Upper Columbia River Valley Air Quality Monitoring

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Goals

- Find potential sources of anthropogenic PM2.5 emissions.
- Identify which areas, if any, have the worst ambient PM2.5 levels and why.
- Identify any evidence in data that could help distinguish between different sources of PM2.5 (dust vs industrial emissions vs wildfire smoke).

Method

For this research, PurpleAir Flex Air Quality sensors placed in the Upper Columbia River Valley were used. PurpleAir Flex uses dual laser sensors, referred to as channels A and B. Data was downloaded from the PurpleAir API (data download tool). Weekly or monthly averages were used, and data is the averaged value of both channels. Humidity data was downloaded from the API as well. All data was corrected using the original EPA PurpleAir Correction model $\mathbf{PM_{2.5}} = \mathbf{pm2.5\_cf\_1} \times \mathbf{0.52} - \mathbf{RH} \times \mathbf{0.085} + \mathbf{5.71}$ (Barkjohn et al, 2021). Each day listed for the weekly average is the start date for that week's data. Data on point source emissions were found on the Washing State Department of Ecology's Air Emissions Inventory webpage.

Trail and Northport Weekly $PM_{2.5}$

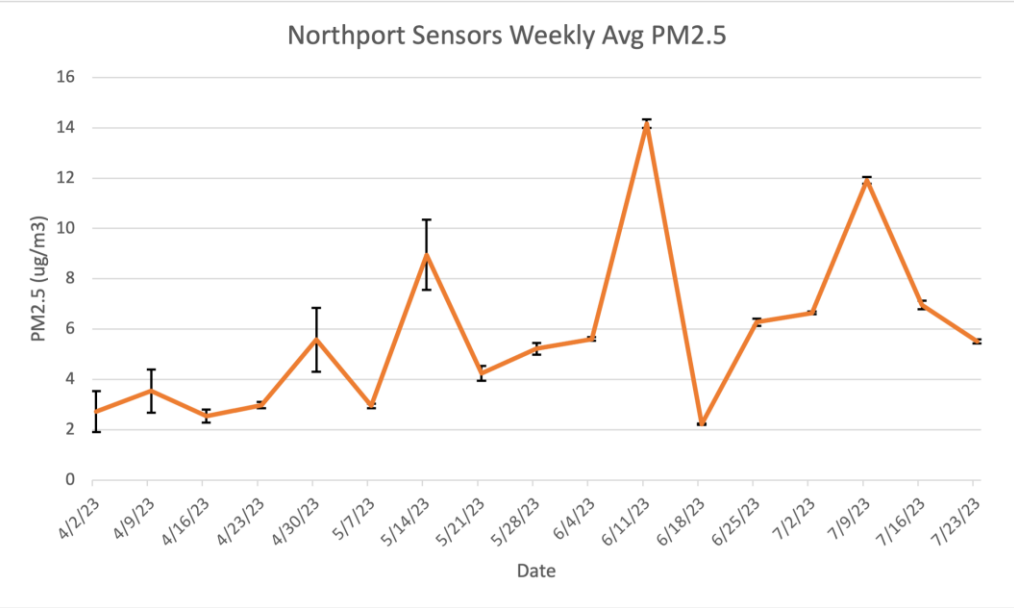
April 23, 2023 – August 6, 2023

Weekly $PM_{2.5}$ Concentrations (in ug/m^3) in Trail, BC and Northport, Washington

Week	Trail, BC	Northport, WA
4/2/23	-0.40	2.72
4/9/23	1.55	3.54
4/16/23	0.00	2.55
4/23/23	0.12	2.98
4/30/23	2.83	5.58
5/7/23	0.39	2.95
5/14/23	7.57	8.95
5/21/23	1.57	4.24
5/28/23	1.96	5.22
6/4/23	2.05	5.60
6/11/23	13.06	14.17
6/18/23	0.00	2.22
6/25/23	2.68	6.27
7/2/23	2.53	6.64
7/9/23	12.66	11.92
7/16/23	3.90	6.96
7/23/23	3.57	5.51

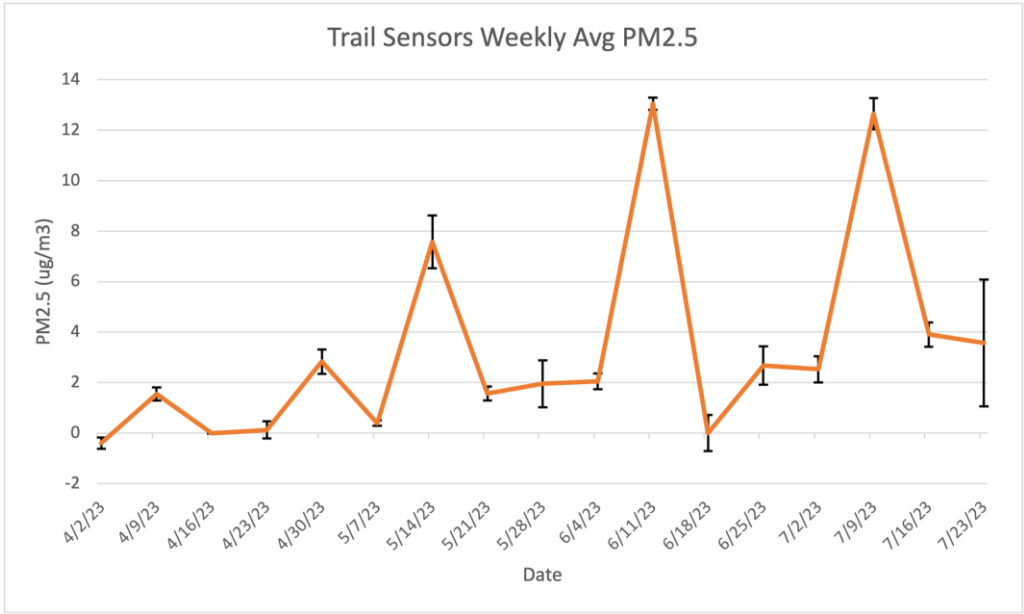
Weekly $PM_{2.5}$ concentrations from week of April 2 to week of July 23, 2023. Concentrations are calculated averages from two sensors in Trail (PA sensor indexes: 90699, 104066) and two in Northport (PA sensor indexes: 149001, 148745).

