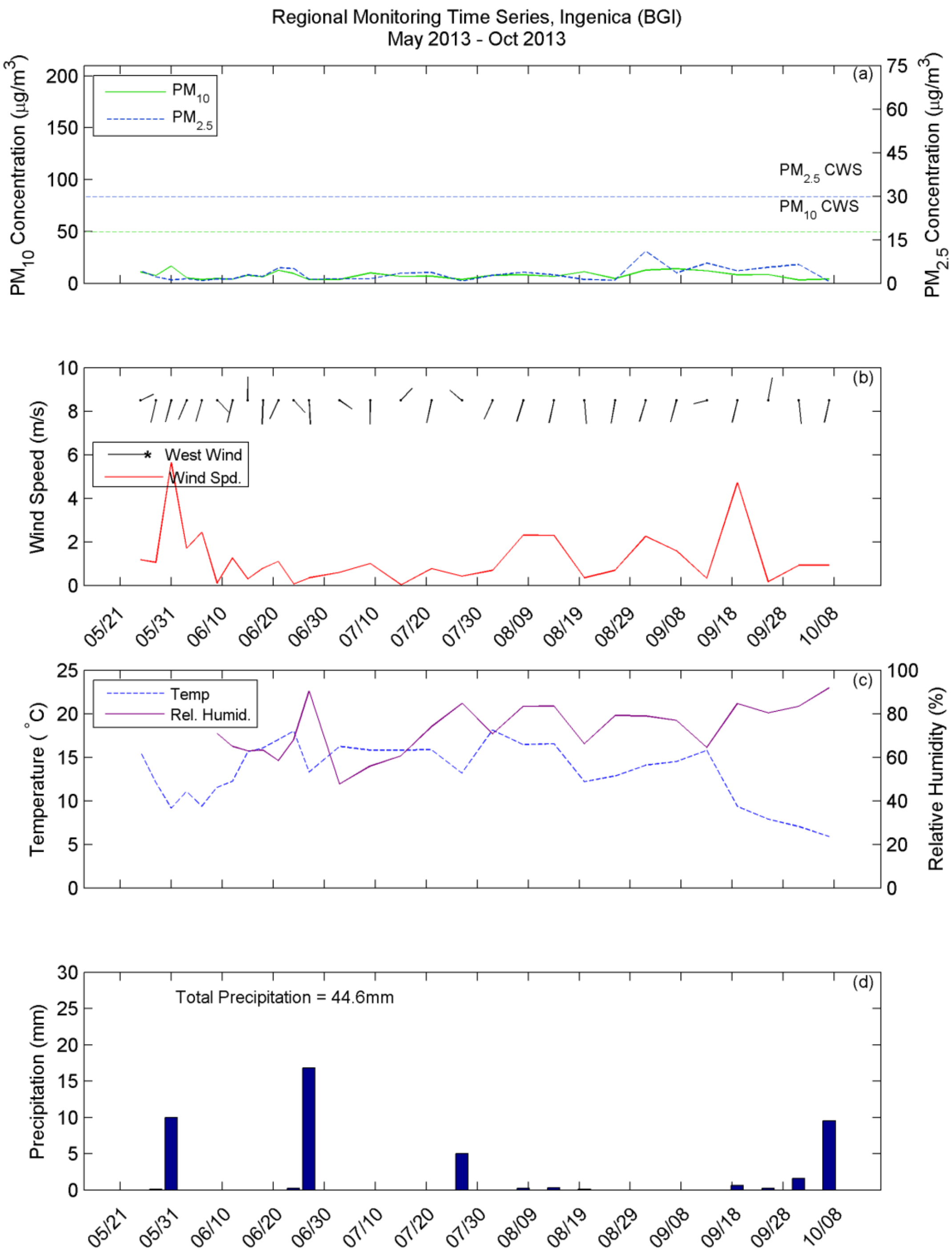


FIGURE 4.1G. TIME SERIES OF 24-HR AVERAGE BGI PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR INGENICA.

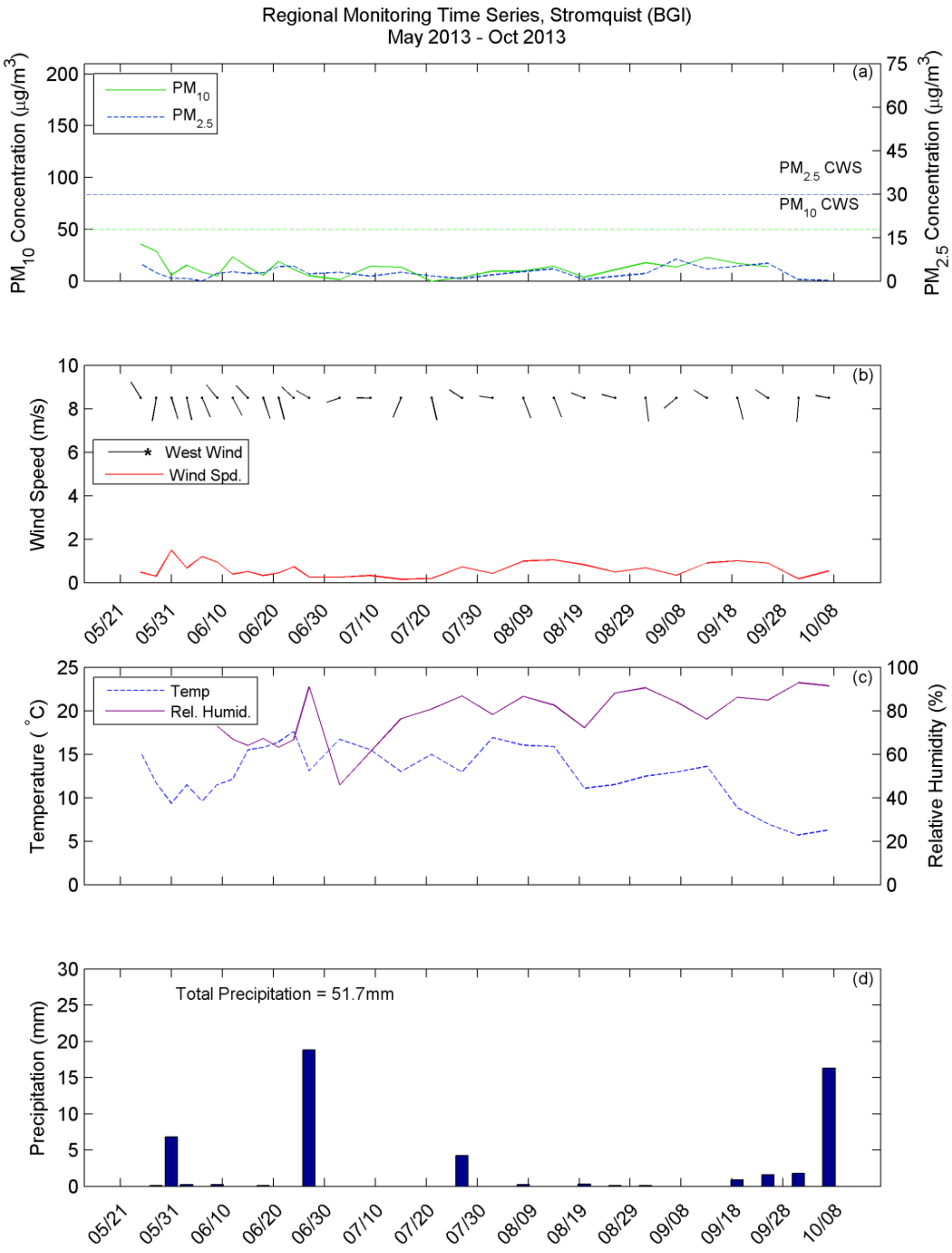


FIGURE 4.10H. TIME SERIES OF 24-HR AVERAGE BGI PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR STROMQUIST.

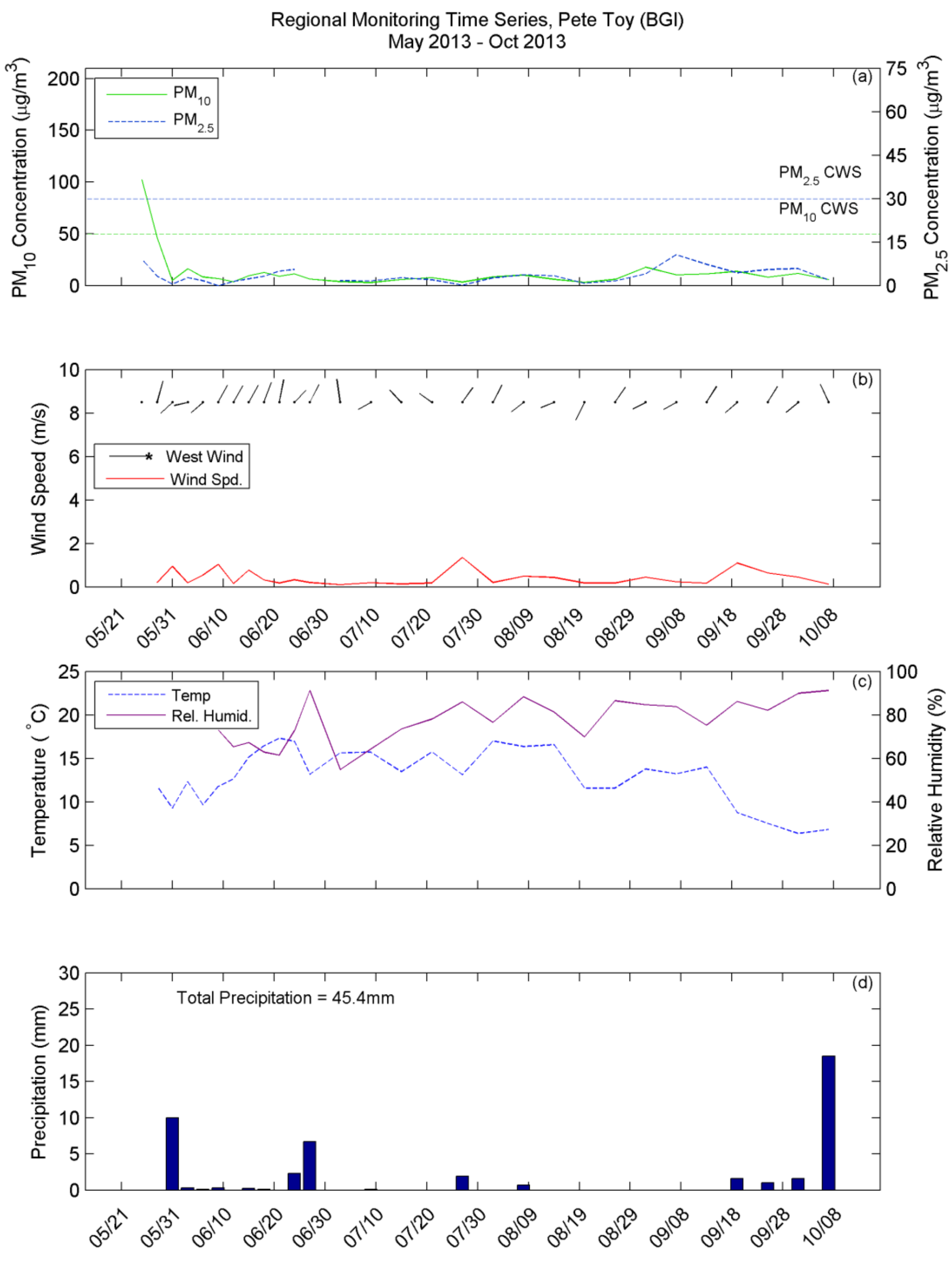


FIGURE 4.10I. TIME SERIES OF 24-HR AVERAGE BGI PM_{10} AND $PM_{2.5}$ CONCENTRATIONS SHOWING WIND SPEED AND DIRECTION, TEMPERATURE, RELATIVE HUMIDITY AND PRECIPITATION FOR PETE TOY.

TABLE 4.1. 24-HR AVERAGE $PM_{2.5}$ AND PM_{10} CONCENTRATIONS MEASURED AT THE BGI SAMPLING SITES, 2013.

Date	Lafferty		Davis		Chowika		Van Somer		Tsay Keh		Rat Lake		Ingenica		Stromquist		Pete Toy	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
	24-hr Average Concentration (µg/m^3)																	
25-May-13	57.8	7.1	23.9	11.1	11.0	5.2	10.2	6.2	17.5	11.4	74.7	9.2	10.9	4.4	35.5	5.9	102.2	9.1
28-May-13	7.4	2.1	8.8	12.8	10.1	2.1	6.3	1.4	8.9	3.1	22.5	2.9	7.5	2.2	29.1	2.8	45.8	3.2
31-May-13	3.1	1.2	2.0	1.2	2.7	1.7	5.8	1.0	5.1	1.5	11.3	1.3	16.5	1.2	5.6	1.0	4.8	0.5
03-Jun-13	2.2	1.5	5.1	1.7	7.2	1.4	5.6	1.0	6.7	1.9	7.6	1.7	5.4	1.6	15.5	0.9	16.2	2.7
06-Jun-13	3.7	1.5	1.7	0.1	5.0	0.9	4.7	*	6.1	0.9	5.6	NaN	3.8	1.0	8.4	0.0	8.2	1.6
09-Jun-13	4.9	*	6.0	*	3.3	3.7	3.4	0.8	2.9	0.3	2.8	*	4.6	1.5	4.9	2.7	6.6	*
12-Jun-13	2.9	1.4	2.7	1.7	3.5	*	4.0	3.5	6.3	2.9	7.5	2.0	4.0	1.5	23.5	3.2	3.5	1.4
15-Jun-13	6.7	2.9	3.0	8.1	5.8	3.1	8.5	2.7	7.7	5.2	11.1	2.5	7.7	2.9	13.4	2.6	9.3	2.3
18-Jun-13	5.6	3.1	5.8	2.4	10.4	3.0	5.1	2.9	8.8	3.5	6.2	3.5	6.3	2.4	5.6	2.8	12.4	3.2
21-Jun-13	8.3	4.7	8.4	4.4	11.1	5.2	9.1	4.9	17.8	6.7	14.4	5.7	12.5	5.4	19.0	5.1	8.9	5.0
24-Jun-13	10.4	6.1	10.2	5.5	8.2	5.3	8.3	4.6	12.1	6.2	41.4	5.6	9.7	5.2	11.3	5.1	11.1	5.5
27-Jun-13	3.4	1.7	4.1	1.3	3.5	1.2	3.7	1.6	3.4	2.0	3.5	1.2	3.7	1.4	5.2	2.5	6.3	NaN
03-Jul-13	3.5	1.5	3.7	1.7	3.9	1.8	3.8	1.6	7.0	2.2	5.9	2.0	3.7	1.6	1.4	3.0	3.7	1.6
09-Jul-13	4.0	2.2	2.5	0.3	2.0	*	2.5	0.2	6.2	1.9	3.8	1.3	10.1	1.5	14.4	1.6	2.8	1.5
15-Jul-13	4.4	2.3	7.2	2.7	5.5	3.2	6.0	3.0	14.0	4.7	7.9	3.9	6.7	3.5	13.4	3.0	5.8	2.7
21-Jul-13	NaN	NaN	4.1	NaN	5.2	0.1	27.4	1.6	9.1	2.4	NaN	2.0	6.8	3.7	*	1.7	7.5	2.0
27-Jul-13	2.4	0.2	2.2	*	2.6	0.3	3.5	0.4	3.3	*	4.5	1.9	3.8	0.8	3.4	0.8	3.3	0.1

NaN: Missing Data   * : Below Detectable Limit

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TABLE 4.1. 24-HR AVERAGE $PM_{2.5}$ AND PM_{10} CONCENTRATIONS MEASURED AT THE BGI SAMPLING SITES (CONT'D).

Date	Lafferty		Davis		Chowika		Van Somer		Tsay Keh		Rat Lake		Ingenica		Stromquist		Pete Toy	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
	24-hr Average Concentration (μg/m^3)																	
02-Aug-13	5.6	2.5	5.3	2.5	NaN	3.5	22.8	3.7	12.3	3.4	7.4	NaN	7.9	2.8	9.6	2.1	8.2	2.6
08-Aug-13	6.4	4.2	6.6	4.7	5.6	3.6	8.9	4.4	9.5	3.3	8.3	3.2	8.2	3.9	9.6	3.2	10.0	3.7
14-Aug-13	5.1	3.2	5.9	3.6	5.7	3.5	17.4	3.7	9.5	4.0	10.3	3.7	6.6	3.0	14.4	4.2	5.9	3.4
20-Aug-13	1.6	0.5	2.9	*	1.0	0.6	30.2	0.1	NaN	1.1	3.8	0.5	11.1	1.3	3.8	0.5	3.0	0.8
26-Aug-13	10.1	1.8	5.4	0.7	5.4	0.8	NaN	1.2	7.4	2.1	7.5	1.5	4.6	1.1	10.9	1.7	5.9	1.5
01-Sep-13	13.0	9.1	14.7	8.1	12.0	9.9	11.1	7.2	15.8	7.9	16.0	7.8	12.8	11.1	17.7	2.6	17.8	4.0
07-Sep-13	11.4	5.3	11.4	9.4	13.4	7.2	9.6	2.5	17.2	NaN	15.2	3.2	14.0	3.6	13.5	7.5	10.4	10.6
13-Sep-13	9.7	6.2	11.9	7.9	10.9	6.7	12.6	4.1	40.7	12.7	16.2	7.9	12.0	6.9	22.9	4.1	11.2	7.3
19-Sep-13	8.9	3.7	9.3	4.1	6.4	4.0	10.1	3.3	10.3	5.5	8.4	4.3	8.3	4.3	17.1	5.1	13.7	4.4
25-Sep-13	7.7	4.9	10.7	6.0	7.3	2.0	7.6	4.5	17.4	9.7	8.8	4.8	8.4	5.5	13.8	6.2	8.0	5.5
01-Oct-13	6.7	5.8	9.5	5.2	8.1	4.7	3.7	1.5	8.3	6.6	8.8	6.4	3.3	6.5	NaN	0.5	11.6	5.8
07-Oct-13	4.4	0.5	4.1	2.3	6.2	1.7	2.1	1.2	8.5	7.1	3.8	2.6	4.3	0.6	5.6	0.3	5.8	1.9

NaN: Not Available *: Below Detectable Limit

TABLE 4.2. COMPARISON OF MEAN ANNUAL PM_{10} AND $PM_{2.5}$ VALUES AMONG SITES 2010 – 2013.

Location	Lafferty		Davis South		Chowika		Van Somer		Tsay Key		Rat Lake		Ingenica		Stromquist		Pete Toy		Annual Average	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Year	Concentration (µg m-3)																			
Mean 2013	7.9	3.1	6.9	3.9	6.5	3.1	9.1	2.6	10.7	4.3	12.3	3.4	7.8	3.2	12.4	2.9	12.8	3.4	9.0	3.5
Mean 2012	10	3	7	2.1	7.2	2.5	9.1	2.5	14	4	26	3	7.1	2.4	23	3	10	2	12.7	2.4
Mean 2011	15	3	5	1	na	na	na	na	10	1	8	3	na	na	22	2	14	5	10.6	2.1

Difference	Difference in Concentration Between Years (%)																		Avg. Ann. Diff. %	
																			PM_{10}	$PM_{2.5}$
2013 and 2012	-2.1	0.1	-0.1	1.8	-0.7	0.6	0.0	0.1	-3.3	0.3	-13.7	0.4	0.7	0.8	-10.6	-0.1	2.8	1.4	-3.0	0.6
2013 and 2011	-7.1	0.1	1.9	2.9	na	na	na	na	0.7	3.3	4.3	0.4	na	na	-9.6	0.9	-1.2	-1.6	-1.8	1.0
2012 and 2011	-5	0	3	1	na	na	na	na	4	3	18	0	na	na	-1	1	-4	-3	2.4	0.3

TABLE 4.3. PM_{10} AND $PM_{2.5}$ EXCEEDANCES AT THE BGI SAMPLING SITES DURING THE 2011 - 2013 STUDY PERIOD

Date	Lafferty		Davis		Chowika		Van Somer		Tsay Keh		Rat Lake		Ingenica		Stromquist		Pete Toy			
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$		
21-May-11	51				na	na	na	na					na	na						
27-May-11	51				na	na	na	na	64				na	na						
2-Jun-11					na	na	na	na					na	na	80					
7-Jun-11					na	na	na	na	62				na	na						
13-Jun-11					na	na	na	na					na	na	53					
19-Jun-11					na	na	na	na					na	na	57					
26-Jun-11					na	na	na	na					na	na	159					
27-Jun-11	175				na	na	na	na					na	na						
30-Jun-11	55				na	na	na	na					na	na	77					
1-Jul-11	58	65			na	na	na	na					na	na	104					
13-Jul-11					na	na	na	na					na	na	121					
14-Jul-11					na	na	na	na					na	na	125					
29-Jul-11					na	na	na	na			78		na	na						
2-Sep-11					na	na	na	na	57				na	na					**Total 2011**	**18**
27-May-12	50																61			
30-May-12	82		92				99								139		51			
14-Jul-12											63									
20-Jul-12											91									
7-Aug-12											80									
6-Sep-12											166								**Total 2012**	**11**
25-May-13	57										74						102		**Total 2013**	**3**
Total number of exceedances above CWS 2011-2013	8	1	1	0	0	0	1	0	3	0	6	0	0	0	9	0	3	0	**Total**	**32**

na: equipment not deployed at the particular site during current year

During 2013 there were very few exceedances above the 50 μg m^{-3} PM_{10} BC standard. In addition there were no exceedances of the 30 μg m^{-3} $PM_{2.5}$ CWS or the new BC provincial standard for $PM_{2.5}$ of 25 μg m^{-3} (Table 4.3). Overall, there were a total of eleven exceedances of the BC PM_{10} standard with the largest number at Rat Lake (4) followed by Lafferty and Pete Toy with two each, with one exceedance at Davis, Stromquist and Van Somer. There were no exceedances of either the $PM_{2.5}$ or PM_{10} standards at Tsay Keh, Chowika or Ingenica.

The relatively low dust concentrations and lower number of exceedances of the PM_{10} and $PM_{2.5}$ in 2013 reflects several interrelated factors. Of key importance were the relatively high water levels observed in 2013 that were similar to those observed in 2012 but higher than levels in 2011 (Fig. 3.7). The high water levels were observed at the beginning of the dust seasons in 2012, and 2013, which reduced exposed beach areas thereby limiting the potential source areas for dust entrainment and subsequent transport downwind. Also of importance were the meteorological conditions that worked against entrainment of sand and emission of dust. Wind speeds during 2012 and 2013 were similar in frequency, magnitude and direction and generally lower than those in 2010 with fewer intense storms with regional wind flow from the south (Fig. 3.1 and 4.4). In addition, the 2011 to 2013 monitoring seasons were quite wet with precipitation levels of 250 mm, 277 mm and 286 mm of precipitation during the sampling period in 2011, 2012 and 213 respectively. These high precipitation levels, for over 30-35% of the observation days, in both 2012 and 2013, tended to keep the surface relatively moist, thereby increasing the entrainment threshold and decreasing potential dust emissions. As well, the generally high relative humidity throughout the monitoring periods, in conjunction with the low temperatures and wind speeds likely decreased evaporation keeping the surface relatively moist thereby reducing dust emissions.

Although one might expect that PM_{10} concentrations would tend to increase somewhat proportionally to the increase in wind speed. In 2010, maximum dust concentrations tended to lag up to several hours following the maximum wind speed (Fryrear et al., 2010). In 2013 however, and to some extent in 2011 and 2012, there was little difference between peak wind speeds and maximum concentrations at most sites. This in part reflects the fact that even on windy days dust concentrations were quite low and variable over the 24-hr sampling period and likely derived from individual point sources on the beaches, with little down-wind diffusion that is observed during large dust events and thus not reflected in the 24-hr mean concentrations of PM at individual sites.

It is also of note that in previous years the magnitude and timing of the dust concentrations in relation to wind speed was in many cases controlled by the proximity to large, available dust sources and associated topography. This was not as evident in 2013 because of the low emissions associated with the high water levels and high precipitation. However, the observed pattern of local supply was evident at Lafferty where the instruments are located on a very exposed beach comprised of sand and silts (Fig. 3.3 J). The exposed location and the availability of sediment at this site reflect the relatively large number of exceedances at this site in 2013 (Table 4.3). This pattern reflects the physical processes associated with the entrainment and subsequent transport, diffusion and ultimate deposition of dust in relation to the elevation and physical setting/location of a given sampling site. In general, higher concentrations and shorter lag times are associated with more exposed sites with long fetches and upwind supplies of entrainable sediment. Longer lag times and lower concentrations, often associated with lower wind speeds, are typically associated with less exposed or sites at higher elevations. It should be noted however that these general observations can be skewed as the result of local changes in surface conditions (e.g., moisture content, surface crusting due to precipitation events) and local topography.

4.1 Comparison of TEOM and BGI Measurements at Tsay Keh

Figure 4.5 shows a comparison of the $PM_{2.5}$ and PM_{10} measured with the TEOM and BGI instruments for similar days at Tsay Keh and Fort Ware during 2013. In this figure three curves are shown. The black, linear line shows the 1:1 relationship that would represent perfect agreement between the numerical concentration values derived from the TEOM and BGI instruments. The red line shows a standard regression where the curve is forced through zero. Lastly, the green line represents a standard linear best fit regression with both a slope and an intercept, which typically has a higher correlations coefficient (R^2) than the forced zero regression. As can be seen in these figures, the TEOM measurements consistently underestimate the concentrations measured by BGI samplers for both $PM_{2.5}$ and $PM_{10.}$ Although both the $PM_{2.5}$ and the PM_{10} have reasonable linear correlations between the BGI and TEOM the PM_{10} readings are closer to a 1:1 relationship and have a higher correlation coefficient.

Differences between sampling instruments are not uncommon because of the different technologies involved (Charron, et al. 2004: Environment Canada, 2013). The differences in PM concentrations shown in the 2013 data as well as in many other studies can be attributed to several factors. Very small quantities of $PM_{2.5}$ and PM_{10} can be measured more precisely in a laboratory setting with lower error on larger filters such as that used in the BGI, rather than the much smaller TEOM filter that uses a micro-balance based on an oscillating tapered element.

In addition, the relative weighing error increases as the quantity of sediment measured decreases. In this regard, the relatively low atmospheric concentrations encountered at Williston are at the lower limit of the TEOM sensitivity, especially when hourly measurements are taken. With hourly measurements the mass collected in this time interval at these sites is for most sampling intervals typically minute. The change in the frequency of oscillation of the tapered element cannot be accurately resolved by the associated electronics within the instrument hence there is more uncertainty on the measurement. This can be improved by increasing the length of time between measurements of the oscillation frequency so the mass collected on the filter is greater, but at a loss of temporal resolution.

Another possible error with the TEOM instrument may be associated with the continuous heating of the tapered element environment that ensures a stable environment without which the frequency of oscillation can drift with temperature, but may also result in the loss of volatile components in the PM that would not occur in the standard gravimetric analysis of the BGI filters (Green et al., 2009). In that the differences between the two instruments were relatively small and concentrations very low for both $PM_{2.5}$ and PM_{10}, calibration corrections were not made to the TEOM concentrations based on the relationships in Figs. 4.5 and 4.6.

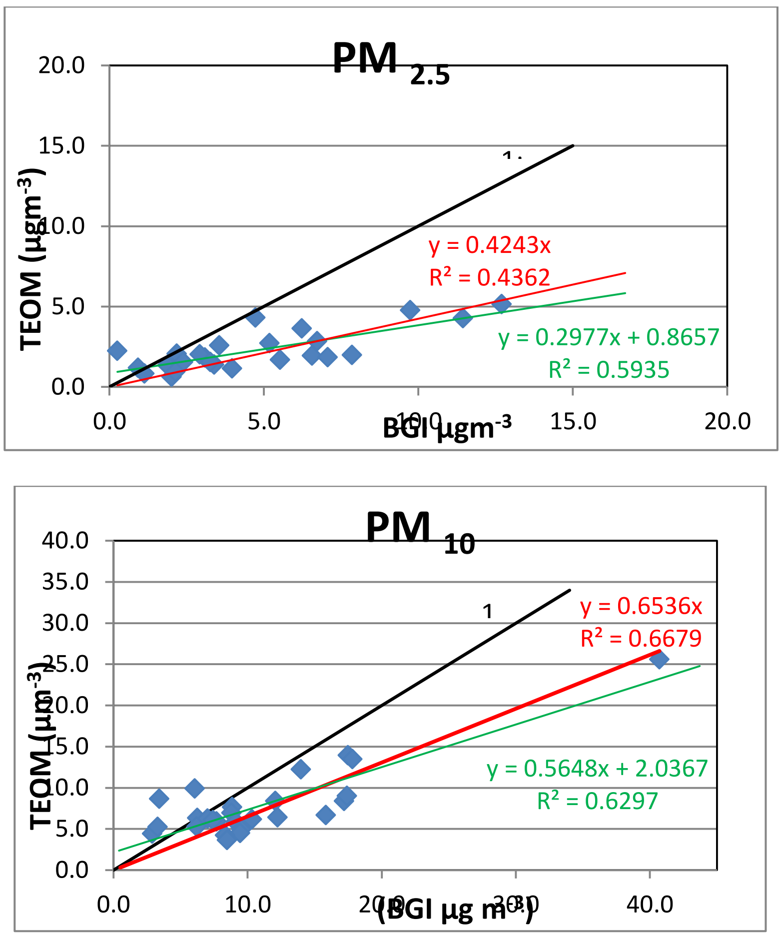

FIGURE 4.5. COMPARISON OF 24-HR PM_{10} (BOTTOM PANEL) AND $PM_{2.5}$ (TOP PANEL) CONCENTRATIONS MEASURED WITH THE TEOM AND THE BGI AT TSAY KEH DURING THE 2013 MONITORING SEASON.

4.3 Inter Year Comparison of PM Concentrations at the Williston Reservoir

During the course of the study (2011-2013) annual average $PM_{2.5}$ and PM_{10} concentrations measured with TEOMs and BGIs were relatively low and quite consistent from year to year. Average PM_{10} values for the three dust seasons (May to September, informally called "*snow to snow*") when atmospheric loadings are typically highest, ranged from 9.0 to 10.6 µg m^{-3} with $PM_{2.5}$ values ranging from 2.1 to 3.5 µg m^{-3} . It should be noted that these values would be considerably lower if the annual average was computed for all 12 months using the Canada wide standard methodology, which is based on the 98th percentile measurement annually, averaged over three consecutive years (Environment Canada, 2014, *Canada Wide Standards*).

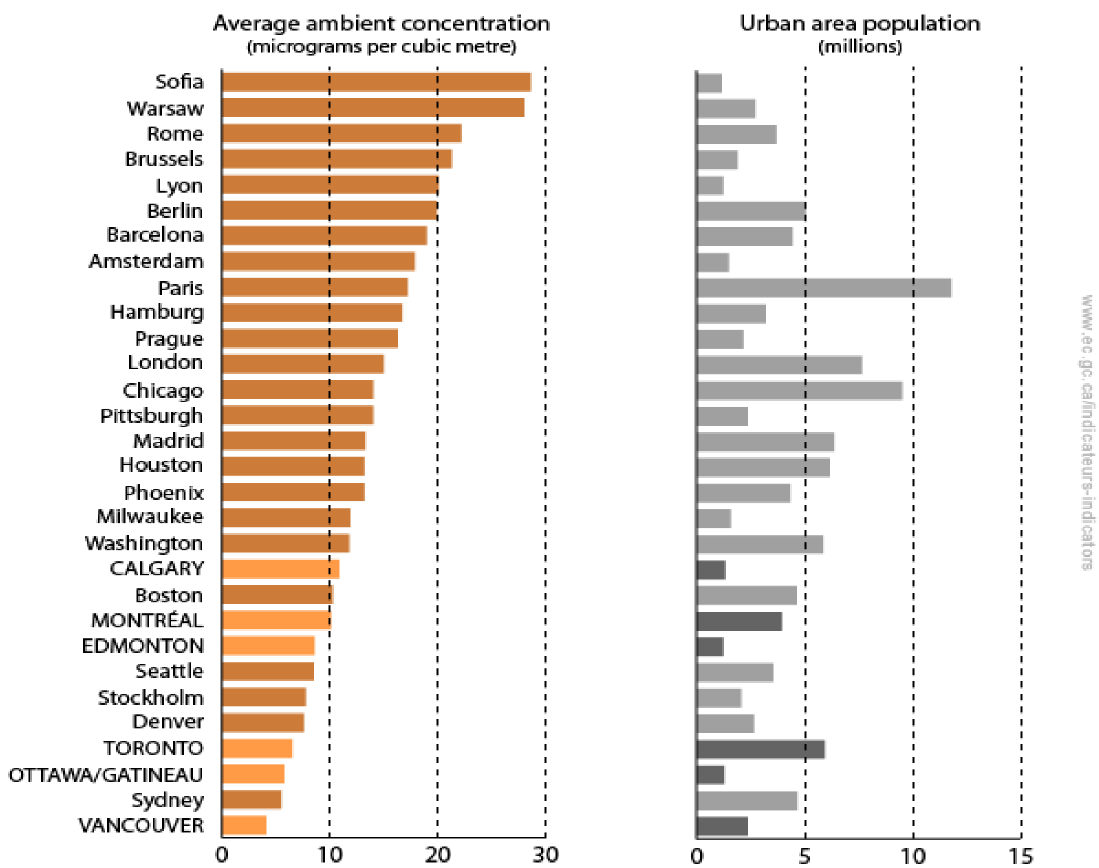

FIGURE 4.6. ANNUAL AVERAGE CONCENTRATIONS OF FINE PARTICULATE MATTER FOR SELECTED CANADIAN AND INTERNATIONAL URBAN AREAS, 2011 (SOURCE: ENVIRONMENT CANADA (2014)

Figure 4.6 above shows a comparison of $PM_{2.5}$ concentrations based on the numerical average of 24-hour daily average concentrations (µg m^{-3}) measured in 2013 for several international urban areas with populations comparable to Canadian urban areas with populations >1 million. It should be noted that caution must be exercised when comparing air quality from these different areas. Beyond population, other factors such as climate, geography, local emissions and trans-boundary pollution can influence air quality. As well, technical and methodological factors such as the type of monitoring equipment used, station location and number of stations for an urban area can also influence the results of the comparison (Environment Canada, 2014).

For the cities used in the comparison (Fig. 4.6), average $PM_{2.5}$ concentrations ranged from a low of 4.1 μgm^{-3} for Vancouver to a high of 28.6 μgm^{-3} in Sofia, Bulgaria. Calgary had the highest $PM_{2.5}$ concentration (10.9 $\mu g\ m^{-3}$) among the large Canadian cities compared in this study. Although not cited in the above study because of its considerably smaller size, Whitehorse has the lowest $PM_{2.5}$ levels (3.06 $\mu g\ m^{-3}$, 8 year average) of all recording cities in Canada (Environment Yukon, 2013) and approximately half the national average of 6.6 μgm^{-3}. Internationally, Canada is viewed to have very good air quality having the third lowest $PM_{2.5}$ values in a recent study of air quality in 33 countries (World Health Organization, 2011). Very high dust concentrations are found in many countries and cities throughout the world with the highest annual average $PM_{2.5}$ concentrations being found in China and India with the highest average urban concentrations found in Beijing (118.5 $\mu g\ m^{-3}$) and Delhi (153.0 $\mu g\ m^{-3}$). Beijing however, holds the dubious honour of having the single highest 24-hr concentration ever recorded (950 μgm^{-3}, January 14, 2013).

Very few $PM_{2.5}$ and PM_{10} data are available in the literature or on government websites for non-urban areas. This results primarily from the fact that in almost all cases PM standards are based on health effects and focus on areas with greater populations.

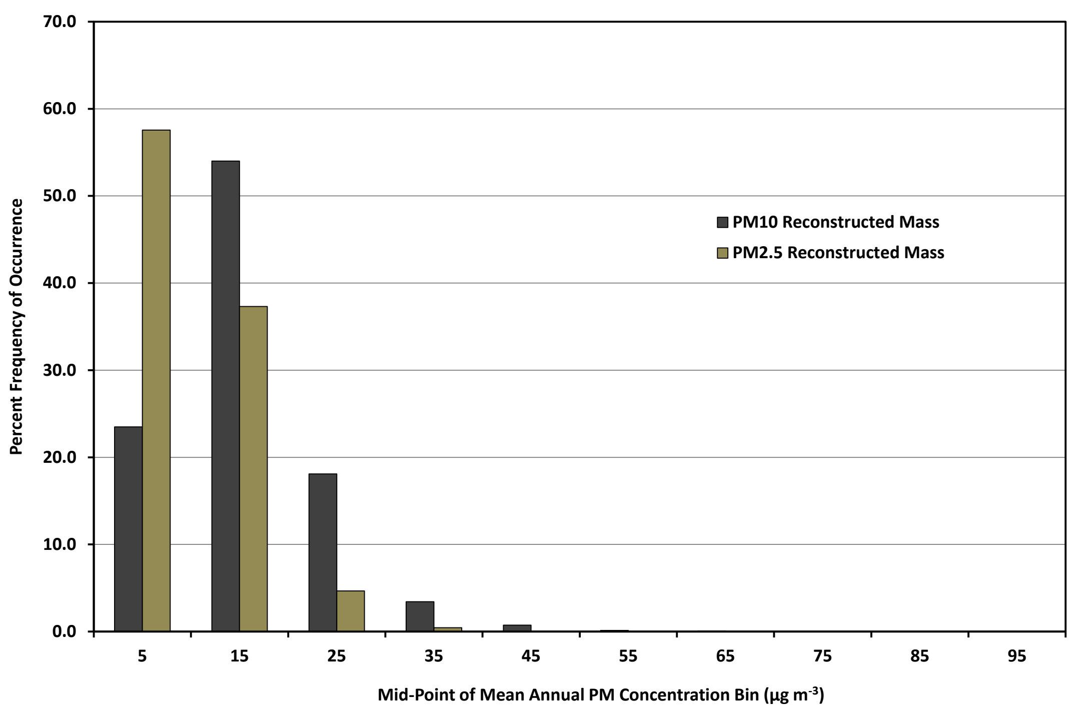

FIGURE 4.7. MEAN ANNUAL PM CONCENTRATION DATA FOR RURAL SITES ACROSS THE USA AS MEASURED AT IMPROVE SITES.

An exception to this is the data collected by the Interagency Monitoring of Protected Visual Environments (IMPROVE) for selected rural locations in the USA on lands under the jurisdiction of the US National Parks Service, Forest Service, Fish and Wildlife Service, Tribal entities, and a host of other governmental agencies. The available data from 1988 through 2008 (http://vista.cira.colostate.edu/improve/Data/IMPROVE/summary_data.htm) indicate that in US rural environments represented by IMPROVE sampling the annual mean reconstructed mass concentration of PM (the IMPROVE estimate for PM_{10}) is 10.5 µg m^{-3} (±7.4 µg m^{-3}). For (reconstructed) $PM_{2.5}$ the annual mean is 5.7 µg m^{-3} (±4.6 µg m^{-3}). The frequency distribution of reconstructed mass concentrations (PM_{10} and $PM_{2.5}$) for the 120 plus IMPROVE sampling locations for the 20 years of available data is shown in Fig. 4.7. As Fig. 4.7 shows, 54% of the data lies between 10 and 20 µg m^{-3}, with 23% between 0 and 5 µg m^{-3} for PM_{10}, and 58% of $PM_{2.5}$ lying between 0 and 5 µg m^{-3}. The three year record of PM data from Tsay Keh and Ft. Ware are well within this range of IMPROVE data, and indeed suggest that the annual mean PM levels at these locations are for the most part lower than those measured in the rural USA as represented by IMPROVE monitoring sites.