Northport, WA



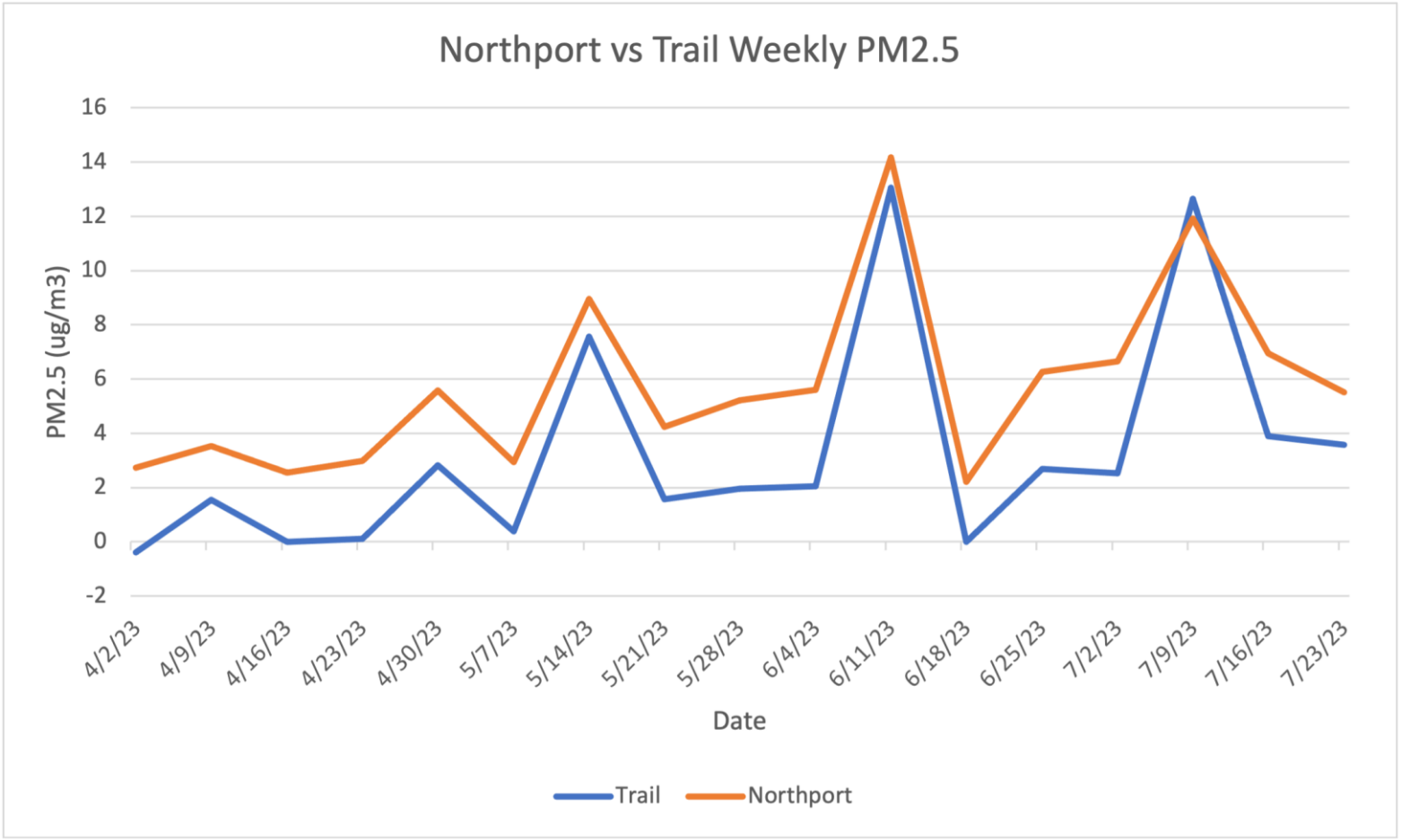
Avg. Weekly $PM_{2.5}$ from 4027 Flat Creek Rd and Wilcox Rd sensors in Northport, April-August 2023. One standard deviation is given at each of the weekly points and was calculated using the weekly data from both sensors.

Trail, British Columbia



Avg. Weekly $PM_{2.5}$ from Trail and Sunningdale sensors in Trail, April-August 2023. One standard deviation is given at each of the weekly points and was calculated using the weekly data from both sensor.

Northport sensors consistently measure larger $PM_{2.5}$ values compared to Trail. It is unlikely that any of the smelter activities in Trail is contributing to the poorer air quality in Northport due to the difference in their ambient levels of particulate matter. Northport's elevated ambient $PM_{2.5}$ levels could be coming from wood heating in colder months and outdoor and residential burning during non-smoke periods.



Avg. Weekly $PM_{2.5}$ Trail and Northport Sensors, April-August 2023.

Upper Columbia River Valley Weekly $PM_{2.5}$

April 23, 2023 – August 6, 2023

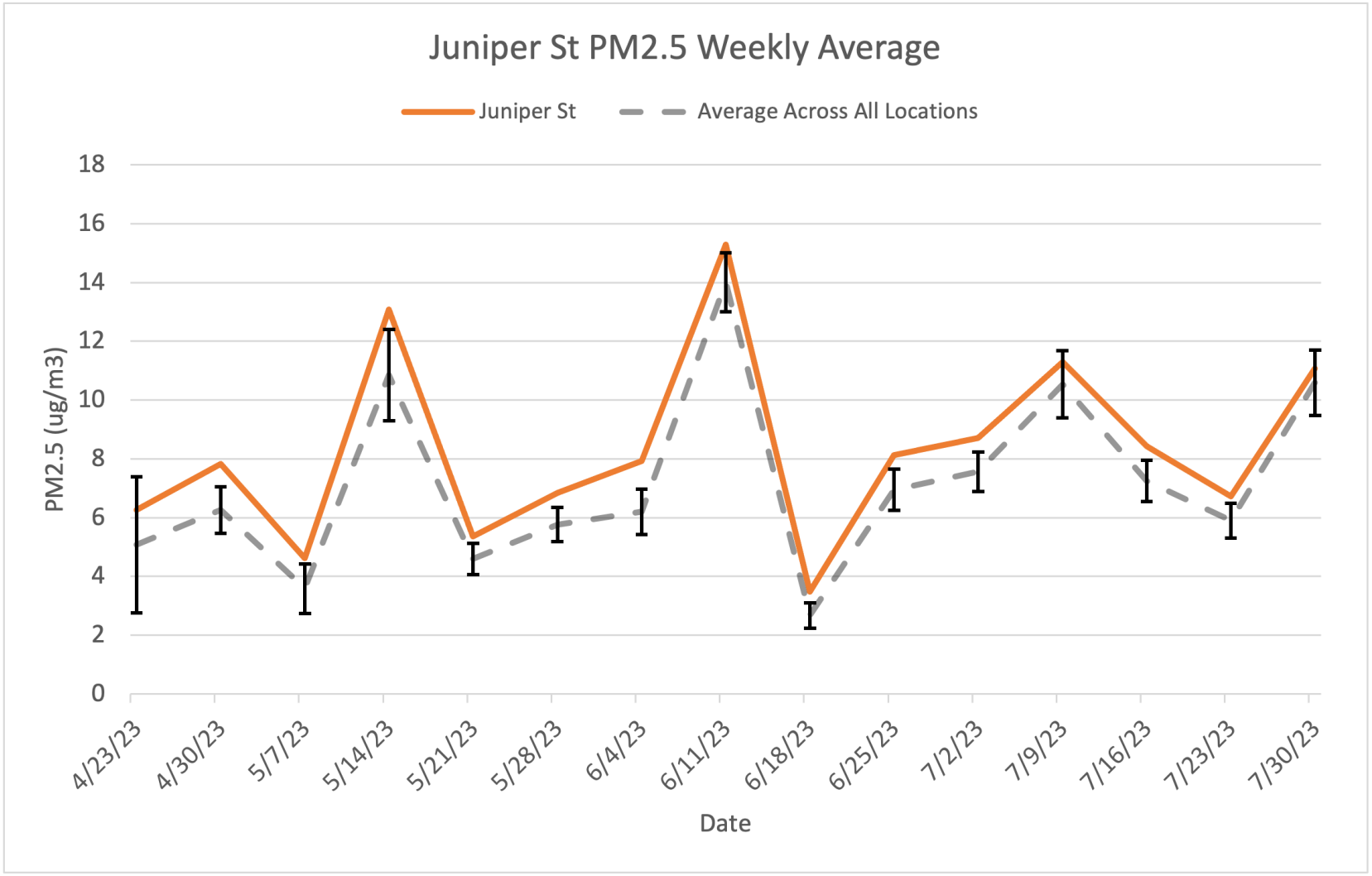
Weekly $PM_{2.5}$ Concentrations (in ug/m^3) in Upper Columbia River Valley, Washington