In light of the above discussions air quality, at least over the past three years, is surprisingly good around the Williston Reservoir and Ft. Ware, and certainly well below the Canadian average $PM_{2.5}$ concentration of 6.6 µg m^{-3} and well below the CWS (Environment Canada, 2012). However, it is clear that in certain years, particularly when water levels are low in the early spring, and recharge is slow, dust emissions around the reservoir and in Tsay Keh can be quite high with many exceedances above the CWS. This was certainly the case in 2010 when following the clearing of the winter ice cover the pool level was at 656.7 m and only rose to 665.5 m leaving a large area of exposed beaches (Fig. 3.7). The low water levels, coupled with relatively low precipitation levels resulted in very dusty conditions in the region during the spring months. In contrast, higher water levels (Fig. 3.7) and higher than average precipitation, particularly during the spring and early summer months of 2012 and 2013, were associated with very low levels of dust with very few exceedance of the CWS and BC AQO.

Although tillage is well documented as an effective control against sand transport and dust emissions there has not yet been enough hectares effectively tilled at Williston Reservoir, as suggested by Fryrear et al. (2009 and 2010) to definitively asses the role that tillage has had in affecting dust emissions over the past three years.

Despite the measured low atmospheric concentrations of $PM_{2.5}$ and PM_{10} and the very few exceedances of the CWS measured over the past three years, as well as in the comparable low PM levels measured in the earlier Tsay Keh health study (REF ??), **Harry ,can this be cited, I have seen a draft copy of the report but not the final version, do you have the reference. I could not find it on the BC Hydro website!)** there remains a distinct impression in the village that atmospheric dust concentrations in the atmosphere remain high. An important question therefore arises as to why there is such a strong feeling held by many in Tsay Keh as to an apparent high frequency and high levels of dust despite the measurements that have been made over the past several years.

One important factor may be perceptual in nature, which in this case.is how the human eye perceives visibility changes due to the presence of aerosols, which affect aerosol optical depth (AOD). AOD is a measure of transparency and is defined by the quantity of light removed from a beam by scattering and absorption due to the presence of particles during its travel through the atmosphere. This parameter is frequently used as a surrogate measure of atmospheric dust concentrations and is a basic measurement used by the MODIS Satellite to investigate global dust concentrations, although the principle is also used at much small scales to assess atmospheric turbidity. In principle, if light passes through a set distance of relatively clean air (such as on a clear winter day) the optical depth is relatively long. If however, the air over this same distance contains suspended particles, AOD is reduced and we perceive this as dust haze or smog in urban and rural settings. As PM concentrations increase over the same physical distance, the optical depth decreases and we cannot see as far and the air appears to become increasingly "dirty"

This principle comes into play at Williston when one looks down or across the reservoir towards some distant point such as a mountain peak within the valley, on a day with a moderate amount of dust suspended in the atmosphere. In this case the view may seem slightly obscured or hazy. However if one looks further down the lake, and assuming that the dust concentration remains the same per unit distance, the air further in the distance will seem much dirtier and the view more obscured because one is looking at the effect of many more particles that are absorbing and scattering the light (i.e., the optical depth is shorter), and the view more obscured even though the atmospheric dust concentration remains at the same relatively low concentration.

It has also been suggested (H. Brownlow, 2014, pers. comm.) that the perception of the dust problem in Tsay Keh reflects short term observations of high dust loadings, which may better reflected by hourly dust concentrations rather than the 24 hour averages, which are used in the application of the CWS. As an example, during a given day there may be three or four individual hours in a given day (either spread out or grouped) where dust concentrations are high and that may well exceed the CWS. However, during the remaining hours of the day concentrations may be well below the numerical value of the CWS (30 µg m^{-3}) because of lower localized wind speed and/or direction, a precipitation event or changes in anthropogenic activities in the general area. In this case if the high concentrations during a few hours are averaged with larger number of low concentration hours, it is likely that the overall 24-hour mean concentration may be well below the CWS. However, the perception is that there was a dust issue during this particular day, and for certain, during those high concentration hours there was. It is important to keep in mind however, that based on a large number of health studies throughout the world, it has been determined that a health risk is reached when the 24-hr concentration exceeds 25-30 µg m^{-3}, depending on the criteria used in a given country or district. As well, there are studies that indicate short term exposure to exceptionally high levels of particular pollutants can have serious health effects but to our knowledge there is as yet no data to show that short term exposure to relatively high dust concentrations poses a serious health hazard.

5.0 Discussion and Conclusions

The data of hourly, daily, and annual PM levels collected by the air quality monitoring network established in the northern reach of Williston Reservoir, and in the villages of Tsay Keh and Ft. Ware has made it possible to begin to characterize its spatial and temporal patterns. In the future it is also expected that this network can fulfill the objective of evaluating the efficacy of control measures used to reduce the dust from wind erosion on the exposed Williston Reservoir beaches. Ultimately the data collected by the network will allow the longer term trends in air quality, and in particular PM, to be defined. The PM database can be used to define whether there is a decline in the number of exceedances of 24 hour AOQ and that the annual PM averages are also within accepted limits. In addition, the meteorological and PM data could be used to inform a predictive model that can be used to provide forewarning of probable dust emission events, their intensity and duration. Upon delivery of this information to the local population (e.g., via the Internet, e-mail, text message) decisions could be made to take actions to minimize exposure to elevated PM levels.

With only three years of data now available the minimum number of years required for calculating the mean annual PM_{10} and $PM_{2.5}$ values has almost been achieved. It is not yet possible as the length of the data record is compromised by periods for which the TEOM instruments were not operating due to instrument failure and the need to receive parts to correct the malfunctions and subsequently travel to Tsay Keh and Ft. Ware unfortunately sometimes took weeks. In subsequent years these values can be tracked to define change and to benchmark against the amount and type of dust control measures that are put in place on the reservoir beaches.

Although the data record is only three years long, and incomplete with respect to compliance monitoring requirements, it suggests that, for the most part, the annual mean PM levels in the Williston Reservoir air-shed are low. Compared to rural monitoring sites in the US, the annual PM mean values are comparable and perhaps slightly lower. When high values of hourly PM are observed in Tsay Keh the source of the PM_{10} can be attributed to periods of elevated wind speed from the south indicating that it is caused by wind erosion and dust emissions. This is not as well defined for Ft. Ware, where elevated hourly PM_{10} levels appear to be, for the existing data record, to be a result of local activities such as driving on unpaved roads and construction. For both locations periods of elevated $PM_{2.5}$ are most associated with winter conditions suggesting that this is a result of combustion associated with residential heating.

The data collected to date indicates that there is indeed year-to-year variability in, most obviously, the 24 hour mean PM values. The source of that variability cannot yet be attributed definitively as the length of the data record is insufficient to allow this. However, two causes are plausible: 1) the magnitude of the dust control measures, and 2) weather/climate related.

Based on earlier research and testing a management decision was taken to use tillage as a method to reduce wind erosion and the associated dust emissions on beaches identified as having high dust emission potential. There is a large body of scientific literature from the dust bowl era, as well as more recent research on conservation tillage practices from many locations throughout the world, that clearly demonstrates that tillage can be a very effective method to reduce dust emissions. At this time several factors are limiting the evaluation of its performance at the Williston Reservoir. The first is that the data record that combines the regional air quality data with data from the tillage program, regional meteorology, and regional hydrology is not of sufficient length (or even assembled into a comprehensive database that can be queried) to evaluate the inter-relationships among these factors and how they affect the regional air quality when conditions are present that result in high winds and wind erosion. Based on the available data and first-hand observations some preliminary explanation for the observed patterns can be provided.

It would appear that, in the case of the Williston Reservoir, during years with high water levels during the period associated historically with observed dust emissions (i.e., spring) and moderate to high precipitation that dust emissions are low because of the smaller areal extent of exposed beaches and their lower emissivity due to moisture effects. This appears to be the case for the years 2011-2013. Caution needs to be exercised in examining the role of tillage to control wind erosion and dust emission during the period 2011-2013. Earlier recommendations from the tillage study (Fryrear at al. 2010) suggested that reduction in emissions would require extensive and on-going tillage on erodible beaches on the order of 4,000 or more hectares. For a variety of logistical and managerial reasons the number of hectares tilled has been well below this with estimates of 948, 1148 and 1200 ha in 2011, 2012 and 2013 respectively (H. Brownlow, pers. comm.).

It is very difficult to evaluate the efficacy of tillage in this short-term record, considering the areas tilled, the fact that three out of the four years of available observations occurring during cooler, wetter, and higher spring pool condition. Despite the inconclusive evidence to date at Williston, the inability to categorically evaluate the effectiveness of tillage should not yet be used to judge the effectiveness of this proven control method. It does suggest however, that there is an opportunity to refine the tillage management practices to provide a more effective approach to its application at the Williston Reservoir.

In years with a low pool level in the spring, warmer than average temperatures, lower than average precipitation, and winds that exceed the typical threshold for sand transport (6 m s^{-1}), wind erosion derived dust occurs more frequently and with greater intensity (i.e., high PM levels), such was the case in 2010 and during the years that the tillage trials were being carried out. This observation clearly suggests that a strategy to best utilize tillage to control wind erosion and dust emission needs to be developed. This strategy needs to take into account water levels and exposed surface area, meteorology and beach emissivity with some understanding of which areas of the reservoir should be protected most or at least first. Developing such a strategy is a very difficult task based solely on field measurements where individual variables vary greatly from year to year and from place to place, but air quality and meteorological monitoring is a critical component for developing such a strategy.

Based on the success of previous efforts to quantify the dust-emission potential of the beaches, extend this information across a wider area of the Williston Reservoir (Nickling et al., 2011, 2012), and demonstrate that meteorological and dust emission data from the reservoir coupled with dispersion modelling can be used to develop an understanding of the important dust sources and the consistent transport pathways to identified receptor sites (Nickling et al., 2013) suggests that this approach can be used in a more sophisticated manner to aid in the development of an effective methodology and *predictive dust event model* for the Williston Reservoir. The model can be used to help identify specific beaches that will be prone to dust emissions based on a forecast of weather, dust-emission strength, and modified by the condition of these beaches (e.g., reservoir water level). Knowledge of the likelihood of an erosion and dust-emission event is important so that a given control method can be implemented at the right location in a timely manner to allow preventive measures to be undertaken to reduce or eliminate dust emissions. This approach can result in reduced control costs by applying appropriate mitigation measures to only those areas that have the greatest potential to erode and release dust. As demonstrated by Nickling et al. (2013), dispersion models coupled with regional wind data can also be used to develop an understanding of the rank importance of different beaches or beach complexes to affect air quality at specified receptor sites. This information can also be used by the community to make informed decisions to reduce their exposure to wind-generated dust. The development of a dust prediction model will require PM and meteorological data to evaluate the model's ability to predict PM concentration and the meteorological conditions that give rise to dust events.

Although an integral component for the successful management of Williston Reservoir dust emissions, operation of an air quality monitoring network at the Williston Reservoir remains a challenge due to its remote location, complex topography and airflow patterns, the lack of a road network to potential sampling sites at beach locations and the lack of mains power at the remote sampling sites. The originally-conceived and implemented network, for the first time, allowed for the development of a spatially and temporally resolved data set of hourly and daily (i.e., 24 hour) mean values of PM_{10} and $PM_{2.5}$ at Tsay Keh and Ft. Ware, and a less temporally resolved data set of daily mean PM_{10} and $PM_{2.5}$ values in the northern reach of the reservoir. The data acquired from this network allowed for an evaluation of the PM levels in the region and the meteorological conditions that were associated with elevated levels. The data support that elevated PM are associated with strong southerly winds, indicating PM has been emitted from wind erosion processes on the beaches and also in the winter months due most likely to residential heating and wood burning in particular. It is not yet possible for these data to be used to evaluate the effectiveness of the dust control management practices. This will require a longer time record to allow comparison of observed PM levels for years with different weather patterns (e.g., moist cool springs vs. warm dry springs) and careful accounting of the amount of area on the beaches that has been controlled. It will also be important to have metrics to define the level of effectiveness of the control measures, as a poorly controlled area will perform differently than one with high effectiveness and they cannot be rated as equivalent when establishing overall control effectiveness of the dust controls. Maintenance of the air quality monitoring network should remain a high priority for BC Hydro and Tsay Keh as it offers the only means to evaluate how PM impacts the communities in the Williston Reservoir airshed and the effectiveness of the dust control measures

6.0 Recommendations

In that the air quality monitoring network is the basis for evaluating the effect of PM emissions from wind erosion on the reservoir beaches on regional air quality and the effectiveness of the control measures put in place to reduce those emissions it is imperative to have the network acquire a high quality data set. With the scale of the reservoir and the size of the air shed influenced by the emission of dust from the beaches it is important to return to the basic question of what is needed of the monitoring network to achieve a sufficient characterization of the PM and meteorology of the region. The key question that can still be posed is how many stations are required and how often are measurements needed? To the first part, at present, the number of stations provides an adequate representation of the PM in the northern reach of the reservoir; however, there are no measurements in the southern reach. Whether this is deemed important requires discussion and agreement among the principals (i.e., BC Hydro and Tsay Keh Dene). In terms of monitoring PM for its potential to impact the greatest density of population, this is achieved by the locations currently in the northern reach.

Of more importance, and a current weakness of the monitoring system outside of Tsay Keh and Ft. Ware villages, is the temporal resolution of the PM measurements. The greatest improvement to the existing network would be to add instruments that can provide every-day-monitoring, with one hour PM average concentration values being the goal for every current measurement location. By necessity, this would entail adding instruments that can be run on solar power/batteries. There are, however, no currently available instruments that achieve the level of a Federal Reference Equivalent standard that could be deployed without the addition of a large bank of solar panels and battery back-up. Non-equivalence instruments for PM are available that could be added and co-located with the BGI PQ2000 filter samplers that would allow for a calibration of the non-equivalence method used. These acquired data could provide much-needed information on the daily patterns of PM and meteorology to augment the information gained from the network leading to a better characterization of the dust emission system at the reservoir. Increased temporal resolution of the PM in the northern reach of the reservoir would provide a more comprehensive data base on which to judge whether there has been an incremental decrease in PM due to measures put in place to reduce the dust emissions from the reservoir beaches.

A second weakness that has been identified is the fragility of the communications network that allows remote monitoring of TEOM instrument performance, particularly at Tsay Keh. This weakness is associated primarily with the following: 1) the satellite link between Tsay Keh and the Internet that due to failures of power, network hardware external to the air quality monitoring network (i.e., hardware outside the monitoring sheds), and 2) poor management of the communication network by an outside provider. This resulted in periods where it was impossible to discern if the instruments were functioning within their performance specifications. It must be noted, however, that if the instruments were not compromised due to power failure or internal hardware/software problems, the data were not lost as they were being stored at multiple locations within the datalogging system and thus were recovered upon re-establishing the communications link. It is recommended that to reduce or eliminate these issues the communication system be upgraded and/or overhauled to eliminate the identified weaknesses. The communications problems contribute substantially to issues related to display of the data on the internet host site and for the Tsay Keh community.

As the control of the air quality monitoring network for the Williston Reservoir has transitioned to a different contractor, some recommendations are provided that are designed to provide BC Hydro with means to evaluate performance of the network and the contractor in subsequent years. Simple metrics that will provide an evaluation of operator performance include: 1) percent data recovery based on the expected number of sampling days, 2) percent of data outside of instrument performance standards (e.g., flow rate, internal temperature, filter loading limits for TEOMs, etc.), 3) successful completion of scheduled internal and external audits of instrument performance, 4) time elapsed until completion of corrective actions identified by system audits, 5) quantification of measurement uncertainties (proper numbers of lab and field blanks, propagation of errors using standard methods), and 6) chain of custody forms completed and documented. For a more thorough accounting of air quality monitoring quality assurance procedures the US EPA provides a handbook (http://www.epa.gov/ttnamti1/files/ambient/pm25/qa/QA-Handbook-Vol-II.pdf).

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APPENDIX I

TEOM Particulate and Meteorological Data for Tsay Key (2013)

Tsay Keh PM and Meteorological Data (January, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms^{-1})	Wind Direction (degrees)	Air Temp. (^0C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Jan-13	NaN	NaN	-	1.30	159	-9.4	87.8	0	102.7
2-Jan-13	NaN	NaN	-	2.42	184	-7.3	83.9	0	101.7
3-Jan-13	NaN	NaN	-	0.69	331	-6.1	86.4	0	101.6
4-Jan-13	NaN	NaN	-	1.48	191	-7.7	86.3	0	101.7
5-Jan-13	NaN	NaN	-	0.75	300	-5.8	88.7	0	101.5
6-Jan-13	NaN	NaN	-	0.79	243	-5.6	87.5	0	100.7
7-Jan-13	NaN	NaN	-	0.64	173	-8.4	86.7	0	100.1
8-Jan-13	NaN	NaN	-	0.68	347	-13.7	79.6	0	100.6
9-Jan-13	2.3	3.5	0.64	1.48	0	-13.1	73.2	0	101.4
10-Jan-13	2.4	3.1	0.79	0.89	358	-22.4	68.7	0	102.1
11-Jan-13	3.2	3.6	0.89	0.54	216	-21.2	70.4	0	102.4
12-Jan-13	1.7	2.1	0.80	0.51	156	-18.2	73.3	0	102.8
13-Jan-13	2.3	2.6	0.86	0.37	2	-16.5	74.7	0	102.6
14-Jan-13	4.0	4.9	0.81	0.58	2	-13.1	79.9	0	102.1
15-Jan-13	4.2	5.1	0.82	1.85	209	-5.7	86.0	0	101.7
16-Jan-13	9.6	11.5	0.84	1.08	210	-3.9	90.2	0	101.9
17-Jan-13	0.5	0.8	0.53	2.98	185	2.0	86.5	14.3	100.6
18-Jan-13	5.1	6.1	0.84	1.50	342	-1.9	76.5	4.5	101.2
19-Jan-13	4.6	5.6	0.82	1.40	356	-8.3	76.1	0.1	102.6
20-Jan-13	3.0	3.5	0.85	0.87	357	-9.6	70.0	0	102.9
21-Jan-13	3.8	5.0	0.75	0.42	349	-8.4	80.4	0	102.1
22-Jan-13	6.8	8.7	0.78	0.37	256	-8.2	84.9	0	101.7
23-Jan-13	4.6	6.1	0.76	1.23	193	-7.6	85.3	0	100.9
24-Jan-13	3.5	4.8	0.71	2.10	188	-5.6	88.1	0	101.0
25-Jan-13	1.7	2.1	0.78	2.32	185	-3.4	88.0	0	100.6
26-Jan-13	0.6	0.9	0.69	2.66	182	-2.5	86.9	0	100.5
27-Jan-13	1.5	1.8	0.83	1.25	196	-4.1	84.7	0	100.3
28-Jan-13	5.4	16.5	0.33	3.97	1	-16.5	74.2	0	101.0
29-Jan-13	2.7	5.8	0.46	2.37	3	-21.8	63.2	0	102.1
30-Jan-13	2.1	4.6	0.46	0.52	3	-16.7	68.2	0	102.1
31-Jan-13	4.3	5.3	0.81	0.41	352	-11.4	78.7	0	101.7