Week of	4/23/23	4/30/23	5/7/23	5/14/23	5/21/23	5/28/23	6/4/23	6/11/23	6/18/23	6/25/23	7/2/23	7/9/23	7/16/23	7/23/23	7/30/23
4027 Flat Creek Rd	2.89	4.68	3.01	7.97	4.03	5.06	5.65	14.05	2.20	6.17	6.61	11.82	6.84	5.46	10.76
Wilcox Rd	3.06	6.48	2.89	9.94	4.45	5.38	5.55	14.29	2.24	6.38	6.68	12.01	7.08	5.56	10.84
Juniper St	6.26	7.83	4.62	13.07	5.35	6.85	7.93	15.28	3.47	8.13	8.71	11.29	8.42	6.72	11.07
Fumi Circle Rd	5.72	7.19	4.38	11.45	4.73	6.22	7.27	14.50	3.05	7.67	7.69	10.59	7.93	6.79	10.76
Valley Westside Rd	4.03	6.05	3.37	8.52	4.23	5.60	6.11	13.94	3.00	7.16	7.65	10.26	7.73	6.36	10.44
E Hawthorne Ave	4.79	5.81	3.60	10.90	4.57	6.34	6.13	13.64	2.65	7.02	7.65	10.11	7.30	5.88	9.94
E Columbia Ave	4.80	6.20	3.87	11.18	4.80	6.52	6.93	14.34	3.26	7.94	8.79	10.87	8.21	6.78	10.83
Brooks Rd	11.79	5.94	5.44	9.73	5.07	5.17	5.60	14.09	2.95	6.25	7.05	10.99	6.89	5.28	9.95
2213 Hwy 25	4.45	7.13	3.36	11.04	4.66	5.85	6.31	15.73	2.48	7.18	7.51	12.11	7.65	5.85	11.17
124 Putnam Rd	3.68	5.78	2.65	10.72	4.40	5.08	5.55	11.95	2.09	6.07	7.13	8.29	5.94	5.49	8.59
39 Short Cut Rd	6.61	6.41	3.83	11.69	5.32	5.85	6.52	13.49	2.49	7.42	8.03	9.35	6.89	5.96	10.51
3747C Hwy 25 S	3.93	6.15	3.19	11.48	4.77	5.83	5.70	12.48	2.56	6.50	7.20	9.24	6.94	5.43	9.36
Riverview Lane	3.95	5.77	2.46	13.43	3.38	5.23	5.35	14.37	2.32	6.39	7.61	10.10	6.46	5.06	13.40
Average	5.07	6.26	3.59	10.85	4.60	5.77	6.20	14.01	2.67	6.94	7.56	10.54	7.25	5.89	10.59
Standard Deviation (1 σ)	2.31	0.79	0.84	1.56	0.53	0.58	0.78	1.01	0.43	0.70	0.67	1.15	0.71	0.60	1.12

From the week of April 23, 2023, through through the week of July 30, 2023, for 13 PA sensors placed in Upper Columbia River Valley. Average and one standard deviation were calculated using values from all locations during the given week.

Juniper St, Kettle Falls

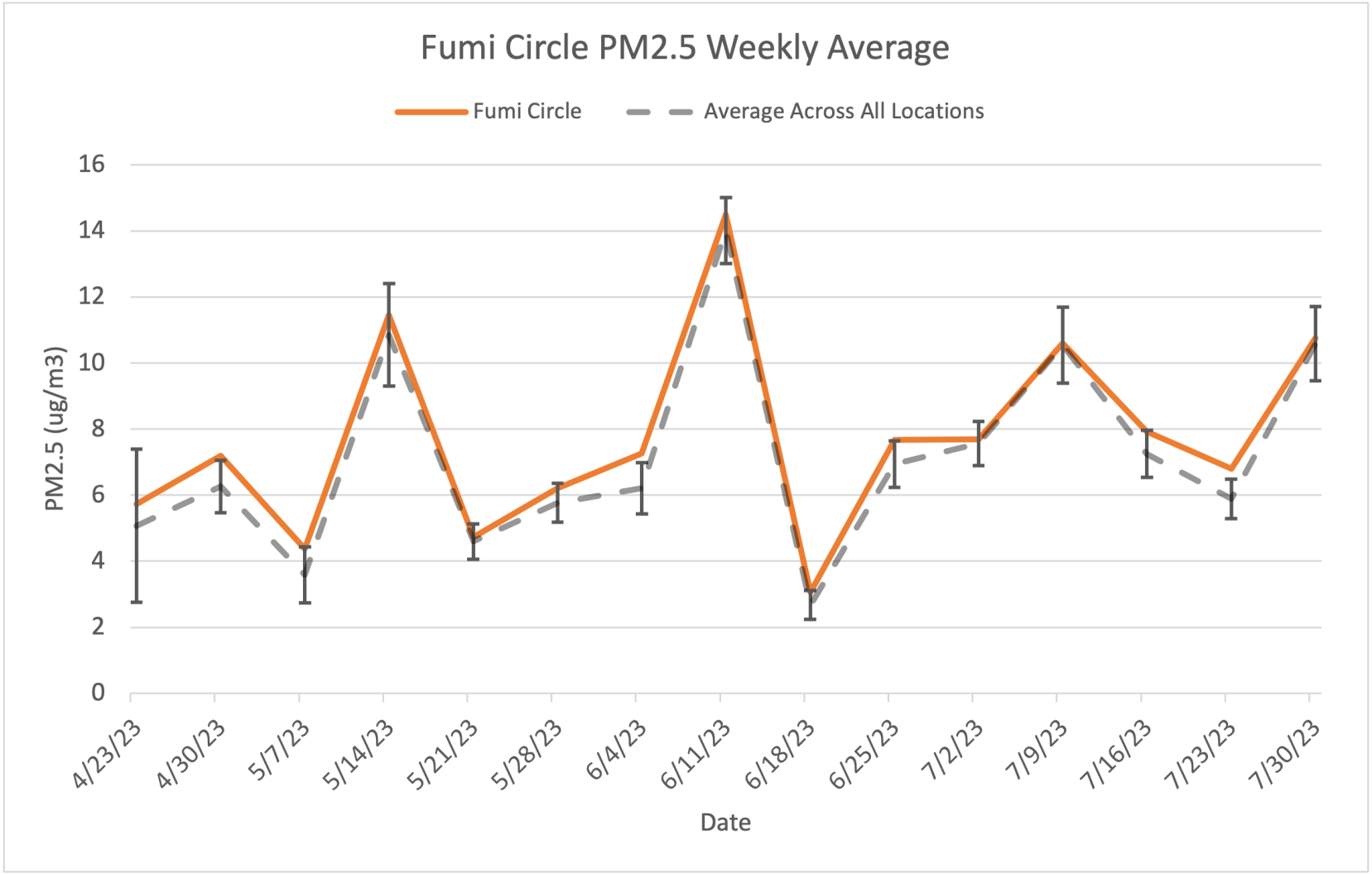
The Juniper St sensor weekly $PM_{2.5}$ exceeded the averaged $PM_{2.5}$ from all 13 locations by at least 1 standard deviation in 12 of the 15 weeks. It had the highest location average at 8.33 ug/m^3. Of the 12 weeks where the average plus one standard deviation was exceeded, 10 of these occurrences happened during weeks where little to no smoke was present in the Upper Columbia River Valley. This data, especially when considered with the Fumi Circle data, points to there being a source other than wildfire smoke that is elevating $PM_{2.5}$ levels in Kettle Falls.



Weekly $PM_{2.5}$ at Juniper St sensor from April-August 2023. One standard deviation from the mean $PM_{2.5}$ of all 13 locations is given at each of the weekly points.

Fumi Circle, Kettle Falls

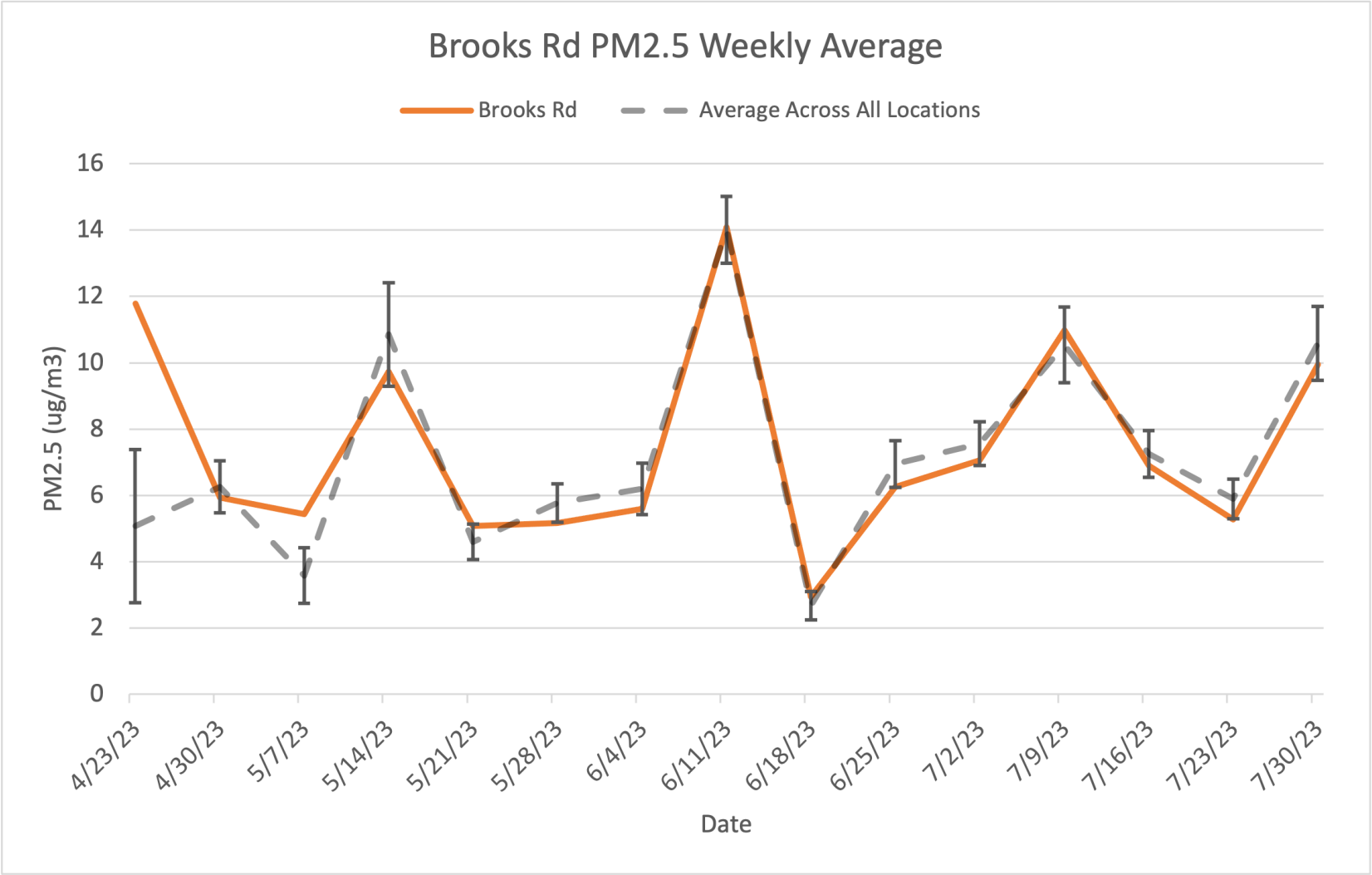
The Fumi Circle sensor weekly $PM_{2.5}$ exceeded the average $PM_{2.5}$ all 15 weeks and exceeded the average $PM_{2.5}$ by at least 1 standard deviation 4 of the weeks. It had the second highest location average at 7.73 ug/m^3. Every occurrence where the average plus one standard deviation was exceeded happened during weeks where little to no smoke was present in the Upper Columbia River Valley. When considered with the Juniper St sensor data, it is likely there is a source other than wildfire smoke that is elevating $PM_{2.5}$ levels in Kettle Falls.



Weekly $PM_{2.5}$ at Fumi Circle sensor from April-August 2023. One standard deviation from the mean $PM_{2.5}$ of all 13 locations is given at each of the weekly points.

Brooks Rd, Evans

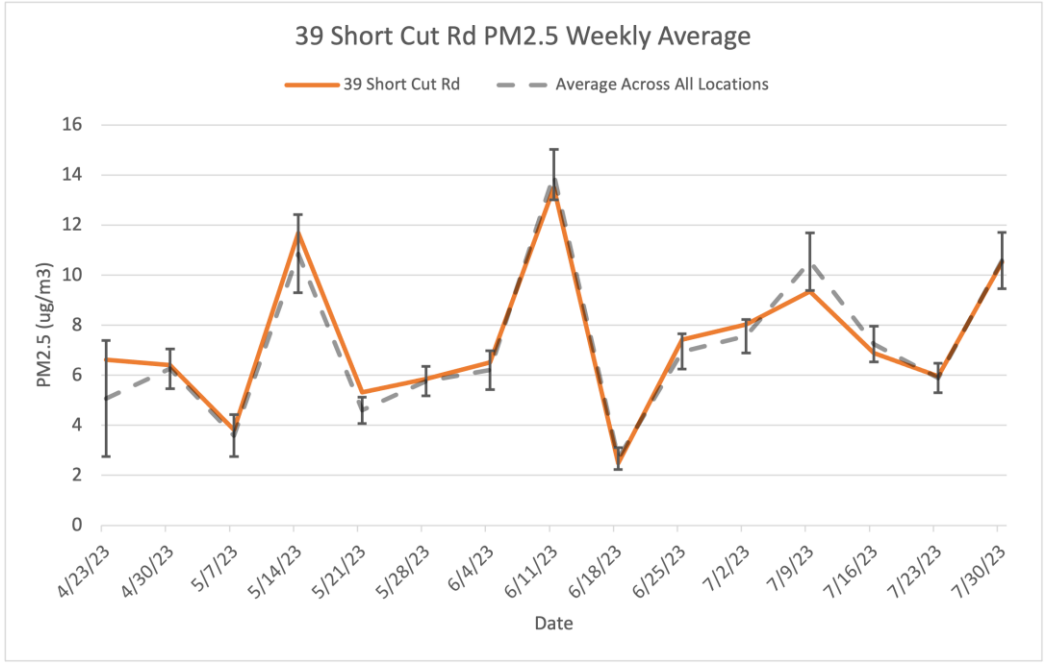
The Brooks Rd sensor overall measured lower than the average $PM_{2.5}$ during smoke events however, prior to the first smoke during the week of 5/14, the Brooks Rd sensor measured $PM_{2.5}$ above the average plus one standard deviation two separate times. In addition, the Brooks Rd sensor is one of the only sensors that has a decline in $PM_{2.5}$ in the week of 4/23. The $PM_{2.5}$ starting this high could be due to several things such as local burning or an error with the sensor.



Weekly $PM_{2.5}$ at Brooks Rd sensor from April-August 2023. One standard deviation from the mean $PM_{2.5}$ of all 13 locations is given at each of the weekly points.