Tsay Keh PM and Meteorological Data (February, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms^{-1})	Wind Direction (degrees)	Air Temp. (^{0}C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Feb-13	6.4	8.0	0.80	0.46	224	-8.9	83.3	0	102.0
2-Feb-13	4.0	4.7	0.85	1.27	192	-2.9	89.9	0.2	101.8
3-Feb-13	1.7	2.0	0.84	1.68	185	-2.7	92.7	0	100.9
4-Feb-13	11.6	13.3	0.88	0.61	336	-8.5	77.3	1.6	100.8
5-Feb-13	5.3	6.2	0.85	0.62	11	-11.0	82.9	0	100.5
6-Feb-13	5.3	6.1	0.87	0.62	356	-5.5	84.5	0.1	100.6
7-Feb-13	5.2	6.4	0.81	0.80	198	-5.4	88.6	0	101.0
8-Feb-13	1.1	1.2	0.89	1.84	187	-5.4	90.6	0	101.3
9-Feb-13	5.9	6.8	0.86	0.73	5	-6.2	90.2	0	101.9
10-Feb-13	3.0	3.5	0.84	2.24	186	-5.3	90.8	0	101.7
11-Feb-13	1.3	1.6	0.82	1.48	185	-2.0	79.4	0	101.2
12-Feb-13	3.3	3.9	0.84	3.16	182	-1.1	89.0	0.4	100.6
13-Feb-13	9.5	10.6	0.90	0.71	357	-11.8	71.5	0.5	102.1
14-Feb-13	3.8	4.7	0.80	1.13	186	-9.1	77.9	0	102.5
15-Feb-13	1.1	1.4	0.75	3.38	183	0.9	86.3	8.4	101.5
16-Feb-13	2.7	3.2	0.85	1.80	201	0.4	73.9	2	101.1
17-Feb-13	4.4	5.5	0.81	1.07	213	-8.1	74.3	0	101.5
18-Feb-13	3.8	4.6	0.82	0.84	192	-5.7	84.4	0	101.0
19-Feb-13	7.5	8.8	0.85	0.66	2	-6.3	81.2	0	101.1
20-Feb-13	3.8	4.8	0.79	1.85	184	-4.1	85.1	0	100.5
21-Feb-13	0.9	1.3	0.71	3.12	181	-2.3	88.0	0.4	100.0
22-Feb-13	2.9	3.6	0.80	3.47	180	-1.4	90.0	0.2	99.0
23-Feb-13	5.3	6.2	0.86	1.09	231	-5.3	82.2	0	100.6
24-Feb-13	3.9	4.5	0.87	1.72	179	-3.9	83.2	0.9	100.6
25-Feb-13	7.5	9.1	0.82	0.93	1	-11.7	73.1	0	101.2
26-Feb-13	6.2	7.2	0.87	1.04	187	-11.9	78.1	0	101.6
27-Feb-13	6.4	6.3	1.03	1.74	182	-3.5	83.7	0.6	101.3
28-Feb-13	0.2	0.1	2.20	3.28	181	-1.8	85.9	0	101.2

Tsay Keh PM and Meteorological Data (March, 2013)									
Date	$PM_{2.5}$ (μg m^{-3})	PM_{10} (μg m^{-3})	PM Ratio	Wind Speed (ms^{-1})	Wind Direction (degrees)	Air Temp. (^0C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Mar-13	14.1	15.0	0.94	1.25	204	-5.5	78.6	0	101.6
2-Mar-13	6.5	7.7	0.84	0.76	357	-7.8	71.1	0	101.7
3-Mar-13	4.9	5.5	0.88	1.06	352	-5.5	67.6	0	102.3
4-Mar-13	6.1	7.1	0.86	2.26	358	-2.7	57.7	0	102.5
5-Mar-13	7.9	8.9	0.88	0.86	359	-11.5	64.7	0	101.9
6-Mar-13	10.6	12.3	0.87	0.76	12	-14.7	64.4	0	101.4
7-Mar-13	16.1	19.1	0.84	0.96	43	-15.0	64.3	0	101.6
8-Mar-13	11.2	13.5	0.83	0.74	41	-13.0	65.7	0	101.7
9-Mar-13	8.2	10.4	0.79	1.22	190	-8.7	71.6	0	101.8
10-Mar-13	1.8	2.5	0.72	2.07	297	0.2	49.2	0	101.8
11-Mar-13	6.8	8.1	0.84	1.13	199	-5.2	61.6	0	102.1
12-Mar-13	1.5	2.6	0.57	1.50	356	-5.8	76.0	0	101.1
13-Mar-13	3.1	4.5	0.68	1.24	326	-13.0	68.6	0.1	101.4
14-Mar-13	5.6	6.4	0.87	0.78	351	-12.3	76.0	0	101.8
15-Mar-13	2.5	3.2	0.78	1.35	357	-12.7	72.8	0	102.0
16-Mar-13	3.4	4.0	0.85	1.17	7	-9.5	72.2	1	101.2
17-Mar-13	2.1	2.7	0.77	3.41	5	-10.7	59.2	0.3	101.2
18-Mar-13	3.8	4.8	0.79	1.96	291	-14.3	61.6	0	101.3
19-Mar-13	6.5	8.5	0.77	2.90	183	-9.1	74.8	0	100.9
20-Mar-13	2.7	5.6	0.48	4.15	1	-5.2	83.1	0	99.6
21-Mar-13	4.1	5.4	0.76	3.78	2	-9.6	54.4	0.1	101.2
22-Mar-13	10.6	12.5	0.85	1.13	151	-12.0	59.9	0	102.3
23-Mar-13	11.2	13.2	0.85	1.23	205	-13.0	66.3	0	102.4
24-Mar-13	5.5	6.5	0.84	1.18	208	-10.5	63.9	0	102.1
25-Mar-13	6.0	7.6	0.79	1.68	186	-5.4	67.0	0	101.6
26-Mar-13	8.1	9.6	0.85	1.45	194	-1.0	74.7	0.5	101.2
27-Mar-13	9.9	12.2	0.81	1.14	197	-2.7	67.2	0	101.5
28-Mar-13	9.7	13.9	0.70	1.12	154	-3.5	66.1	0	101.6
29-Mar-13	10.1	13.7	0.74	1.12	165	-3.8	66.6	0	101.9
30-Mar-13	9.0	11.6	0.77	0.81	101	0.9	60.8	0	102.1
31-Mar-13	7.0	8.6	0.82	0.88	164	1.5	63.2	0	102.1

Tsay Keh PM and Meteorological Data (April, 2013)									
Date	**$PM_{2.5}$ (µg m^{-3})**	**PM_{10} (µg m^{-3})**	**PM Ratio**	**Wind Speed (ms^{-1})**	**Wind Direction (degrees)**	**Air Temp. (^{0}C)**	**RH (%)**	**Total Precip (mm)**	**Barometric Pressure (kPa)**
1-Apr-13	5.0	6.5	0.77	1.17	201	0.2	70.9	0	101.4
2-Apr-13	5.8	7.0	0.82	2.04	325	1.3	49.8	0	101.4
3-Apr-13	8.1	10.0	0.81	1.00	183	-1.5	54.9	0	102.0
4-Apr-13	2.0	3.7	0.54	1.08	216	0.0	73.5	0	101.2
5-Apr-13	1.4	2.6	0.55	2.03	184	-7.0	72.7	0.1	101.0
6-Apr-13	2.5	3.4	0.73	1.59	191	-2.8	74.8	1.9	100.7
7-Apr-13	3.7	4.7	0.80	2.17	187	-0.1	69.5	0	101.3
8-Apr-13	6.0	7.3	0.83	1.70	183	-1.4	62.1	0	101.9
9-Apr-13	1.6	3.5	0.47	4.65	178	-0.2	82.7	1.1	100.9
10-Apr-13	2.8	3.7	0.75	1.58	277	3.7	58.3	0	100.6
11-Apr-13	4.5	6.0	0.75	1.20	292	-1.8	52.7	0	101.7
12-Apr-13	2.3	3.4	0.68	1.69	7	-1.2	69.7	0.2	100.7
13-Apr-13	2.7	3.8	0.70	2.88	7	2.1	49.8	0	101.3
14-Apr-13	5.8	8.2	0.71	1.27	184	-0.3	52.7	0	102.2
15-Apr-13	3.4	4.7	0.71	1.63	352	0.7	50.7	0	102.7
16-Apr-13	7.9	9.6	0.83	1.54	185	-0.1	61.8	0	102.7
17-Apr-13	2.1	3.6	0.58	2.67	184	1.6	76.6	0	101.7
18-Apr-13	5.0	5.9	0.85	2.50	185	0.8	89.5	0.6	101.5
19-Apr-13	1.5	2.5	0.61	3.65	351	3.1	71.2	0.1	100.8
20-Apr-13	3.2	4.5	0.70	2.48	357	-1.8	47.5	0	102.4
21-Apr-13	9.2	12.6	0.73	1.12	18	-1.7	49.4	0	102.7
22-Apr-13	4.1	8.0	0.51	1.30	32	1.7	50.3	0	102.7
23-Apr-13	4.2	6.5	0.65	2.51	7	6.1	43.5	0	102.7
24-Apr-13	1.4	3.2	0.43	1.64	295	5.3	51.6	0	101.3
25-Apr-13	1.2	2.9	0.42	1.64	181	5.4	67.3	0	100.2
26-Apr-13	0.6	2.4	0.27	2.86	196	6.7	58.9	0	100.2
27-Apr-13	2.0	4.2	0.47	3.15	251	4.8	53.3	1.9	100.2
28-Apr-13	2.6	3.7	0.72	2.43	186	0.6	77.3	0	100.4
29-Apr-13	2.9	4.2	0.70	3.85	3	0.2	53.5	2.7	101.0
30-Apr-13	3.5	7.8	0.45	2.47	351	-0.4	49.9	0	102.0

Tsay Keh PM and Meteorological Data (May, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms^{-1})	Wind Direction (degrees)	Air Temp. (^{0}C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-May-13	1.9	4.8	0.39	3.19	184	-0.2	72.8	0	102.3
2-May-13	2.8	4.6	0.62	2.24	205	6.2	65.7	0	102.2
3-May-13	3.1	7.2	0.43	1.28	172	8.3	53.6	0	102.7
4-May-13	3.9	8.8	0.44	1.61	201	9.8	52.4	0	102.4
5-May-13	4.4	9.5	0.46	1.58	187	8.9	50.9	0	101.7
6-May-13	4.9	12.4	0.40	2.24	357	11.1	42.8	0	101.2
7-May-13	0.5	0.7	0.73	1.36	177	6.8	56.4	0	101.8
8-May-13	0.7	0.9	0.82	1.52	171	8.1	49.8	0	101.8
9-May-13	0.7	0.8	0.84	2.49	3	11.4	37.8	0	102.2
10-May-13	0.6	0.8	0.83	1.66	189	9.8	47.3	0	102.3
11-May-13	0.7	0.8	0.86	1.46	188	7.4	72.1	0.4	101.4
12-May-13	2.5	3.1	0.79	1.97	202	10.8	73.4	4.8	100.4
13-May-13	0.9	1.1	0.87	1.82	196	10.1	62.8	0.9	100.6
14-May-13	0.8	0.9	0.89	1.74	241	8.9	55.8	0.2	101.1
15-May-13	0.6	0.7	0.94	1.85	192	8.4	60.2	0	101.2
16-May-13	0.7	0.8	0.88	1.55	176	9.7	54.5	0	101.3
17-May-13	0.6	0.7	0.86	1.60	176	10.0	53.5	0	101.1
18-May-13	9.5	10.0	0.95	1.62	189	10.9	72.7	7.7	101.3
19-May-13	6.1	8.2	0.75	1.65	300	9.0	46.4	0	102.2
20-May-13	7.9	11.0	0.72	1.58	71	6.4	47.0	0	102.3
21-May-13	NaN	NaN	-	4.37	354	6.9	62.2	0.3	102.0
22-May-13	4.2	39.3	0.11	2.93	16	12.0	45.9	0	101.7
23-May-13	5.1	27.9	0.18	1.57	174	13.8	49.5	0	101.3
24-May-13	4.9	18.3	0.27	1.58	191	14.2	52.9	0	101.5
25-May-13	4.3	13.9	0.31	1.54	65	16.4	43.6	0	101.4
26-May-13	4.3	20.8	0.21	1.76	162	15.0	40.6	0	101.2
27-May-13	3.3	20.7	0.16	1.48	173	13.1	59.3	0.6	101.0
28-May-13	1.8	7.6	0.24	1.37	172	14.1	54.1	0	100.6
29-May-13	2.0	8.2	0.25	2.15	348	12.1	80.4	7.7	100.9
30-May-13	3.8	5.7	0.66	2.18	359	11.8	84.2	6.2	101.3
31-May-13	NaN	NaN	-	2.45	182	9.8	93.9	21.2	101.9

Tsay Keh PM and Meteorological Data (June, 2013)									
Date	**$PM_{2.5}$ (µg m^{-3})**	**PM_{10} (µg m^{-3})**	**PM Ratio**	**Wind Speed (ms^{-1})**	**Wind Direction (degrees)**	**Air Temp. (^{0}C)**	**RH (%)**	**Total Precip (mm)**	**Barometric Pressure (kPa)**
1-Jun-13	NaN	NaN	-	1.22	159	11.1	60.7	0	101.9
2-Jun-13	NaN	NaN	-	1.59	152	11.9	56.0	0	101.9
3-Jun-13	NaN	NaN	-	1.50	182	11.6	68.5	0.9	101.9
4-Jun-13	NaN	NaN	-	1.56	187	13.2	64.8	0	101.4
5-Jun-13	1.1	4.5	0.24	1.89	291	13.2	48.6	0.3	101.3
6-Jun-13	1.2	9.9	0.12	1.70	183	9.6	59.8	0	101.4
7-Jun-13	0.7	2.1	0.36	0.96	139	10.7	79.2	4.8	101.1
8-Jun-13	0.8	2.1	0.38	1.09	355	10.7	81.5	2.2	101.5
9-Jun-13	2.2	4.4	0.51	1.50	10	12.6	63.9	0	101.7
10-Jun-13	0.9	3.8	0.24	1.10	132	13.9	51.7	0	101.7
11-Jun-13	1.5	5.8	0.27	1.54	194	13.0	52.5	0	101.6
12-Jun-13	2.0	6.3	0.32	1.18	174	13.8	56.9	0	101.7
13-Jun-13	1.6	5.4	0.29	1.31	173	14.0	65.2	1.7	101.5
14-Jun-13	1.9	4.1	0.46	1.20	9	13.9	77.4	0.7	101.7
15-Jun-13	2.7	5.9	0.46	2.43	6	17.0	52.8	0	102.0
16-Jun-13	1.9	6.4	0.30	1.38	28	16.8	49.6	0	102.1
17-Jun-13	2.2	7.9	0.28	2.34	357	15.1	57.4	0	101.4
18-Jun-13	2.6	6.9	0.37	1.55	9	17.7	53.6	0	101.6
19-Jun-13	5.9	11.4	0.51	0.79	176	15.9	67.9	0	101.8
20-Jun-13	4.0	9.5	0.42	1.50	11	19.1	52.2	0	101.7
21-Jun-13	12.8	23.4	0.55	1.20	169	18.2	53.2	0	101.6
22-Jun-13	5.6	16.2	0.35	1.27	116	19.8	55.0	0	101.2
23-Jun-13	4.2	15.1	0.28	1.56	222	19.2	62.9	0	100.8
24-Jun-13	3.6	8.4	0.44	1.50	7	18.4	61.7	1.5	100.4
25-Jun-13	3.9	6.6	0.59	1.03	141	15.5	83.2	4.6	100.5
26-Jun-13	1.7	3.4	0.49	0.84	210	13.8	94.4	26.3	100.9
27-Jun-13	6.3	8.6	0.73	0.92	349	13.8	88.7	20.4	101.7
28-Jun-13	1.4	4.7	0.29	1.50	209	15.4	74.7	1.5	102.1
29-Jun-13	1.5	3.7	0.40	1.51	185	17.0	78.6	3.7	101.9
30-Jun-13	2.0	5.3	0.37	1.13	6	17.0	72.6	1.6	101.9

Tsay Keh PM and Meteorological Data (July, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms^{-1})	Wind Direction (degrees)	Air Temp. (^{0}C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Jul-13	2.0	5.3	0.38	0.94	172	17.7	75.0	0.3	101.6
2-Jul-13	1.2	4.1	0.30	1.73	276	18.2	52.4	0	101.4
3-Jul-13	2.1	6.2	0.33	1.54	23	16.5	45.6	0	101.6
4-Jul-13	2.1	9.8	0.21	2.38	356	16.7	43.9	0	101.4
5-Jul-13	2.8	5.5	0.51	1.52	188	13.4	72.9	6.2	101.6
6-Jul-13	2.1	4.6	0.47	1.30	175	15.0	62.5	0	101.6
7-Jul-13	3.4	7.2	0.48	1.39	195	17.3	61.6	0	101.4
8-Jul-13	3.5	9.8	0.36	1.16	208	17.1	60.4	0.1	101.3
9-Jul-13	1.4	5.3	0.26	1.30	220	16.6	53.2	0	101.4
10-Jul-13	1.1	5.1	0.22	1.34	189	10.9	71.6	5.5	101.1
11-Jul-13	1.0	3.5	0.30	1.32	187	11.1	83.5	12	100.6
12-Jul-13	2.7	4.4	0.61	1.64	200	9.6	87.0	14.1	101.2
13-Jul-13	0.8	3.0	0.27	1.50	197	9.8	83.6	5.4	102.0
14-Jul-13	2.9	7.2	0.40	2.26	355	14.0	62.3	2.5	102.0
15-Jul-13	4.3	12.2	0.35	1.23	3	15.9	57.5	0	101.9
16-Jul-13	7.5	17.4	0.43	1.26	199	15.9	65.8	0	101.9
17-Jul-13	10.6	21.9	0.48	1.00	110	17.1	66.9	0	101.6
18-Jul-13	9.2	23.7	0.39	0.98	190	18.1	69.7	0	101.6
19-Jul-13	8.0	17.3	0.46	1.45	3	19.5	63.0	2.4	101.6
20-Jul-13	3.3	6.6	0.50	1.89	355	18.1	74.8	1.2	101.2
21-Jul-13	1.5	5.8	0.26	1.18	122	16.9	67.2	0	101.1
22-Jul-13	1.3	4.8	0.28	2.05	3	15.9	60.0	0	101.4
23-Jul-13	1.5	3.6	0.41	1.43	349	14.4	79.5	6.8	101.9
24-Jul-13	2.3	6.3	0.36	0.72	237	15.5	81.6	3.1	101.9
25-Jul-13	2.7	7.1	0.37	1.26	332	16.5	71.9	0	101.7
26-Jul-13	1.7	5.4	0.31	1.35	347	14.4	72.5	4.8	101.7
27-Jul-13	2.2	5.2	0.42	2.41	357	13.6	80.6	3.4	101.8
28-Jul-13	4.6	7.8	0.59	1.01	134	14.6	72.2	0.1	102.1
29-Jul-13	2.9	6.2	0.47	0.88	191	12.9	83.7	2.4	102.0
30-Jul-13	3.0	6.9	0.43	1.23	163	15.3	76.5	0.1	102.1
31-Jul-13	2.8	7.8	0.35	1.58	190	18.2	70.4	1.3	102.1

Tsay Keh PM and Meteorological Data (August, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms^{-1})	Wind Direction (degrees)	Air Temp. (^0C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Aug-13	1.3	7.4	0.18	1.04	130	18.7	72.1	0	101.7
2-Aug-13	1.4	6.4	0.22	1.16	123	18.3	67.0	0	101.5
3-Aug-13	1.4	4.8	0.30	1.85	358	19.7	64.3	0.3	89.4
4-Aug-13	1.9	6.9	0.28	1.17	174	17.5	70.0	0	58.1
5-Aug-13	3.4	13.6	0.25	1.06	209	18.2	67.6	0	58.1
6-Aug-13	3.5	10.7	0.32	1.78	194	19.6	68.2	10.6	58.1
7-Aug-13	1.1	4.0	0.29	1.13	196	17.4	78.4	0.4	58.1
8-Aug-13	1.5	4.9	0.31	1.07	187	17.8	76.1	0.1	58.1
9-Aug-13	1.6	5.8	0.27	0.99	195	18.8	73.3	0	58.3
10-Aug-13	7.3	15.4	0.48	1.07	128	18.4	66.2	0	58.1
11-Aug-13	2.6	8.2	0.32	1.24	168	19.5	61.9	0	58.4
12-Aug-13	8.4	16.3	0.51	1.00	177	20.7	61.0	0	77.6
13-Aug-13	2.6	7.0	0.38	1.17	216	18.0	73.4	2.7	101.7
14-Aug-13	1.2	4.5	0.26	1.11	190	17.6	77.8	0.7	101.3
15-Aug-13	1.8	6.7	0.26	0.91	197	15.1	79.3	0.4	101.2
16-Aug-13	1.6	10.9	0.14	1.44	189	14.3	78.8	2.5	101.1
17-Aug-13	0.7	7.5	0.09	1.88	185	16.5	72.3	0.6	101.1
18-Aug-13	0.5	2.7	0.20	1.21	197	14.3	72.1	3.2	100.8
19-Aug-13	1.5	3.2	0.46	1.35	181	13.5	60.0	0.2	100.8
20-Aug-13	0.8	2.3	0.36	0.95	357	12.7	63.5	0.1	101.4
21-Aug-13	0.8	7.8	0.11	1.73	189	14.1	66.0	0	101.7
22-Aug-13	2.1	7.5	0.28	1.70	183	17.1	57.6	0.4	101.1
23-Aug-13	1.6	10.4	0.15	1.13	204	11.9	70.3	0	100.9
24-Aug-13	1.1	3.6	0.31	1.21	201	13.8	83.2	2	100.6
25-Aug-13	1.1	3.5	0.31	0.94	181	12.8	89.0	NaN	101.0
26-Aug-13	0.9	6.0	0.16	0.77	306	12.8	77.4	0	101.1
27-Aug-13	1.1	4.8	0.22	1.58	195	12.6	83.6	3	100.9
28-Aug-13	1.0	4.6	0.23	1.24	200	14.9	73.0	0	101.2
29-Aug-13	1.4	5.0	0.27	0.86	293	12.5	80.9	0	101.4
30-Aug-13	1.9	6.7	0.28	1.32	194	14.8	81.9	0	101.4
31-Aug-13	1.0	4.8	0.22	1.44	194	16.8	79.3	0	101.6