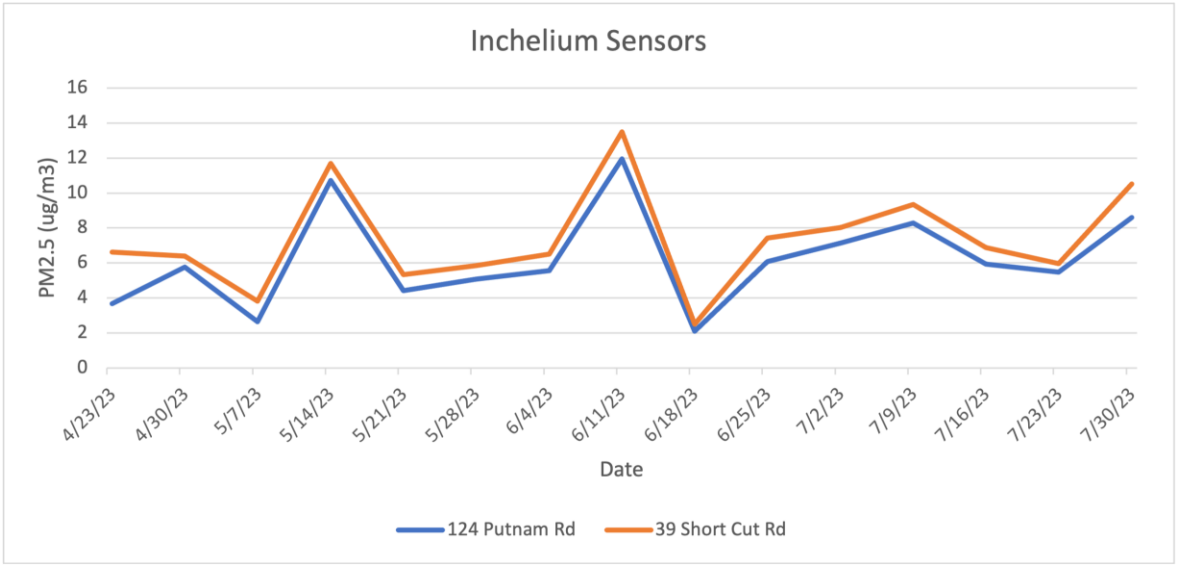
Short Cut Rd, Inchelium

The Short Cut Rd sensor overall measured higher than the average $PM_{2.5}$ during most weeks and is the only sensor, other than Brooks Rd, that shows $PM_{2.5}$ declining during the week of 4/23. When compared with the other sensor located in Inchelium on Putnam Rd, the Short Cut Rd sensor consistently measures higher levels of $PM_{2.5}$. This could be due to Short Cut Rd being in a more urbanized area compared to Putnam Rd. Given that the largest deviation between the two sensors is in the beginning of the monitoring period, leading up to smoke events, $PM_{2.5}$ levels at these two locations should be compared outside of fire season.



Above: Weekly $PM_{2.5}$ at Short Cut Rd sensor from April-August 2023. One standard deviation from the mean $PM_{2.5}$ of all 13 locations is given at each of the weekly points.

Below: Weekly $PM_{2.5}$ at both Inchelium Sensors.



Wintertime Monthly Averages

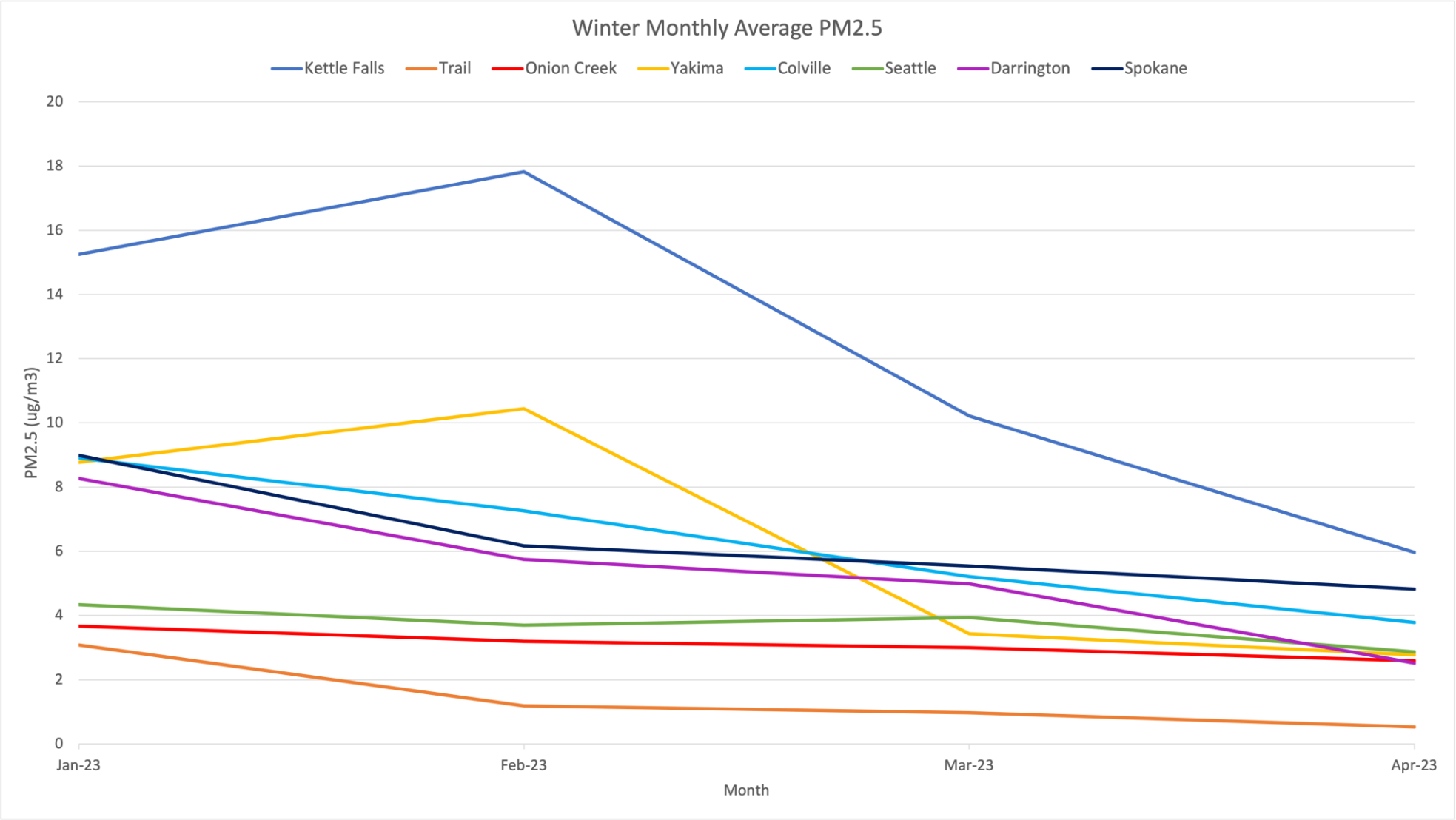
January– April 2023

Monthly $PM_{2.5}$ at 8 locations around or near Washington State

Month-Year	Colville (ug/m^3)	Darrington (ug/m^3)	Kettle Falls (ug/m^3)	Onion Creek (ug/m^3)	Seattle (ug/m^3)	Spokane (ug/m^3)	Trail, BC (ug/m^3)	Yakima (ug/m^3)
Jan-23	8.90	8.27	15.25	3.67	4.33	8.99	3.08	8.78
Feb-23	7.26	5.75	17.82	3.20	3.70	6.17	1.19	10.44
Mar-23	5.21	4.99	10.21	3.00	3.94	5.54	0.97	3.43
Apr-23	3.78	2.52	5.96	2.59	2.86	4.82	0.53	2.77

Monthly $PM_{2.5}$ concentrations for 8 PA sensors around Washington State and Trail, BC between January – April 2023.

Monthly $PM_{2.5}$ at 8 locations around or near Washington State

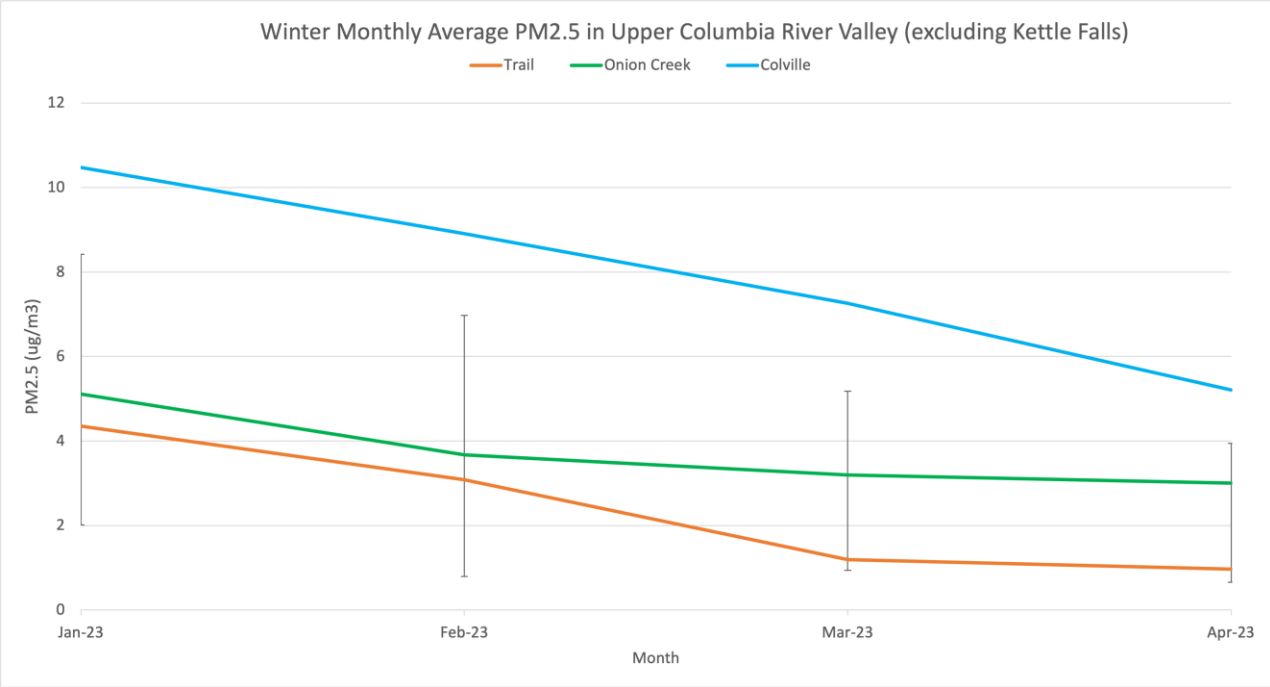


Monthly $PM_{2.5}$ concentrations for 8 PA sensors around Washington State and Trail, BC between January – April 2023.

Winter Ambient $PM_{2.5}$ Takeaways

Colville

- While within acceptable levels of $PM_{2.5}$, Colville has concentrations larger than other areas in the region (excluding Kettle Falls), specifically Onion Creek and Trail, BC.
  - Onion Creek is ~20 mi N of Colville and Trail is ~55 mi N of Colville
  - Spokane was not considered here due to its population size and proximity to a heavily used interstate.
- The shape of the Colville graph steadily declines over time, likely due to the decrease of wood burning stove usage in warmer months.



Monthly $PM_{2.5}$ at 3 locations in the Upper Columbia River Valley, Jan-April 2023. One standard deviation from the mean $PM_{2.5}$ of the 3 locations is shown for each month.

- The Washington State Department of Ecology lists two significant point source emitters of $PM_{2.5}$ in Colville:
  1) Vaagen Brothers Lumber Inc, which generated **33.9** tons/year of $PM_{2.5}$ in 2021
  2) Boise Cascade Wood Products, LLC Arden Lumber, which generated **4.00** tons/year of $PM_{2.5}$ in 2021

Winter Ambient $PM_{2.5}$ Takeaways

Kettle Falls

- Kettle Falls has the worst monthly air quality in Washington State, peaking in February at 17.82 ug/m^3.
- The shape of the Kettle Falls graph is like Yakima's, but the greater levels of particulate matter indicate a higher level of ambient $PM_{2.5}$.
  - The shape could come from an increase in the use of wood burning stoves and fireplaces during colder months.
- According to the Washington State Department of Ecology, Kettle Falls is home to three facilities responsible for point source emissions.
  1) Avista's Kettle Falls Biomass Generating Station generated **8.27** tons/year of $PM_{2.5}$ in 2021
  2) Boise Cascade Wood Products, LLC Kettle Falls Plywood generated **50.69** tons/year of $PM_{2.5}$ in 2021
  3) Boise Cascade Wood Products, LLC Kettle Falls Lumber generated **10.89** tons/year of $PM_{2.5}$ in 2021

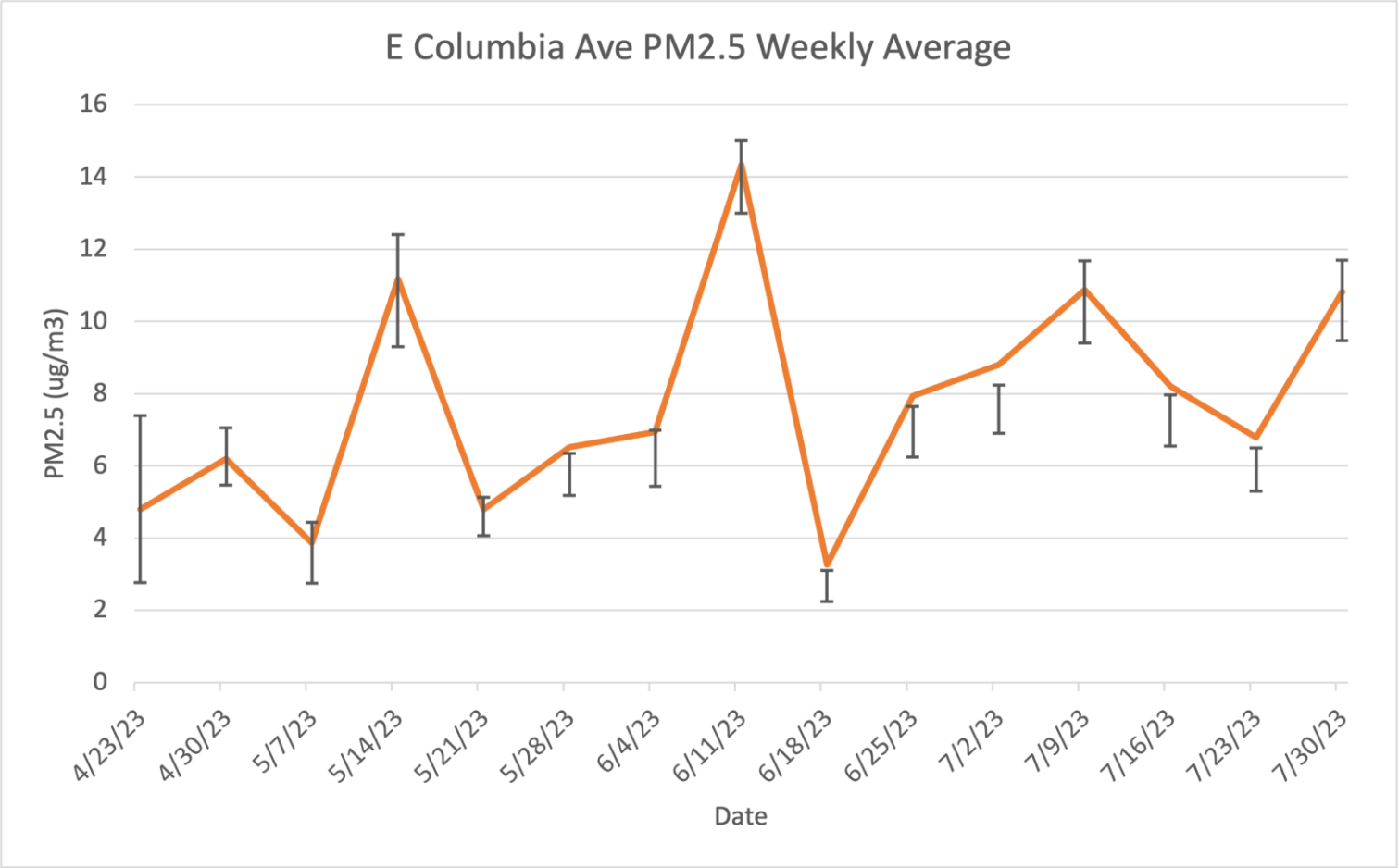
Next Steps

- While we cannot say with absolute certainty that the lumber facilities create the higher levels of ambient $PM_{2.5}$ we see in Kettle Falls, and to a lesser extent, Colville, they likely contribute to it. More research should be done as the PA sensors collect more data.
- It may be useful to survey residents in Colville, Kettle Falls, and the surrounding areas to quantify how many people use wood burning heat sources, like stoves and fireplaces, in the colder months.
- Look for patterns that emerge in the ambient $PM_{2.5}$ data.