Tsay Keh PM and Meteorological Data (September, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms^{-1})	Wind Direction (degrees)	Air Temp. (^{0}C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Sep-13	2.0	6.6	0.30	1.28	198	14.0	76.9	0	101.2
2-Sep-13	1.9	8.4	0.23	1.04	211	13.2	74.7	0	101.3
3-Sep-13	2.1	8.4	0.25	1.26	215	12.8	75.3	0	101.5
4-Sep-13	3.2	11.3	0.28	1.43	216	13.7	73.4	0	101.4
5-Sep-13	2.2	8.6	0.25	0.73	188	16.6	66.7	0	101.8
6-Sep-13	1.5	9.4	0.16	1.27	3	15.6	63.4	0	102.2
7-Sep-13	2.2	8.4	0.26	1.27	218	13.7	72.6	0	101.8
8-Sep-13	2.3	7.8	0.30	1.67	281	15.1	65.5	0	101.3
9-Sep-13	4.0	13.8	0.29	0.98	3	11.7	59.5	0	101.5
10-Sep-13	3.5	13.3	0.27	1.28	216	10.5	68.3	0	101.9
11-Sep-13	2.3	13.7	0.17	1.22	201	11.8	68.8	0	102.1
12-Sep-13	4.6	19.7	0.24	1.29	218	13.2	74.4	0	101.5
13-Sep-13	5.1	25.6	0.20	1.11	354	14.0	67.8	0	101.5
14-Sep-13	3.2	17.1	0.19	1.07	202	12.1	70.1	0	101.5
15-Sep-13	4.9	26.3	0.19	1.06	9	12.1	71.6	0	100.9
16-Sep-13	6.1	10.6	0.58	0.91	347	11.5	93.6	16.7	100.3
17-Sep-13	1.5	4.1	0.36	0.78	347	8.5	82.4	0.1	100.9
18-Sep-13	2.1	5.3	0.39	1.26	225	7.4	82.1	0	101.1
19-Sep-13	1.7	6.1	0.27	2.22	185	8.7	83.5	1.5	100.9
20-Sep-13	1.7	13.7	0.12	2.99	183	13.9	68.3	1.3	100.1
21-Sep-13	1.0	6.9	0.15	1.48	198	9.4	73.4	0	99.7
22-Sep-13	0.6	4.5	0.12	2.23	187	10.0	71.7	0	99.3
23-Sep-13	0.8	2.8	0.28	1.37	208	9.4	73.1	4.1	99.8
24-Sep-13	0.4	2.0	0.21	1.13	182	7.3	79.5	2.4	100.8
25-Sep-13	4.8	9.0	0.53	0.88	352	7.4	80.8	0.3	101.8
26-Sep-13	1.7	4.0	0.42	1.47	204	5.3	83.4	0	101.4
27-Sep-13	1.0	2.8	0.35	0.86	229	8.0	69.1	0	100.4
28-Sep-13	1.3	3.1	0.41	1.94	186	8.3	75.9	1	99.1
29-Sep-13	1.4	3.3	0.44	1.76	182	7.7	79.1	7.5	98.8
30-Sep-13	2.2	4.4	0.50	1.71	357	5.6	81.4	0	99.6

Tsay Keh PM and Meteorological Data (October, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms^{-1})	Wind Direction (degrees)	Air Temp. (^0C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Oct-13	1.9	4.2	0.46	1.13	292	6.9	82.1	1.1	100.9
2-Oct-13	1.2	3.6	0.34	0.96	328	6.1	76.6	0	101.9
3-Oct-13	3.5	9.5	0.37	1.71	184	4.2	82.2	0.1	102.3
4-Oct-13	3.8	11.3	0.34	4.27	178	7.7	80.3	0.1	101.5
5-Oct-13	2.9	4.8	0.61	1.18	256	7.6	72.2	0	101.4
6-Oct-13	1.0	2.6	0.36	1.33	187	5.9	88.8	9.6	101.0
7-Oct-13	1.8	3.6	0.51	1.41	345	6.5	88.9	5.5	100.0
8-Oct-13	1.6	2.8	0.57	2.41	359	6.2	65.7	0	101.4
9-Oct-13	1.3	3.0	0.43	1.78	182	6.3	70.9	0.1	100.4
10-Oct-13	1.6	2.6	0.62	1.14	292	6.2	57.2	0	100.7
11-Oct-13	1.4	2.6	0.53	1.21	197	3.5	72.4	0	101.6
12-Oct-13	2.5	4.0	0.64	0.72	222	3.7	79.9	0	102.0
13-Oct-13	4.3	6.2	0.68	0.99	214	3.7	78.5	0	102.4
14-Oct-13	5.5	8.0	0.68	2.36	185	4.2	83.0	0	102.5
15-Oct-13	5.6	7.7	0.72	2.43	355	7.6	66.5	0	102.2
16-Oct-13	4.0	5.4	0.75	1.54	355	2.2	67.0	0	102.5
17-Oct-13	5.3	6.9	0.77	0.88	308	0.4	78.4	0	102.6
18-Oct-13	6.5	8.4	0.78	0.77	343	2.5	82.0	0	102.1
19-Oct-13	7.0	8.8	0.80	0.76	193	5.2	83.3	0	102.0
20-Oct-13	6.2	7.9	0.78	1.22	181	5.9	90.0	0	101.9
21-Oct-13	4.9	6.9	0.71	1.09	197	7.4	89.0	0	101.8
22-Oct-13	5.7	7.9	0.72	0.87	357	5.0	88.3	0	102.1
23-Oct-13	7.7	11.4	0.67	1.19	192	6.5	88.8	0.4	101.9
24-Oct-13	7.9	10.6	0.75	0.99	349	1.8	92.9	0.1	101.6
25-Oct-13	5.5	6.8	0.82	0.78	352	0.5	92.2	0.1	102.2
26-Oct-13	4.4	6.8	0.65	1.72	338	4.7	86.7	0	101.9
27-Oct-13	2.6	4.1	0.62	3.12	3	3.4	61.4	0.1	103.1
28-Oct-13	4.1	5.5	0.75	0.72	311	-1.8	79.0	0	102.4
29-Oct-13	17.9	33.1	0.54	2.42	190	-0.2	75.3	0	101.2
30-Oct-13	14.3	21.2	0.68	1.69	192	0.5	81.7	1	100.7
31-Oct-13	9.8	11.6	0.84	0.95	211	3.5	82.2	0	100.7

Tsay Keh PM and Meteorological Data (November, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms^{-1})	Wind Direction (degrees)	Air Temp. (^0C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Nov-13	4.7	5.7	0.81	0.88	320	1.7	71.9	0	101.4
2-Nov-13	3.4	4.7	0.71	1.27	354	-1.9	74.3	0	101.4
3-Nov-13	6.1	8.5	0.72	0.93	353	-6.9	76.6	0	101.8
4-Nov-13	NaN	NaN	-	0.90	287	-8.4	77.4	0	101.5
5-Nov-13	NaN	NaN	-	0.83	234	-1.0	75.8	0	101.0
6-Nov-13	NaN	NaN	-	0.82	185	-0.1	80.6	0	101.7
7-Nov-13	NaN	NaN	-	0.67	300	0.1	83.3	0	101.0
8-Nov-13	NaN	NaN	-	1.64	354	-2.1	78.2	0	101.0
9-Nov-13	1.5	4.0	0.37	4.36	359	-7.5	61.1	0.1	102.1
10-Nov-13	2.2	8.8	0.25	1.71	352	-11.5	68.9	0	102.6
11-Nov-13	1.5	2.5	0.62	0.83	359	-6.7	70.8	0	102.4
12-Nov-13	NaN	NaN	-	0.77	346	-3.6	86.0	0	101.4
13-Nov-13	NaN	NaN	-	0.92	352	-1.8	89.8	0	101.5
14-Nov-13	NaN	NaN	-	0.91	347	0.1	85.8	2.4	100.8
15-Nov-13	NaN	NaN	-	3.37	10	-1.5	86.0	1.2	99.7
16-Nov-13	NaN	NaN	-	0.80	353	-8.0	74.3	0	100.5
17-Nov-13	NaN	NaN	-	2.70	360	-14.1	75.1	0	100.7
18-Nov-13	NaN	NaN	-	2.07	356	-19.8	67.4	0	101.4
19-Nov-13	NaN	NaN	-	0.92	343	-27.9	62.1	0	101.6
20-Nov-13	NaN	NaN	-	1.16	360	-24.5	66.0	0	102.0
21-Nov-13	2.7	2.6	1.04	1.61	351	-16.3	75.5	0	102.4
22-Nov-13	3.2	4.1	0.77	0.97	5	-12.1	79.9	0	102.9
23-Nov-13	6.4	7.7	0.82	2.69	179	-0.8	87.9	0.3	101.7
24-Nov-13	4.1	4.7	0.86	1.42	340	-4.8	84.0	0	102.2
25-Nov-13	1.1	1.7	0.66	1.24	355	-8.4	82.0	0	102.4
26-Nov-13	4.0	5.5	0.74	0.85	4	-4.0	87.2	0	102.0
27-Nov-13	5.4	7.3	0.73	1.25	179	-0.9	90.4	0.1	101.7
28-Nov-13	4.6	5.4	0.86	3.18	181	0.1	83.9	10.7	100.8
29-Nov-13	3.1	3.7	0.83	2.31	178	-3.8	85.0	1.3	101.3
30-Nov-13	1.4	1.6	0.84	3.10	180	1.8	89.2	4.6	100.9

Tsay Keh PM and Meteorological Data (December, 2013)									
Date	$PM_{2.5}$ ($\mu g\ m^{-3}$)	PM_{10} ($\mu g\ m^{-3}$)	PM Ratio	Wind Speed (ms^{-1})	Wind Direction (degrees)	Air Temp. (^0C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Dec-13	2.6	5.0	0.52	5.18	6	-10.4	77.6	0	100.9
2-Dec-13	2.6	5.0	0.52	5.53	5	-15.7	61.7	0.2	103.1
3-Dec-13	2.4	2.8	0.85	1.41	352	-21.7	65.0	0	103.6
4-Dec-13	0.5	0.5	0.98	1.07	5	-25.4	63.9	0	103.1
5-Dec-13	1.3	1.6	0.84	1.30	354	-19.7	67.6	0	103.3
6-Dec-13	1.0	0.9	1.02	1.04	351	-27.5	61.8	0	103.5
7-Dec-13	1.1	1.3	0.89	0.97	9	-22.5	65.3	0	102.7
8-Dec-13	1.7	2.0	0.85	0.27	336	-15.1	76.6	0	102.5
9-Dec-13	4.6	5.4	0.86	0.79	217	-13.0	78.5	0	102.0
10-Dec-13	5.1	5.9	0.85	0.76	3	-10.9	80.6	0	102.0
11-Dec-13	3.0	3.9	0.79	1.18	356	-9.2	84.2	0	101.1
12-Dec-13	1.1	2.1	0.51	1.95	0	-12.1	80.6	0	101.0
13-Dec-13	1.6	2.3	0.71	1.76	358	-14.4	77.2	0	101.5
14-Dec-13	1.6	1.9	0.87	2.99	179	-4.2	87.1	14.2	100.3
15-Dec-13	1.5	2.1	0.71	1.40	198	-1.8	71.5	0.3	100.4
16-Dec-13	6.5	7.8	0.84	0.79	51	-9.2	83.8	0	101.4
17-Dec-13	1.4	2.3	0.60	3.87	3	-6.6	80.7	0	100.4
18-Dec-13	2.0	2.5	0.83	3.63	4	-17.0	65.7	0	102.2
19-Dec-13	1.2	1.3	0.91	0.80	3	-24.1	67.0	0	101.9
20-Dec-13	2.4	2.8	0.87	1.20	357	-16.8	71.4	0	100.8
21-Dec-13	3.4	3.8	0.88	0.68	4	-20.3	70.1	0	101.6
22-Dec-13	1.8	2.1	0.88	0.84	207	-14.1	77.7	0	101.3
23-Dec-13	5.0	5.7	0.88	0.94	356	-10.3	81.8	0	100.7
24-Dec-13	5.9	6.9	0.85	1.05	200	-10.0	80.5	0	101.9
25-Dec-13	0.4	0.6	0.64	5.19	181	-0.9	91.5	0	101.3
26-Dec-13	0.4	0.6	0.78	3.15	180	1.4	93.5	9.2	100.4
27-Dec-13	2.6	3.6	0.74	3.55	359	-6.5	79.4	2.1	101.1
28-Dec-13	2.2	2.9	0.76	1.67	1	-14.9	68.1	0	102.7
29-Dec-13	2.4	2.8	0.84	1.26	355	-12.0	80.2	0	101.5
30-Dec-13	1.6	1.9	0.82	0.98	354	-10.4	82.5	0.0	101.2
31-Dec-13	3.6	4.4	0.82	0.58	10	-9.1	86.8	0.0	101.6

Tsay Keh PM and Meteorological Data (January, 2014)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms^{-1})	Wind Direction (degrees)	Air Temp. (^{0}C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Jan-14	2.5	2.9	0.86	1.10	189	-7.7	87.1	0.0	101.7
2-Jan-14	1.3	1.6	0.83	1.40	343	-3.1	91.4	0.0	100.7
3-Jan-14	1.8	2.2	0.83	0.88	350	-12.2	79.2	0.0	101.5
4-Jan-14	3.3	4.3	0.78	2.02	336	-9.9	77.2	0.0	102.9
5-Jan-14	0.2	4.5	0.04	2.29	178	-11.1	75.3	0.0	103.0
6-Jan-14	2.5	3.1	0.80	0.83	7	-7.9	79.1	0.0	102.1
7-Jan-14	2.0	2.8	0.71	0.77	182	-7.9	85.6	0.0	101.3
8-Jan-14	4.2	5.7	0.74	0.48	354	-6.2	87.0	0.0	100.4
9-Jan-14	0.8	1.2	0.61	1.55	187	-4.1	87.3	0.0	99.5
10-Jan-14	0.5	1.0	0.49	1.70	192	-7.2	83.5	0.0	99.9
11-Jan-14	2.3	3.8	0.60	1.36	360	-6.8	86.9	0.0	98.6
12-Jan-14	1.0	1.7	0.59	2.61	182	-9.7	84.9	0.0	99.4
13-Jan-14	5.1	6.1	0.84	0.87	190	-8.8	82.5	0.0	100.8
14-Jan-14	*	*	-	4.68	184	1.8	80.3	21.8	100.9
15-Jan-14	4.6	6.7	0.69	1.87	304	2.2	52.9	0.2	102.1
16-Jan-14	1.4	2.4	0.60	2.47	184	-0.1	87.1	0.1	102.3
17-Jan-14	4.9	5.7	0.86	0.53	356	-5.7	90.3	0.0	102.2
18-Jan-14	2.0	2.5	0.82	1.03	184	-5.0	91.1	0.0	101.2
19-Jan-14	3.7	4.5	0.82	0.83	355	-9.8	81.1	0.0	101.9
20-Jan-14	2.7	3.3	0.81	0.67	3	-10.3	83.1	0.0	102.6
21-Jan-14	2.0	2.5	0.80	0.45	5	-5.6	86.5	0.0	102.6
22-Jan-14	2.7	3.6	0.75	0.58	14	-3.4	89.1	0.0	102.7
23-Jan-14	2.1	2.8	0.75	0.57	171	-1.2	94.2	0.3	103.0
24-Jan-14	1.1	1.4	0.80	0.96	187	0.3	95.0	2.3	103.0
25-Jan-14	0.9	1.0	0.90	0.55	347	-1.6	91.0	0.0	102.8
26-Jan-14	0.8	0.8	0.89	0.70	354	-3.9	89.0	0.0	102.9
27-Jan-14	0.5	0.6	0.92	0.38	180	-3.1	89.5	0.1	102.5
28-Jan-14	*	*	-	1.84	185	-4.6	91.5	0.0	101.9
29-Jan-14	*	*	-	0.39	354	-6.7	87.4	0.0	101.4
30-Jan-14	*	*	-	0.77	351	-18.8	72.2	0.0	102.0
31-Jan-14	0.7	1.0	0.68	0.53	2	-23.0	65.5	0.0	102.1

Tsay Keh PM and Meteorological Data (February, 2014)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms^{-1})	Wind Direction (degrees)	Air Temp. (^0C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Feb-14	0.5	0.8	0.65	0.80	359	-20.1	69.2	0.0	102.2
2-Feb-14	0.3	0.4	0.83	0.89	5	-15.4	73.8	0.0	102.4
3-Feb-14	4.3	5.2	0.83	0.50	352	-24.4	65.4	0.0	103.3
4-Feb-14	*	*	-	0.62	4	-28.6	59.4	0.0	104.0
5-Feb-14	1.5	1.8	0.80	0.97	357	-28.3	58.9	0.0	104.0
6-Feb-14	*	*	-	0.84	14	-30.9	57.9	0.0	102.4
7-Feb-14	1.7	2.5	0.70	1.06	357	-30.1	56.1	0.0	101.8
8-Feb-14	1.5	1.7	0.88	0.63	7	-27.4	58.7	0.0	102.4
9-Feb-14	1.0	1.3	0.78	0.41	11	-26.9	58.3	0.0	101.9
10-Feb-14	0.6	1.6	0.34	1.60	358	-24.7	64.3	0.0	101.5
11-Feb-14	0.8	1.7	0.45	1.56	359	-19.3	68.3	0.0	101.1
12-Feb-14	1.5	1.7	0.88	0.46	185	-18.4	71.1	0.0	99.7
13-Feb-14	4.0	5.0	0.80	1.38	355	-20.0	69.8	0.0	100.3
14-Feb-14	1.3	1.6	0.79	1.00	182	-12.4	78.4	0.0	99.9
15-Feb-14	1.7	2.1	0.81	0.55	334	-11.3	77.2	2.8	100.1
16-Feb-14	0.9	1.3	0.69	1.29	279	-6.7	83.1	0.0	99.1
17-Feb-14	0.5	0.9	0.55	1.24	192	-7.4	82.8	0.0	99.5
18-Feb-14	1.4	1.9	0.73	1.44	194	-8.9	82.4	0.0	99.6
19-Feb-14	1.2	1.7	0.74	1.74	187	-9.2	79.8	0.0	100.1
20-Feb-14	1.8	2.2	0.80	0.95	345	-8.0	77.9	0.4	100.6
21-Feb-14	0.1	0.2	0.41	0.93	211	-13.7	75.1	0.0	101.8
22-Feb-14	2.3	2.8	0.80	2.94	4	-13.4	61.3	0.0	102.6
23-Feb-14	1.4	1.7	0.82	0.89	357	-20.2	59.4	0.0	102.8
24-Feb-14	1.3	1.5	0.84	1.18	5	-23.9	57.6	0.0	102.9