April – August 2023

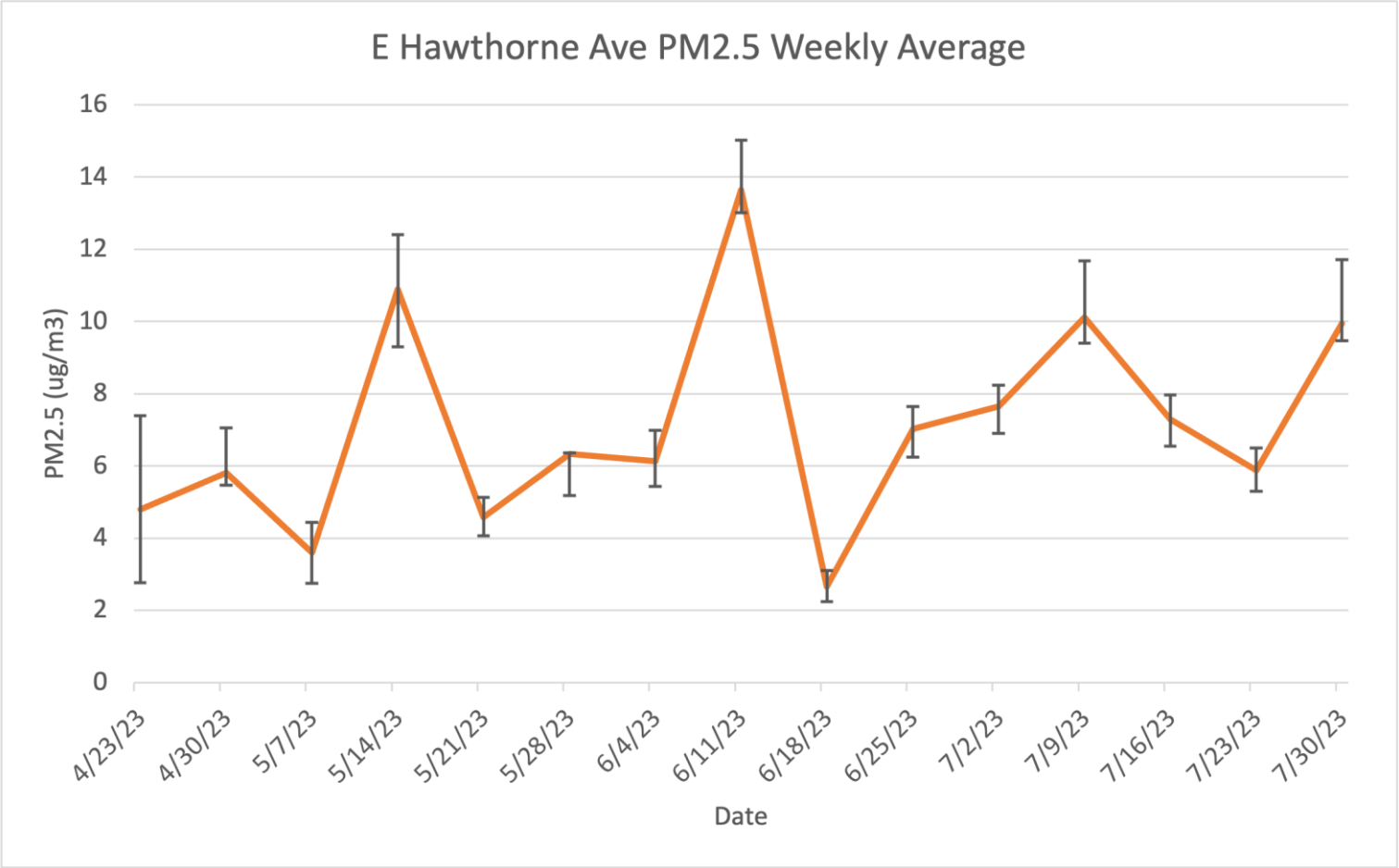
Supplemental Figures

E Columbia Ave, Colville



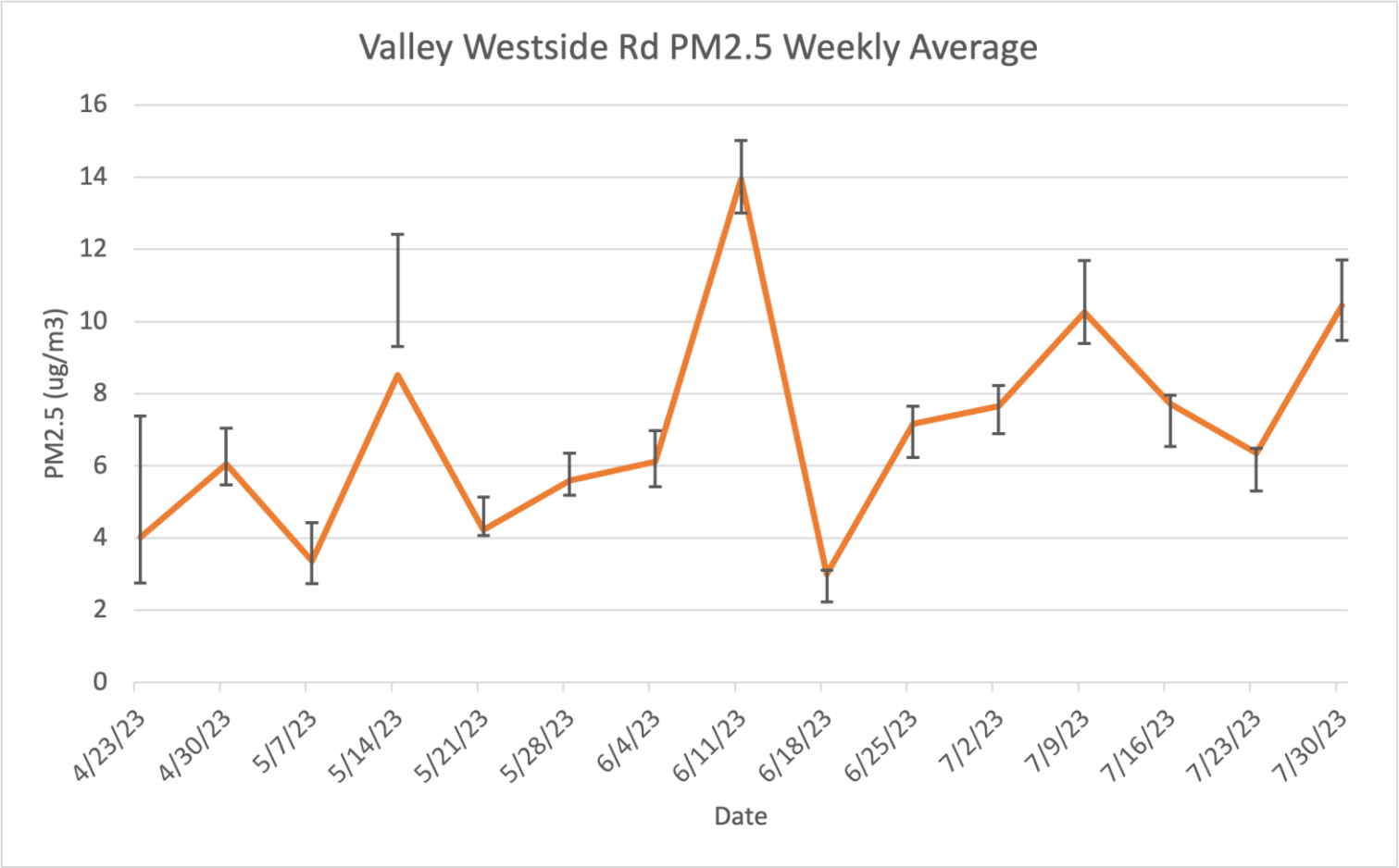
Weekly $PM_{2.5}$ from April - August 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