NaN = Instrument decommissioned or malfunctioning

* = Value below detectable limit

APPENDIX II

TEOM Particulate and Meteorological Data for Fort Ware (2013)

Fort Ware PM and Meteorological Data (January, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms_{-1})	Wind Direction (degrees)	Air Temp (°C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Jan-13	3.1	3.8	0.83	0.53	354	-12.3	83.2	0	102.4
2-Jan-13	7.2	8.5	0.85	0.44	343	-10.4	83.1	0	101.4
3-Jan-13	7.1	8.2	0.86	0.31	352	-7.2	85.6	0	101.3
4-Jan-13	5.8	7.0	0.83	0.88	149	-6.1	86.2	0	101.4
5-Jan-13	7.2	8.7	0.83	0.19	34	-6.2	88.8	0	101.2
6-Jan-13	4.5	5.2	0.87	0.37	354	-7.0	87.4	0	100.4
7-Jan-13	10.1	11.3	0.89	0.33	325	-8.2	86.9	0	99.8
8-Jan-13	13.7	16.4	0.83	0.36	359	-12.4	81.8	0	100.3
9-Jan-13	5.4	6.9	0.78	1.04	342	-13.4	79.5	0	100.7
10-Jan-13	10.3	11.3	0.91	0.17	3	-21.3	68.4	0	101.4
11-Jan-13	6.9	7.8	0.89	0.36	5	-20.5	70.0	0	101.4
12-Jan-13	4.3	4.9	0.88	0.27	324	-19.1	71.7	0	101.8
13-Jan-13	6.1	6.8	0.89	0.17	148	-17.1	74.5	0	101.7
14-Jan-13	5.1	6.2	0.83	0.49	128	-13.0	81.1	0	101.1
15-Jan-13	7.6	8.6	0.88	0.92	147	-8.2	86.6	0	100.7
16-Jan-13	24.0	27.1	0.89	0.43	124	-5.3	89.1	0	101.0
17-Jan-13	2.7	3.5	0.78	1.77	157	1.1	92.7	12.8	99.6
18-Jan-13	10.5	12.3	0.85	0.90	301	-2.2	82.5	1.3	100.2
19-Jan-13	14.0	16.9	0.83	0.76	328	-9.7	77.0	0	101.6
20-Jan-13	2.3	2.6	0.88	0.62	338	-12.4	71.4	0	102.0
21-Jan-13	7.1	8.6	0.82	0.18	242	-9.1	83.6	0	101.2
22-Jan-13	14.3	16.8	0.85	0.13	342	-7.4	84.4	0	100.7
23-Jan-13	5.5	6.8	0.81	0.66	143	-7.3	84.8	0	100.0
24-Jan-13	5.1	7.5	0.68	0.85	133	-6.3	89.9	0	100.1
25-Jan-13	3.6	4.3	0.84	1.07	148	-4.3	87.9	0	99.6
26-Jan-13	1.5	1.8	0.83	2.68	158	-1.8	86.6	0	99.5
27-Jan-13	6.8	7.7	0.88	0.75	138	-4.6	86.9	0	99.3
28-Jan-13	5.4	9.2	0.59	2.10	334	-18.1	69.2	0	100.2
29-Jan-13	3.0	3.8	0.78	0.78	330	-23.5	61.5	0	101.2
30-Jan-13	6.1	7.2	0.85	0.36	352	-16.5	69.4	0	101.1
31-Jan-13	11.9	13.6	0.87	0.19	193	-11.2	77.8	0	100.8
Fort Ware PM and Meteorological Data (February, 2013)									

Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms_{-1})	Wind Direction (degrees)	Air Temp (°C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Feb-13	11.4	13.0	0.88	0.28	202	-7.0	80.6	0.5	101.0
2-Feb-13	9.5	11.7	0.81	0.34	177	-4.0	91.3	0	100.9
3-Feb-13	3.8	4.9	0.78	1.03	155	-1.2	94.9	0	100.0
4-Feb-13	13.0	15.6	0.84	0.55	137	-5.9	82.1	0	99.9
5-Feb-13	10.2	12.3	0.83	0.42	336	-11.2	80.3	0	99.6
6-Feb-13	6.1	7.0	0.87	0.43	347	-6.5	82.0	0	99.7
7-Feb-13	11.3	13.0	0.86	0.29	115	-4.5	85.3	0	100.1
8-Feb-13	2.1	2.6	0.80	1.64	151	-4.7	89.7	0	100.3
9-Feb-13	6.9	7.9	0.87	0.38	313	-3.5	85.3	0.3	101.0
10-Feb-13	3.2	3.9	0.83	1.90	151	-4.2	91.1	0	100.7
11-Feb-13	6.3	7.3	0.87	0.88	152	-2.2	85.8	0	100.2
12-Feb-13	5.9	7.2	0.82	1.72	149	-1.3	81.7	0.1	99.6
13-Feb-13	28.1	32.7	0.86	0.52	345	-10.9	69.6	0	101.1
14-Feb-13	16.2	20.0	0.81	0.66	127	-10.3	77.0	0	101.5
15-Feb-13	5.6	6.4	0.87	0.60	332	-3.5	85.7	0	100.5
16-Feb-13	12.2	14.0	0.87	0.83	342	-1.8	76.4	4.1	100.1
17-Feb-13	9.7	11.9	0.82	0.87	147	-7.2	68.3	0.5	100.6
18-Feb-13	10.0	11.4	0.88	0.30	330	-6.7	80.6	0	100.1
19-Feb-13	6.9	8.2	0.84	0.75	352	-6.6	77.7	0	100.2
20-Feb-13	7.8	9.5	0.83	1.12	142	-5.7	79.5	0.1	99.6
21-Feb-13	2.4	2.8	0.85	1.60	155	-2.6	80.2	1	99.0
22-Feb-13	6.5	7.6	0.86	1.20	142	-2.3	89.6	0.1	98.1
23-Feb-13	5.7	6.7	0.86	0.80	35	-5.5	82.4	0	99.6
24-Feb-13	9.5	11.0	0.86	0.80	146	-2.0	75.9	5.6	99.7
25-Feb-13	12.4	14.7	0.85	0.82	343	-10.2	72.5	0.9	100.3
26-Feb-13	11.4	14.3	0.80	0.80	127	-12.0	74.1	0	100.6
27-Feb-13	2.2	2.6	0.85	1.35	143	-4.0	77.3	0.1	100.4
28-Feb-13	2.8	3.5	0.79	2.59	158	-1.3	82.2	0	100.1

Fort Ware PM and Meteorological Data (March, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms_{-1})	Wind Direction (degrees)	Air Temp (°C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Mar-13	8.5	10.2	0.83	1.04	152	-2.9	73.8	1.7	100.5
2-Mar-13	17.1	20.2	0.84	0.35	325	-7.1	69.0	2.3	100.8
3-Mar-13	7.8	8.9	0.88	1.13	341	-4.4	68.1	2.1	101.3
4-Mar-13	3.3	3.8	0.87	1.50	347	-3.4	59.9	1.8	101.6
5-Mar-13	11.2	12.6	0.88	0.82	345	-8.9	61.0	0.6	101.0
6-Mar-13	11.1	13.4	0.83	0.60	336	-12.4	61.3	0	100.5
7-Mar-13	13.0	15.8	0.82	0.69	355	-11.0	57.8	0	100.7
8-Mar-13	18.7	21.9	0.86	0.35	187	-11.2	60.8	0	100.7
9-Mar-13	14.6	16.8	0.87	0.70	152	-9.2	68.4	0	100.9
10-Mar-13	8.2	9.5	0.87	1.83	309	-1.0	52.8	0.1	100.8
11-Mar-13	8.8	10.2	0.86	0.77	112	-4.2	54.6	0	101.2
12-Mar-13	4.2	5.8	0.72	0.99	331	-7.1	68.6	0.4	100.2
13-Mar-13	6.5	8.0	0.80	0.90	326	-12.1	58.8	0.9	100.4
14-Mar-13	1.4	2.2	0.63	0.79	312	-13.6	69.0	0	100.9
15-Mar-13	2.7	3.5	0.78	0.80	337	-14.3	67.9	0	101.1
16-Mar-13	1.7	2.3	0.76	1.08	326	-10.9	65.4	2.7	100.3
17-Mar-13	1.7	2.2	0.76	2.19	332	-12.7	54.8	0	100.3
18-Mar-13	13.8	16.3	0.84	0.93	332	-14.5	58.9	0.3	100.4
19-Mar-13	10.1	11.6	0.87	1.70	149	-9.4	66.3	0	100.0
20-Mar-13	2.1	4.5	0.46	2.51	334	-7.1	75.8	0	98.8
21-Mar-13	4.2	5.0	0.84	1.43	328	-11.1	52.8	1.6	100.3
22-Mar-13	13.1	16.2	0.81	1.04	352	-10.4	56.2	1.6	101.3
23-Mar-13	16.8	20.1	0.83	0.74	160	-11.2	56.5	0.1	101.4
24-Mar-13	16.4	19.7	0.83	0.66	164	-8.7	56.8	0.5	101.2
25-Mar-13	17.3	21.1	0.82	0.91	150	-5.4	61.5	0	100.7
26-Mar-13	12.9	15.3	0.85	0.84	241	1.3	57.8	0	100.2
27-Mar-13	17.8	21.8	0.82	0.50	12	-2.4	59.2	0	100.5
28-Mar-13	14.4	19.2	0.75	0.72	326	-1.6	54.2	0	100.6
29-Mar-13	11.8	16.2	0.73	0.67	293	-1.1	54.0	0	100.9
30-Mar-13	9.1	11.5	0.79	0.81	303	1.9	57.0	0	101.2
31-Mar-13	9.3	11.4	0.82	0.52	25	2.9	59.4	0	101.1

Fort Ware PM and Meteorological Data (April, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms_{-1})	Wind Direction (degrees)	Air Temp (°C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Apr-13	8.7	11.7	0.75	1.28	153	2.9	60.6	0	100.4
2-Apr-13	3.8	5.0	0.76	1.61	300	2.6	45.7	0.1	100.4
3-Apr-13	5.3	7.0	0.76	0.72	354	-0.7	49.3	0	101.0
4-Apr-13	1.4	3.3	0.44	1.14	323	-0.9	68.3	0.3	100.3
5-Apr-13	1.1	2.1	0.51	1.39	175	-7.2	63.5	0.3	100.0
6-Apr-13	2.0	3.0	0.69	0.72	145	-1.0	62.3	0.1	99.7
7-Apr-13	2.7	3.4	0.79	1.23	151	1.4	69.7	1.4	100.3
8-Apr-13	1.6	2.4	0.68	2.34	153	2.0	50.0	0	100.9
9-Apr-13	1.6	3.3	0.48	3.50	154	0.6	73.2	0.5	99.9
10-Apr-13	2.0	2.9	0.68	1.48	248	3.2	56.2	0	99.6
11-Apr-13	5.2	8.3	0.62	0.97	295	-1.3	44.6	0	100.7
12-Apr-13	3.7	5.0	0.73	0.81	235	-1.5	64.5	0	99.8
13-Apr-13	2.9	4.0	0.73	1.68	64	0.9	55.3	1	100.3
14-Apr-13	6.3	9.9	0.63	0.84	146	0.3	44.6	0	101.2
15-Apr-13	8.5	11.3	0.75	0.73	194	0.1	50.5	0	101.8
16-Apr-13	6.2	7.9	0.78	1.11	150	0.9	54.8	0	101.8
17-Apr-13	1.7	3.8	0.45	2.20	155	3.3	57.8	0	100.7
18-Apr-13	1.7	3.1	0.54	1.92	149	2.5	78.1	0.2	100.6
19-Apr-13	1.7	3.2	0.53	2.25	332	2.4	74.3	0.1	99.9
20-Apr-13	2.5	8.0	0.31	1.82	329	-1.5	41.1	0	101.5
21-Apr-13	5.6	15.1	0.37	1.25	331	-0.9	39.9	0	101.7
22-Apr-13	5.7	23.9	0.24	1.03	301	1.1	48.9	0	101.8
23-Apr-13	2.8	22.4	0.13	1.52	312	5.7	46.5	0	101.8
24-Apr-13	5.7	33.3	0.17	1.08	290	5.2	51.8	0	100.5
25-Apr-13	5.2	23.2	0.22	0.73	111	6.6	64.8	0.5	99.2
26-Apr-13	3.0	14.6	0.21	1.96	162	6.2	69.2	0.4	99.1
27-Apr-13	2.2	5.5	0.40	2.05	249	4.0	54.0	2.2	99.2
28-Apr-13	3.6	9.8	0.36	1.68	148	1.4	63.3	0	99.4
29-Apr-13	2.8	10.3	0.28	2.83	341	-0.9	43.8	0	100.1
30-Apr-13	3.5	20.4	0.17	1.44	321	-1.2	41.4	0	101.1

Fort Ware PM and Meteorological Data (May, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms_{-1})	Wind Direction (degrees)	Air Temp (°C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-May-13	4.0	31.0	0.13	2.12	151	-0.3	65.7	0	101.3
2-May-13	1.9	22.2	0.08	1.58	162	7.6	57.7	0	101.2
3-May-13	3.9	40.2	0.10	1.12	274	9.2	48.6	0	101.7
4-May-13	4.8	49.8	0.10	1.13	148	11.9	48.7	0	101.4
5-May-13	8.6	41.6	0.21	0.97	227	10.7	47.5	0	100.8
6-May-13	7.9	59.5	0.13	1.36	334	9.2	46.1	0	100.3
7-May-13	2.8	24.5	0.11	1.01	330	9.6	44.2	0	100.8
8-May-13	4.0	22.3	0.18	1.26	329	11.1	36.3	0	100.9
9-May-13	3.1	28.3	0.11	1.60	339	10.9	36.1	0	101.3
10-May-13	2.7	48.7	0.06	1.41	134	12.8	38.7	0	101.4
11-May-13	4.1	49.0	0.08	1.31	156	9.1	60.7	0	100.5
12-May-13	1.9	5.4	0.36	1.02	252	11.5	70.4	3.7	99.4
13-May-13	2.9	17.0	0.17	1.05	270	10.9	53.0	0	99.6
14-May-13	4.6	34.7	0.13	1.27	236	8.7	50.7	0	100.0
15-May-13	6.7	24.1	0.28	0.94	229	8.8	51.5	0	100.2
16-May-13	6.2	11.7	0.53	0.92	300	9.8	49.8	0	100.3
17-May-13	3.3	10.6	0.32	0.76	118	9.8	46.5	0	100.2
18-May-13	5.8	12.3	0.47	1.57	155	10.8	62.0	0.5	100.2
19-May-13	2.3	4.3	0.53	1.35	281	8.1	48.9	0	101.2
20-May-13	2.1	5.4	0.38	1.43	15	6.8	39.5	0	101.4
21-May-13	1.0	2.8	0.35	1.43	325	5.1	65.4	0	101.3
22-May-13	3.8	28.7	0.13	1.76	166	16.4	29.9	0	100.6
23-May-13	3.5	12.8	0.28	1.20	337	21.6	44.3	0	100.5
24-May-13	5.6	16.6	0.34						
25-May-13	5.4	16.4	0.33	1.67	87	22.4	17.2	0.01	100.3
26-May-13	5.4	20.0	0.27	1.20	53	15.9	34.5	0	100.4
27-May-13	4.7	21.8	0.21	1.33	138	13.5	46.3	0	100.1
28-May-13	3.3	8.7	0.38	1.22	19	13.1	53.3	0	99.8
29-May-13	1.4	3.2	0.44	0.62	146	11.6	78.7	3.7	99.9
30-May-13	4.4	9.9	0.44	0.82	352	11.6	85.0	2.5	100.4
31-May-13	1.1	3.6	0.32	1.56	154	10.9	90.1	9.4	100.9

Fort Ware PM and Meteorological Data (June, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms_{-1})	Wind Direction (degrees)	Air Temp (°C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Jun-13	1.9	4.8	0.40	1.08	185	12.1	61.7	0	101.0
2-Jun-13	2.5	6.3	0.39	1.23	345	12.2	52.3	0	101.0
3-Jun-13	3.5	7.3	0.48	1.24	151	13.6	54.2	0	100.9
4-Jun-13	1.9	4.8	0.39	0.92	176	14.4	55.3	0.2	100.5
5-Jun-13	NaN	NaN	-	1.10	299	11.9	53.7	0.1	100.4
6-Jun-13	NaN	NaN	-	1.11	157	10.1	53.0	0	100.5
7-Jun-13	NaN	NaN	-	0.66	105	10.8	73.5	4.3	100.1
8-Jun-13	NaN	NaN	-	0.31	22	9.8	89.7	8.9	100.6
9-Jun-13	NaN	NaN	-	0.71	345	12.5	67.7	0	100.8
10-Jun-13	NaN	NaN	-	0.96	11	14.4	50.2	0	100.9
11-Jun-13	NaN	NaN	-	1.28	95	13.7	47.1	0	100.7
12-Jun-13	NaN	NaN	-	0.82	140	13.5	50.8	0	100.8
13-Jun-13	NaN	NaN	-	0.87	8	14.3	62.0	0.2	100.6
14-Jun-13	NaN	NaN	-	0.87	324	14.7	68.7	2.1	100.8
15-Jun-13	NaN	NaN	-	1.09	347	15.5	61.5	0	101.2
16-Jun-13	NaN	NaN	-	1.13	1	15.7	55.6	0	101.2
17-Jun-13	NaN	NaN	-	0.99	8	14.2	63.1	3.3	100.5
18-Jun-13	NaN	NaN	-	1.18	57	17.0	54.6	0.1	100.7
19-Jun-13	NaN	NaN	-	0.50	90	15.9	59.8	0	100.9
20-Jun-13	NaN	NaN	-	0.76	124	18.9	53.6	0	100.8
21-Jun-13	NaN	NaN	-	0.68	158	20.0	49.3	0	100.7
22-Jun-13	NaN	NaN	-	0.81	11	21.0	50.6	0	100.2
23-Jun-13	6.3	29.4	0.22	0.84	140	20.7	54.1	0	99.9
24-Jun-13	5.3	17.2	0.31	1.02	349	18.1	66.2	5.2	99.5
25-Jun-13	4.7	7.6	0.62	0.74	9	15.7	81.8	4	99.6
26-Jun-13	NaN	NaN	-	0.73	163	14.1	93.1	17	99.9
27-Jun-13	NaN	NaN	-	0.77	163	12.8	93.2	12.3	100.7
28-Jun-13	1.4	8.7	0.16	0.65	164	16.1	72.6	0	101.2
29-Jun-13	1.3	4.6	0.27	1.03	149	17.4	73.4	1.2	100.9
30-Jun-13	1.8	5.3	0.33	0.73	27	17.8	67.6	0.1	101.0

Fort Ware PM and Meteorological Data (July, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms_{-1})	Wind Direction (degrees)	Air Temp (°C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Jul-13	1.1	4.8	0.23	0.74	353	16.6	76.4	1.6	100.7
2-Jul-13	1.5	6.1	0.25	0.72	281	16.6	57.6	0	100.5
3-Jul-13	0.9	5.6	0.16	0.97	327	15.8	45.9	0	100.6
4-Jul-13	0.8	5.0	0.16	0.93	341	16.1	46.9	0	100.5
5-Jul-13	2.3	10.5	0.22	1.04	341	16.4	45.9	0	100.7
6-Jul-13	4.1	13.8	0.30	0.80	165	16.5	51.3	0	100.7
7-Jul-13	6.4	15.0	0.43	1.17	145	19.6	46.4	0	100.4
8-Jul-13	3.8	14.4	0.27	0.63	192	17.4	57.0	0	100.4
9-Jul-13	1.9	7.1	0.26	1.15	328	15.8	52.8	0	100.5
10-Jul-13	0.6	8.0	0.08	0.88	157	10.9	66.4	1.7	100.2
11-Jul-13	0.6	1.8	0.35	0.88	189	11.0	76.7	2.5	99.7
12-Jul-13	1.2	2.3	0.53	0.62	120	9.5	83.4	5.1	100.3
13-Jul-13	0.8	2.3	0.34	0.42	48	8.4	90.1	12	101.0
14-Jul-13	2.3	6.2	0.37	0.88	343	13.8	64.2	0.4	101.2
15-Jul-13	6.3	20.1	0.31	0.57	224	16.3	58.1	0	101.0
16-Jul-13	10.4	30.2	0.35	0.74	135	17.1	62.3	0	101.0
17-Jul-13	14.7	45.0	0.33	0.70	129	19.3	61.2	0	100.7
18-Jul-13	9.9	33.3	0.30	0.58	205	19.4	61.6	0	100.7
19-Jul-13	5.9	23.9	0.25	0.74	354	20.5	56.0	3.2	100.7
20-Jul-13	2.5	6.1	0.41	0.74	324	17.6	75.1	2.9	100.4
21-Jul-13	1.6	7.8	0.20	0.67	23	15.8	69.8	2.3	100.2
22-Jul-13	1.4	12.2	0.11	1.17	346	15.3	63.3	0	100.6
23-Jul-13	1.7	4.4	0.40	0.43	0	13.3	82.2	6.3	101.0
24-Jul-13	1.4	5.3	0.27	0.65	166	14.9	83.5	4.3	101.0
25-Jul-13	3.5	8.2	0.42	1.02	337	16.0	72.9	0.1	100.8
26-Jul-13	1.7	5.4	0.31	0.72	342	13.3	75.5	2.3	100.8
27-Jul-13	1.8	5.5	0.33	0.84	346	14.2	77.4	4.3	100.9
28-Jul-13	2.4	8.4	0.29	0.77	346	15.8	61.3	0	101.2
29-Jul-13	2.0	6.0	0.34	0.68	14	14.9	75.3	2.7	101.0
30-Jul-13	1.8	6.9	0.25	0.52	161	18.3	67.6	0	101.1
31-Jul-13	1.6	13.4	0.12	0.85	138	20.1	66.5	4.2	101.2

Fort Ware PM and Meteorological Data (August, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms_{-1})	Wind Direction (degrees)	Air Temp (°C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Aug-13	4.9	19.4	0.25	NaN	NaN	NaN	NaN	NaN	NaN
2-Aug-13	4.3	16.0	0.27	NaN	NaN	NaN	NaN	NaN	NaN
3-Aug-13	3.0	12.7	0.23	NaN	NaN	NaN	NaN	NaN	NaN
4-Aug-13	3.3	13.5	0.25	NaN	NaN	NaN	NaN	NaN	NaN
5-Aug-13	5.4	18.5	0.29	NaN	NaN	NaN	NaN	NaN	NaN
6-Aug-13	5.0	13.3	0.38	NaN	NaN	NaN	NaN	NaN	NaN
7-Aug-13	19.3	24.5	0.79	0.90	111	20.8	60.4	1.6	100.8
8-Aug-13	NaN	NaN	-	0.92	151	17.5	74.5	1	100.8
9-Aug-13	21.5	27.7	0.78	0.42	139	17.9	76.8	0.6	100.7
10-Aug-13	1.9	10.0	0.19	0.90	354	19.7	61.7	0	100.6
11-Aug-13	2.6	9.0	0.29	1.01	5	20.1	57.1	2	100.7
12-Aug-13	2.2	7.4	0.30	0.72	144	20.6	63.1	0	100.8
13-Aug-13	2.6	6.7	0.39	0.98	14	16.5	71.7	0.6	100.8
14-Aug-13	3.6	21.6	0.17	0.85	160	17.6	74.3	0	100.4
15-Aug-13	4.1	15.1	0.27	0.84	141	16.1	75.2	0.1	100.2
16-Aug-13	1.7	6.0	0.28	0.96	162	15.8	70.8	0.1	100.1
17-Aug-13	1.1	13.2	0.08	1.26	165	16.6	66.4	0	100.1
18-Aug-13	3.9	8.4	0.46	0.70	155	14.0	67.9	2.2	99.8
19-Aug-13	1.4	3.6	0.38	0.74	165	11.7	67.1	0.7	99.8
20-Aug-13	1.2	4.0	0.31	0.83	136	11.4	72.7	0	100.4
21-Aug-13	1.5	19.8	0.08	0.83	150	14.2	65.0	0	100.7
22-Aug-13	2.4	15.6	0.15	0.64	287	15.8	58.1	0	100.1
23-Aug-13	5.3	15.7	0.34	0.90	145	12.3	63.0	0	99.9
24-Aug-13	1.4	3.5	0.40	0.79	157	12.3	80.6	1.7	99.7
25-Aug-13	1.2	4.8	0.25	0.71	153	11.8	93.8	11	100.1
26-Aug-13	NaN	NaN	-	0.42	359	14.3	77.1	0	100.2
27-Aug-13	0.8	3.6	0.24	1.10	152	11.5	80.1	4	99.9
28-Aug-13	0.4	3.3	0.11	0.52	224	13.8	84.4	2.2	100.3
29-Aug-13	0.3	4.0	0.08	0.27	345	12.5	84.7	0.2	100.5
30-Aug-13	0.4	4.8	0.09	0.98	99	14.7	76.0	0	100.4
31-Aug-13	0.2	5.3	0.03	0.61	159	16.5	75.3	1.1	100.7

Fort Ware PM and Meteorological Data (September,2013)									
Date	**$PM_{2.5}$ (µg m^{-3})**	**PM_{10} (µg m^{-3})**	**PM Ratio**	**Wind Speed (ms_{-1})**	**Wind Direction (degrees)**	**Air Temp (°C)**	**RH (%)**	**Total Precip (mm)**	**Barometric Pressure (kPa)**
1-Sep-13	0.5	10.0	0.05	0.66	149	14.9	72.7	0	100.2
2-Sep-13	0.9	10.2	0.09	0.53	171	14.2	69.3	0	100.4
3-Sep-13	0.6	5.5	0.10	0.63	151	14.0	68.3	0	100.6
4-Sep-13	1.1	9.2	0.12	0.70	155	13.8	65.0	0	100.5
5-Sep-13	0.4	4.7	0.09	0.62	15	16.4	60.4	0	100.9
6-Sep-13	0.9	17.8	0.05	0.86	335	15.1	66.1	0	101.3
7-Sep-13	0.6	25.0	0.02	0.66	152	14.6	66.6	0	100.9
8-Sep-13	0.2	5.7	0.04	0.66	243	14.6	64.5	0	100.3
9-Sep-13	1.1	14.7	0.08	0.74	347	13.3	48.2	0	100.6
10-Sep-13	1.5	21.0	0.07	0.70	151	11.9	58.1	0	101.0
11-Sep-13	1.1	6.2	0.17	0.70	139	12.7	62.6	0	101.2
12-Sep-13	0.4	42.9	0.01	0.68	149	14.2	65.6	0	100.6
13-Sep-13	1.0	27.6	0.03	0.55	354	14.3	63.8	0	100.6
14-Sep-13	1.6	48.9	0.03	0.76	149	13.0	63.5	0	100.6
15-Sep-13	1.1	24.9	0.05	0.67	129	13.5	64.9	0	100.0
16-Sep-13	0.7	5.3	0.13	0.37	101	11.0	92.6	19.3	99.4
17-Sep-13	1.5	6.2	0.23	0.41	150	8.3	86.1	0.2	99.9
18-Sep-13	0.8	3.6	0.22	0.43	51	5.8	86.3	1.7	100.2
19-Sep-13	NaN	NaN	-	1.22	158	7.3	89.3	0.8	99.9
20-Sep-13	0.9	6.3	0.14	1.65	146	12.1	73.3	1.1	99.1
21-Sep-13	0.2	3.0	0.07	0.79	155	7.9	80.7	0.1	98.8
22-Sep-13	0.3	3.1	0.11	1.07	150	7.8	80.0	0.6	98.4
23-Sep-13	0.5	2.7	0.19	0.78	146	6.7	88.2	6.3	98.9
24-Sep-13	0.8	2.6	0.30	1.01	154	5.8	90.9	3.3	99.8
25-Sep-13	0.9	4.3	0.22	0.82	355	7.6	76.9	0	100.9
26-Sep-13	8.5	11.4	0.75	0.49	147	4.0	88.1	0.2	100.5
27-Sep-13	4.1	7.9	0.52	0.54	163	6.3	81.5	0.5	99.5
28-Sep-13	3.0	7.2	0.42	0.78	158	5.7	80.2	0.4	98.3
29-Sep-13	1.7	3.9	0.43	1.03	154	6.6	85.5	9.7	97.8
30-Sep-13	2.2	4.7	0.46	0.44	348	5.3	83.7	0.1	98.7

Fort Ware PM and Meteorological Data (October, 2013)									
Date	**$PM_{2.5}$ (µg m^{-3})**	**PM_{10} (µg m^{-3})**	**PM Ratio**	**Wind Speed (ms_{-1})**	**Wind Direction (degrees)**	**Air Temp (°C)**	**RH (%)**	**Total Precip (mm)**	**Barometric Pressure (kPa)**
1-Oct-13	2.7	5.8	0.46	0.38	97	6.5	85.1	2.2	100.0
2-Oct-13	6.0	10.1	0.59	0.42	195	6.3	78.6	0	100.9
3-Oct-13	4.6	8.1	0.57	1.42	153	4.2	81.0	0	101.3
4-Oct-13	4.9	7.5	0.66	3.18	151	7.2	77.9	0	100.4
5-Oct-13	4.9	8.2	0.60	1.65	176	7.5	72.3	0	100.4
6-Oct-13	2.4	4.7	0.51	0.51	142	3.5	92.1	9.2	100.0
7-Oct-13	1.7	3.3	0.50	0.72	340	5.5	86.0	1.7	99.1
8-Oct-13	7.0	9.1	0.76	0.97	329	5.3	66.2	0	100.4
9-Oct-13	4.6	7.0	0.66	2.18	156	5.0	72.5	0.3	99.3
10-Oct-13	1.8	3.1	0.59	1.17	293	6.2	52.9	0	99.7
11-Oct-13	5.4	7.8	0.69	0.90	148	4.5	64.0	0	100.6
12-Oct-13	8.6	11.6	0.74	0.62	152	3.7	75.9	0	101.0
13-Oct-13	12.6	16.7	0.75	0.52	157	2.9	77.1	0	101.4
14-Oct-13	8.1	10.9	0.74	1.42	153	3.3	82.8	0	101.5
15-Oct-13	9.0	11.5	0.78	0.87	331	4.7	76.5	0	101.3
16-Oct-13	8.6	12.5	0.69	1.03	338	1.1	71.9	0	101.5
17-Oct-13	16.4	20.3	0.81	0.69	328	1.4	72.8	0	101.6
18-Oct-13	13.3	15.6	0.86	0.48	119	0.6	87.2	0	101.2
19-Oct-13	15.1	17.1	0.88	0.71	147	4.2	84.9	0	101.0
20-Oct-13	10.3	12.3	0.84	1.29	152	5.3	89.8	0	101.0
21-Oct-13	17.2	20.5	0.84	0.52	144	6.9	94.5	1.7	100.8
22-Oct-13	4.6	6.1	0.74	0.36	341	5.8	91.3	0.3	101.1
23-Oct-13	5.4	8.7	0.62	0.30	26	4.4	92.6	1	101.0
24-Oct-13	6.4	8.2	0.77	0.86	163	5.4	89.5	0	100.6
25-Oct-13	3.3	4.5	0.74	0.74	184	0.7	96.5	0.1	101.2
26-Oct-13	5.6	7.7	0.73	0.86	110	3.1	94.1	0.5	101.0
27-Oct-13	9.0	10.8	0.83	1.23	339	2.9	67.0	0	102.2
28-Oct-13	14.7	17.4	0.85	0.39	170	-0.5	77.7	0	101.5
29-Oct-13	15.2	18.5	0.82	0.98	143	-0.7	78.6	0	100.2
30-Oct-13	21.5	24.9	0.86	0.38	67	-1.9	84.4	0	99.8
31-Oct-13	19.3	22.7	0.85	0.79	145	2.0	86.8	0	99.7

Fort Ware PM and Meteorological Data (November, 2013)									
Date	$PM_{2.5}$ (μg m^{-3})	PM_{10} (μg m^{-3})	PM Ratio	Wind Speed (ms_{-1})	Wind Direction (degrees)	Air Temp (°C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Nov-13	13.3	15.9	0.84	0.71	353	-0.9	76.5	0.1	100.4
2-Nov-13	6.6	8.6	0.77	0.76	350	-1.4	74.2	0	100.5
3-Nov-13	13.6	18.3	0.74	0.90	339	-6.8	77.4	0	100.9
4-Nov-13	8.8	13.9	0.64	0.42	349	-10.7	79.4	0	100.5
5-Nov-13	12.3	16.8	0.73	0.61	139	-3.2	80.2	0.1	100.0
6-Nov-13	12.5	15.2	0.82	0.27	350	-3.5	85.8	0	100.7
7-Nov-13	10.5	12.4	0.85	0.35	342	-1.2	85.4	0	100.1
8-Nov-13	6.9	8.4	0.82	1.33	336	-4.4	74.6	0	100.1
9-Nov-13	4.9	12.7	0.39	1.22	334	-10.9	65.3	0	101.3
10-Nov-13	11.1	26.2	0.42	0.62	343	-15.2	69.6	0	101.6
11-Nov-13	3.9	10.8	0.36	0.50	345	-9.9	71.6	0	101.4
12-Nov-13	7.2	8.6	0.84	0.59	1	-5.8	83.4	0	100.4
13-Nov-13	13.0	14.4	0.91	0.48	351	-2.9	85.3	1.7	100.5
14-Nov-13	7.9	8.2	0.96	1.04	148	-1.6	89.7	0	99.8
15-Nov-13	2.6	4.7	0.56	2.09	336	-2.7	77.1	0	98.8
16-Nov-13	2.0	3.4	0.60	0.35	319	-8.9	71.3	0	99.5
17-Nov-13	2.6	3.6	0.73	1.13	335	-16.2	67.1	0	99.9
18-Nov-13	3.0	3.5	0.84	0.61	333	-20.4	63.1	0	100.5
19-Nov-13	13.7	15.2	0.90	0.68	4	-27.0	61.4	0	100.6
20-Nov-13	15.6	17.5	0.89	0.46	356	-24.6	65.4	0	101.0
21-Nov-13	5.7	6.9	0.83	0.97	341	-17.9	73.1	0	101.4
22-Nov-13	9.7	10.9	0.90	0.49	353	-13.8	77.5	0	101.9
23-Nov-13	11.0	12.3	0.89	1.92	153	-3.2	88.9	0	100.7
24-Nov-13	16.1	17.5	0.92	0.84	353	-7.8	83.9	0	101.3
25-Nov-13	6.1	6.9	0.90	0.67	349	-11.0	80.1	0	101.5
26-Nov-13	13.8	16.4	0.84	0.19	15	-5.4	90.4	0	101.0
27-Nov-13	11.7	14.1	0.83	0.56	123	-2.0	93.9	0	100.6
28-Nov-13	7.0	7.8	0.90	1.77	154	-0.6	91.5	0.8	99.8
29-Nov-13	21.8	23.7	0.92	0.83	148	-6.2	87.9	0	100.3
30-Nov-13	2.7	3.0	0.93	1.76	165	-0.3	90.7	2.5	99.9

Fort Ware PM and Meteorological Data (December, 2013)									
Date	$PM_{2.5}$ (µg m^{-3})	PM_{10} (µg m^{-3})	PM Ratio	Wind Speed (ms_{-1})	Wind Direction (degrees)	Air Temp (°C)	RH (%)	Total Precip (mm)	Barometric Pressure (kPa)
1-Dec-13	3.5	6.0	0.59	3.35	339	-14.6	70.0	0	100.3
2-Dec-13	5.5	6.5	0.84	2.61	338	-17.6	62.0	0	102.4
3-Dec-13	8.0	9.0	0.90	1.23	343	-24.4	65.6	0	102.7
4-Dec-13	4.6	5.2	0.88	0.86	359	-27.8	62.4	0	102.2
5-Dec-13	5.0	5.8	0.86	NaN	NaN	NaN	NaN	NaN	NaN
6-Dec-13	9.5	10.9	0.87	0.90	351	-28.5	59.8	0	102.4
7-Dec-13	9.2	9.6	0.96	0.33	356	-22.9	63.5	0	101.7
8-Dec-13	14.4	15.3	0.94	0.30	114	-15.5	75.6	0	101.5
9-Dec-13	15.8	17.0	0.93	0.49	134	-12.9	79.8	0	101.0
10-Dec-13	19.3	20.5	0.94	0.23	57	-12.0	80.1	0	101.0
11-Dec-13	8.1	8.9	0.91	0.25	307	-10.9	83.0	0	100.2
12-Dec-13	3.9	4.3	0.90	0.39	331	-13.2	80.7	0	100.1
13-Dec-13	7.1	7.8	0.91	0.81	341	-14.9	78.6	0	100.5
14-Dec-13	5.3	5.6	0.94	1.26	146	-7.7	87.6	5.8	99.3
15-Dec-13	9.8	10.7	0.92	1.01	151	-3.1	85.8	6.5	99.3
16-Dec-13	20.9	22.6	0.93	0.47	111	-10.0	84.1	0	100.4
17-Dec-13	3.2	3.7	0.86	1.73	344	-7.3	86.8	0	99.5
18-Dec-13	4.7	5.5	0.86	1.08	338	-15.8	73.7	0	101.3
19-Dec-13	5.1	5.7	0.89	0.30	351	-21.4	69.5	0	100.8
20-Dec-13	5.6	6.4	0.89	1.32	351	-15.3	78.9	0	99.8
21-Dec-13	4.6	5.1	0.89	0.80	346	-15.9	76.8	0	100.6
22-Dec-13	6.6	7.1	0.92	0.54	360	-12.9	81.7	0	100.3
23-Dec-13	20.2	21.6	0.93	0.75	4	-8.5	85.1	0	99.8
24-Dec-13	10.9	11.7	0.93	0.53	135	-6.5	87.9	0	100.9
25-Dec-13	2.2	2.5	0.91	2.66	152	-0.8	95.5	0	100.2
26-Dec-13	2.3	2.6	0.89	1.82	151	0.7	96.9	4.2	99.4
27-Dec-13	4.1	5.3	0.77	2.84	339	-12.9	77.2	0.4	100.4
28-Dec-13	6.1	6.7	0.92	0.86	339	-16.5	71.5	0	101.7
29-Dec-13	7.2	7.8	0.92	0.93	342	-12.1	78.9	0	100.7
30-Dec-13	7.9	8.4	0.93	0.29	332	-11.2	81.1	0	100.3
31-Dec-13	5.9	6.5	0.91	0.49	345	-10.5	81.9	0	100.6

Fort Ware PM and Meteorological Data (January, 2014)									
Date	**$PM_{2.5}$ (μg m^{-3})**	**PM_{10} (μg m^{-3})**	**PM Ratio**	**Wind Speed (ms_{-1})**	**Wind Direction (degrees)**	**Air Temp (°C)**	**RH (%)**	**Total Precip (mm)**	**Barometric Pressure (kPa)**
1-Jan-14	3.5	3.7	0.95	0.63	351	-10.0	82.8	0	100.7
2-Jan-14	3.2	3.5	0.93	0.88	353	-6.3	87.5	0	99.8
3-Jan-14	21.7	24.2	0.90	0.53	349	-10.4	79.7	0	100.6
4-Jan-14	15.9	17.4	0.91	0.54	326	-8.5	82.8	0	102.0
5-Jan-14	3.7	4.1	0.90	1.49	138	-9.2	83.8	0	102.0
6-Jan-14	5.1	5.6	0.92	0.49	70	-8.0	85.2	0	101.1
7-Jan-14	6.3	6.9	0.91	0.43	159	-6.7	87.0	0	100.3
8-Jan-14	9.5	10.6	0.89	0.22	315	-6.0	87.6	0	99.4
9-Jan-14	7.0	7.6	0.93	0.63	111	-4.1	90.8	0	98.5
10-Jan-14	23.6	26.3	0.90	0.69	125	-7.7	83.0	0	98.9
11-Jan-14	13.0	14.3	0.91	0.91	357	-7.3	85.8	0	97.7
12-Jan-14	15.7	17.0	0.92	1.24	143	-8.7	83.6	0	98.3
13-Jan-14	11.5	13.0	0.89	0.59	119	-6.1	86.9	0	99.8
14-Jan-14	2.6	3.5	0.75	3.67	160	0.8	86.6	27.6	99.7
15-Jan-14	5.8	7.2	0.81	1.69	333	1.8	58.5	4.5	101.0
16-Jan-14	4.6	5.3	0.88	1.55	151	-0.2	86.8	0.2	101.3
17-Jan-14	5.6	6.2	0.90	0.56	113	-2.4	92.0	0	101.2
18-Jan-14	3.8	4.1	0.91	0.81	72	-1.9	90.4	0	100.9
19-Jan-14	24.3	27.0	0.90	0.56	36	-9.0	79.2	1.1	101.0
20-Jan-14	34.9	39.3	0.89	0.17	329	-10.6	80.9	0	101.6
21-Jan-14	6.9	7.5	0.92	0.19	337	-6.4	84.5	0	101.6
22-Jan-14	4.2	4.7	0.89	0.46	134	-3.1	86.8	0	101.7
23-Jan-14	3.0	3.3	0.91	0.83	146	-1.6	92.5	0.1	102.0
24-Jan-14	3.8	4.1	0.91	0.55	110	-0.1	92.4	0.1	102.0
25-Jan-14	6.2	6.8	0.92	0.49	348	-2.9	88.7	0	101.8
26-Jan-14	1.9	2.1	0.92	0.51	351	-5.7	85.3	0	101.9
27-Jan-14	3.5	3.8	0.92	0.25	358	-3.4	87.6	0	101.5
28-Jan-14	1.6	1.7	0.92	0.81	94	-4.0	86.8	0.2	100.9

NaN = Instrument decommissioned or malfunctioning

* = Value below detectable limit

APPENNDIX III

PARTICULATE AND METEOROLOGICAL DATA FOR THE BGI MONITORING SITES (2013)

Van Somer

Date	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	Wind Speed (m/s)	Wind Direction (degrees)	Temperature (°C)	RH (%)	Precipitation (mm)
25-May-13	10.2	6.2	0.5	89	15.9	NaN	0.0
28-May-13	6.3	1.4	0.2	81	12.0	NaN	0.0
31-May-13	5.8	1.0	0.9	125	9.3	NaN	15
03-Jun-13	5.6	1.0	0.4	112	10.7	NaN	0.7
06-Jun-13	4.7	*	0.6	127	8.7	NaN	0
09-Jun-13	3.4	0.8	0.7	324	11.5	70.4	0
12-Jun-13	4.0	3.5	0.2	113	12.9	61.4	0
15-Jun-13	8.5	2.7	1.3	350	15.0	63.4	0
18-Jun-13	5.1	2.9	0.4	4	16.4	62.8	0
21-Jun-13	9.1	4.9	0.2	144	17.0	63.3	0
24-Jun-13	8.3	4.6	0.6	30	16.5	75.7	2.1
27-Jun-13	3.7	1.6	0.3	355	13.0	92.7	20.7
03-Jul-13	3.8	1.6	0.1	28	14.2	61.8	0
09-Jul-13	2.5	0.2	0.5	238	15.4	64.7	0
15-Jul-13	6.0	3.0	0.3	351	13.5	71.2	0
21-Jul-13	27.4	1.6	0.4	30	16.3	74.3	0
27-Jul-13	3.5	0.4	2.0	355	12.9	85.5	4.5
02-Aug-13	22.8	3.7	0.3	100	17.2	75.3	0
08-Aug-13	8.9	4.4	0.5	126	16.3	85.3	0.3
14-Aug-13	17.4	3.7	0.4	129	16.7	83.7	0.4
20-Aug-13	30.2	0.1	0.7	274	12.3	70.1	0
26-Aug-13	NaN	1.2	0.1	36	12.0	84.0	0
01-Sep-13	11.1	7.2	0.6	127	13.3	82.5	0
07-Sep-13	9.6	2.5	0.3	87	13.4	77.9	0
13-Sep-13	12.6	4.1	0.2	88	14.0	73.8	0
19-Sep-13	10.1	3.3	0.8	122	7.8	87.6	1.2
25-Sep-13	7.6	4.5	0.5	353	7.2	83.1	0.2
01-Oct-13	3.7	1.5	0.3	24	6.2	85.1	0.4
07-Oct-13	2.1	1.2	0.9	1	6.1	92.2	7.8

* = Below Detectable Limit

NaN = Missing Data

Total Precipitation for Period (mm) **53.3**

Chowika

Date	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	Wind Speed (m/s)	Wind Direction (degrees)	Temperature (°C)	RH (%)	Precipitation (mm)
25-May-13	11.0	5.2	1.2	51	16.8	NaN	0
28-May-13	10.1	2.1	0.5	76	12.4	NaN	0
31-May-13	2.7	1.7	2.0	163	9.1	NaN	11.6
03-Jun-13	7.2	1.4	0.9	148	11.7	NaN	0
06-Jun-13	5.0	0.9	1.1	169	9.6	NaN	0
09-Jun-13	3.3	3.7	1.4	25	12.0	67.3	0
12-Jun-13	3.5	*	0.3	157	12.9	60.8	0
15-Jun-13	5.8	3.1	2.0	16	14.3	68.4	0
18-Jun-13	10.4	3.0	0.6	38	16.0	62.5	0
21-Jun-13	11.1	5.2	0.4	111	17.0	58.9	0
24-Jun-13	8.2	5.3	1.6	21	17.3	70.0	0.3
27-Jun-13	3.5	1.2	0.5	20	13.3	90.9	14.6
03-Jul-13	3.9	1.8	0.9	21	16.3	46.6	0
09-Jul-13	2.0	*	0.8	13	16.2	56.8	0
15-Jul-13	5.5	3.2	0.9	20	15.3	62.5	0
21-Jul-13	5.2	0.1	0.2	21	16.4	74.2	0.1
27-Jul-13	2.6	0.3	2.0	26	12.9	83.5	1.8
02-Aug-13	NaN	3.5	0.6	50	17.9	71.9	1
08-Aug-13	5.6	3.6	1.3	170	17.3	77.5	0.9
14-Aug-13	5.7	3.5	1.3	170	17.2	78.2	0
20-Aug-13	1.0	0.6	1.8	340	13.1	62.0	0.3
26-Aug-13	5.4	0.8	0.6	27	13.1	78.7	0
01-Sep-13	12.0	9.9	1.0	162	14.8	77.3	0
07-Sep-13	13.4	7.2	0.6	70	15.2	73.7	0
13-Sep-13	10.9	6.7	1.3	37	16.0	65.3	0
19-Sep-13	6.4	4.0	1.4	152	9.8	80.9	0.5
25-Sep-13	7.3	2.0	1.3	30	7.9	80.1	0.7
01-Oct-13	8.1	4.7	0.3	119	7.3	79.3	0.3
07-Oct-13	6.2	1.7	1.2	30	6.5	91.3	8.4

* = Below Detectable Limit

NaN = Missing Data

Total Precipitation for Period (mm) **40.5**

Davis

Date	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	Wind Speed (m/s)	Wind Direction (degrees)	Temperature (^oC)	RH (%)	Precipitation (mm)
25-May-13	23.9	11.1	1.4	51	15.7	NaN	0
28-May-13	8.8	12.8	0.1	107	11.4	NaN	0.8
31-May-13	2.0	1.2	3.4	214	8.5	NaN	8.1
03-Jun-13	5.1	1.7	0.9	203	11.0	NaN	0
06-Jun-13	1.7	0.1	1.3	209	8.7	NaN	0
09-Jun-13	6.0	*	0.6	58	11.6	72.8	0.1
12-Jun-13	2.7	1.7	0.1	15	12.4	65.6	0
15-Jun-13	3.0	8.1	0.5	51	14.9	68.3	0.1
18-Jun-13	5.8	2.4	0.2	35	16.7	60.4	0
21-Jun-13	8.4	4.4	0.2	121	16.3	62.2	0
24-Jun-13	10.2	5.5	0.5	56	17.2	72.6	0.6
27-Jun-13	4.1	1.3	0.3	44	13.3	92.7	8.1
03-Jul-13	3.7	1.7	0.1	212	15.2	56.9	0
09-Jul-13	2.5	0.3	0.5	199	15.9	62.9	0
15-Jul-13	7.2	2.7	0.1	187	12.9	74.7	0
21-Jul-13	4.1	NaN	0.2	191	15.4	80.4	0
27-Jul-13	2.2	*	0.7	65	13.5	81.9	3.2
02-Aug-13	5.3	2.5	0.3	76	17.2	75.3	0
08-Aug-13	6.6	4.7	0.5	171	16.4	83.1	0
14-Aug-13	5.9	3.6	0.9	192	16.3	81.1	0
20-Aug-13	2.9	*	0.7	52	11.3	71.5	0.1
26-Aug-13	5.4	0.7	0.8	53	12.0	80.6	0.1
01-Sep-13	14.7	8.1	0.4	164	13.6	84.1	0
07-Sep-13	11.4	9.4	0.4	76	13.1	80.3	0
13-Sep-13	11.9	7.9	0.8	52	13.9	75.3	0
19-Sep-13	9.3	4.1	0.5	103	8.8	88.7	2.4
25-Sep-13	10.7	6.0	1.1	50	7.4	82.2	0.3
01-Oct-13	9.5	5.2	0.1	110	6.8	85.2	0.1
07-Oct-13	4.1	2.3	0.5	88	6.7	93.4	17.7

* = Below Detectable Limit

NaN = Missing Data

Total Precipitation for Period (mm) **41.7**

Tsay Keh

Date	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	Wind Speed (m/s)	Wind Direction (degrees)	Temperature (^oC)	RH (%)	Precipitation (mm)
25-May-13	17.5	11.4	0.8	63	16.4	43.4	0
28-May-13	8.9	3.1	0.5	175	12.8	58.5	0
31-May-13	5.1	1.5	2.4	182	9.7	93.9	20.7
03-Jun-13	6.7	1.9	0.8	181	11.6	68.6	0.9
06-Jun-13	6.1	0.9	1.4	183	9.6	59.9	0
09-Jun-13	2.9	0.3	0.6	8	12.5	63.7	0
12-Jun-13	6.3	2.9	0.6	174	13.8	57.1	0
15-Jun-13	7.7	5.2	2.0	6	17.0	52.6	0
18-Jun-13	8.8	3.5	0.1	350	17.7	53.7	0
21-Jun-13	17.8	6.7	0.7	169	18.2	53.2	0
24-Jun-13	12.1	6.2	0.9	8	18.3	61.7	1.5
27-Jun-13	3.4	2.0	0.2	348	13.8	88.6	20.2
03-Jul-13	7.0	2.2	0.2	25	16.5	45.7	0
09-Jul-13	6.2	1.9	0.4	222	16.6	53.3	0
15-Jul-13	14.0	4.7	0.6	2	15.9	57.5	0
21-Jul-13	9.1	2.4	0.1	108	16.9	67.1	0
27-Jul-13	3.3	*	2.0	356	13.6	80.7	3.4
02-Aug-13	12.3	3.4	0.3	126	18.3	66.8	0
08-Aug-13	9.5	3.3	0.6	186	17.8	76.1	0.1
14-Aug-13	9.5	4.0	0.7	190	17.6	77.8	0.7
20-Aug-13		1.1	0.5	356	12.7	63.6	0.1
26-Aug-13	7.4	2.1	0.1	302	12.8	77.5	0
01-Sep-13	15.8	7.9	0.8	197	14.0	76.8	0
07-Sep-13	17.2	NaN	0.4	217	13.7	72.6	0
13-Sep-13	40.7	12.7	0.5	355	14.0	67.9	0
19-Sep-13	10.3	5.5	1.7	185	8.8	83.5	1.5
25-Sep-13	17.4	9.7	0.6	352	7.3	80.6	0.3
01-Oct-13	8.3	6.6	0.1	287	6.8	82.0	1.1
07-Oct-13	8.5	7.1	0.4	347	6.5	88.7	5.5

* = Below Detectable Limit

NaN = Missing Data

Total Precipitation for Period (mm) **56.0**

Pete Toy

Date	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	Wind Speed (m/s)	Wind Direction (degrees)	Temperature (°C)	RH (%)	Precipitation (mm)
25-May-13	102.2	9.1	NaN	NaN	NaN	NaN	NaN
28-May-13	45.8	3.2	0.2	27	11.8	NaN	0
31-May-13	4.8	0.5	0.9	243	9.3	NaN	10
03-Jun-13	16.2	2.7	0.2	262	12.3	NaN	0.3
06-Jun-13	8.2	1.6	0.5	245	9.6	NaN	0.1
09-Jun-13	6.6	*	1.0	45	11.8	73.0	0.3
12-Jun-13	3.5	1.4	0.2	46	12.6	65.3	0
15-Jun-13	9.3	2.3	0.8	45	15.1	67.3	0.2
18-Jun-13	12.4	3.2	0.3	34	16.5	62.8	0.1
21-Jun-13	8.9	5.0	0.2	19	17.3	61.4	0
24-Jun-13	11.1	5.5	0.3	61	16.9	72.8	2.3
27-Jun-13	6.3	NaN	0.2	43	13.2	91.1	6.7
03-Jul-13	3.7	1.6	0.1	345	15.6	54.8	0
09-Jul-13	2.8	1.5	0.2	253	15.7	64.3	0.1
15-Jul-13	5.8	2.7	0.1	301	13.5	73.5	0
21-Jul-13	7.5	2.0	0.2	292	15.8	78.2	0
27-Jul-13	3.3	0.1	1.3	52	13.1	86.0	1.9
02-Aug-13	8.2	2.6	0.2	44	17.0	76.5	0
08-Aug-13	10.0	3.7	0.5	247	16.4	88.4	0.7
14-Aug-13	5.9	3.4	0.4	257	16.6	81.2	0
20-Aug-13	3.0	0.8	0.2	222	11.6	69.9	0
26-Aug-13	5.9	1.5	0.2	52	11.6	86.5	0
01-Sep-13	17.8	4.0	0.5	253	13.8	84.7	0
07-Sep-13	10.4	10.6	0.2	252	13.2	83.9	0
13-Sep-13	11.2	7.3	0.2	48	14.0	75.2	0
19-Sep-13	13.7	4.4	1.1	244	8.8	86.2	1.6
25-Sep-13	8.0	5.5	0.6	49	7.5	82.1	1
01-Oct-13	11.6	5.8	0.4	245	6.3	89.9	1.6
07-Oct-13	5.8	1.9	0.1	320	6.8	91.2	18.5

* = Below Detectable Limit

NaN = Missing Data

Total Precipitation for Period (mm)	45.4

Rat Lake

Date	PM_{10} (μg/m^3)	$PM_{2.5}$ (μg/m^3)	Wind Speed (m/s)	Wind Direction (degrees)	Temperature (°C)	RH (%)	Precipitation (mm)
25-May-13	74.7	9.2	1.0	110	15.3	NaN	0
28-May-13	22.5	2.9	0.3	109	11.8	NaN	0.2
31-May-13	11.3	1.3	2.6	133	9.1	NaN	0
03-Jun-13	7.6	1.7	0.3	115	10.8	NaN	0.2
06-Jun-13	5.6	NaN	0.7	127	9.2	NaN	0
09-Jun-13	2.8	*	0.1	53	11.9	70.7	0
12-Jun-13	7.5	2.0	0.3	129	12.8	63.6	0
15-Jun-13	11.1	2.5	0.8	349	16.4	59.3	0
18-Jun-13	6.2	3.5	0.2	131	16.4	61.4	0
21-Jun-13	14.4	5.7	0.3	157	17.2	58.9	0
24-Jun-13	41.4	5.6	0.6	359	17.8	69.4	0.1
27-Jun-13	3.5	1.2	0.2	167	13.4	92.5	0
03-Jul-13	5.9	2.0	0.5	354	16.0	50.3	0
09-Jul-13	3.8	1.3	0.6	245	16.1	55.4	0
15-Jul-13	7.9	3.9	0.7	329	14.7	64.9	0
21-Jul-13	NaN	2.0	0.2	284	16.6	72.2	0
27-Jul-13	4.5	1.9	1.0	323	13.0	85.5	13.1
02-Aug-13	7.4	NaN	0.2	348	17.6	74.3	0
08-Aug-13	8.3	3.2	0.6	142	17.0	82.9	0.1
14-Aug-13	10.3	3.7	0.1	93	17.0	83.9	0.3
20-Aug-13	3.8	0.5	0.9	297	12.2	63.5	0
26-Aug-13	7.5	1.5	0.5	331	11.8	85.5	0
01-Sep-13	16.0	7.8	0.2	75	14.2	80.3	0
07-Sep-13	15.2	3.2	0.2	17	13.5	78.6	0
13-Sep-13	16.2	7.9	0.5	317	13.3	77.2	0
19-Sep-13	8.4	4.3	2.5	135	8.1	88.8	0.5
25-Sep-13	8.8	4.8	0.2	22	6.8	86.7	0.4

01-Oct-13	8.8	6.4	0.2	343	6.2	87.6	1
07-Oct-13	3.8	2.6	0.2	120	5.7	93.7	8.8

* = Below Detectable Limit

NaN = Missing Data

Total Precipitation for Period (mm)	**24.7**

Lafferty

Date	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	Wind Speed (m/s)	Wind Direction (degrees)	Temperature (°C)	RH (%)	Precipitation (mm)
25-May-13	57.8	7.1	2.1	27	14.9	NaN	0
28-May-13	7.4	2.1	0.4	272	11.4	NaN	0
31-May-13	3.1	1.2	4.9	179	9.6	NaN	10.8
03-Jun-13	2.2	1.5	0.9	172	12.3	NaN	0
06-Jun-13	3.7	1.5	1.7	177	9.1	NaN	0.8
09-Jun-13	4.9	*	1.5	4	11.1	77.0	2.3
12-Jun-13	2.9	1.4	0.1	64	12.2	64.6	0
15-Jun-13	6.7	2.9	0.8	18	15.0	67.0	0
18-Jun-13	5.6	3.1	1.6	69	16.5	60.4	0.5
21-Jun-13	8.3	4.7	0.5	183	17.7	55.0	0
24-Jun-13	10.4	6.1	1.5	3	17.7	67.7	0.3
27-Jun-13	3.4	1.7	1.3	358	13.7	89.3	6.1
03-Jul-13	3.5	1.5	0.6	313	16.5	52.3	0
09-Jul-13	4.0	2.2	0.9	352	16.5	61.0	1.4
15-Jul-13	4.4	2.3	0.2	154	14.4	66.3	0
21-Jul-13	NaN	NaN	0.9	165	16.6	75.4	0.0
27-Jul-13	2.4	0.2	3.1	33	13.5	79.5	4.8
02-Aug-13	5.6	2.5	0.7	14	18.6	67.8	0
08-Aug-13	6.4	4.2	1.7	180	17.3	76.0	0
14-Aug-13	5.1	3.2	2.0	165	16.5	77.0	0
20-Aug-13	1.6	0.5	2.1	307	13.7	55.5	0
26-Aug-13	10.1	1.8	1.0	32	13.1	76.9	0
01-Sep-13	13.0	9.1	1.8	175	15.4	77.8	0
07-Sep-13	11.4	5.3	0.3	87	14.4	75.9	0
13-Sep-13	9.7	6.2	0.8	61	14.9	71.8	0
19-Sep-13	8.9	3.7	3.7	177	10.7	78.3	0.4
25-Sep-13	7.7	4.9	2.4	41	8.5	72.6	0.1
01-Oct-13	6.7	5.8	1.4	166	7.1	81.3	6.2

07-Oct-13	4.4	0.5	1.0	104	7.3	86.1	27.8

* = Below Detectable Limit

NaN = Missing Data

Total Precipitation for Period (mm)	**61.5**