E Hawthorne Ave, Colville



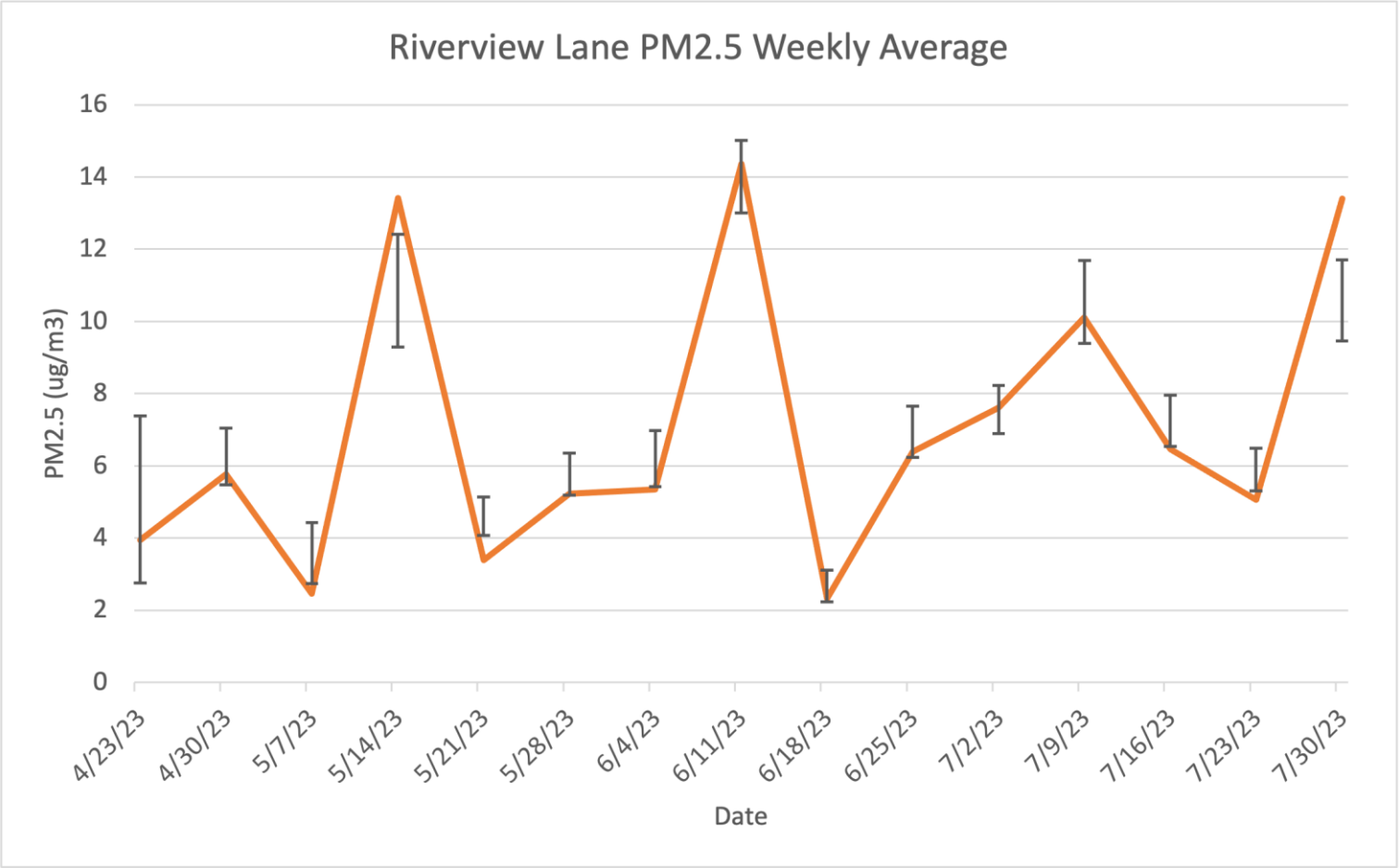
Weekly $PM_{2.5}$ from April - August 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

Valley Westside Rd, Colville



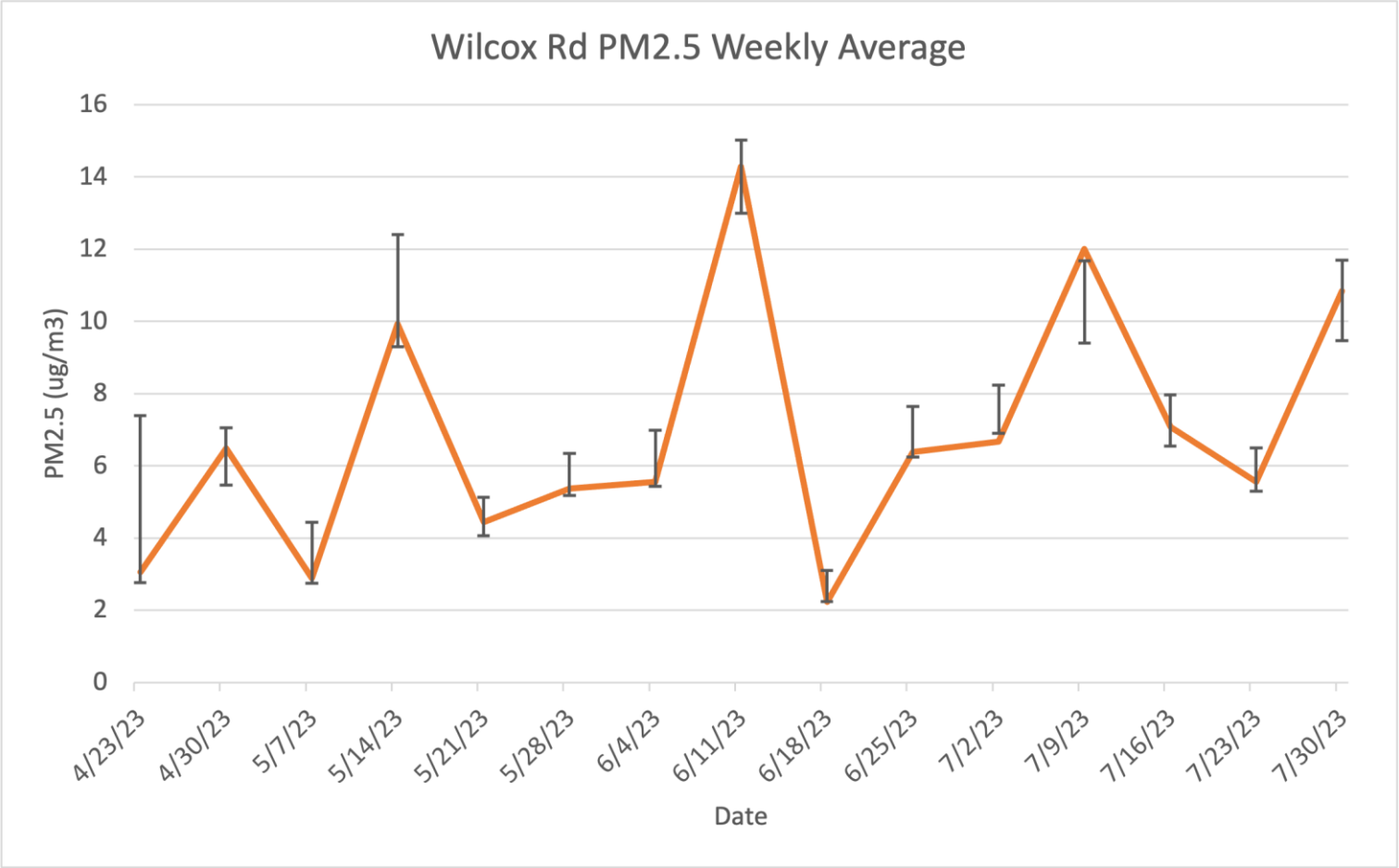
Weekly $PM_{2.5}$ from April - August 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

Riverview Lane, Curlew



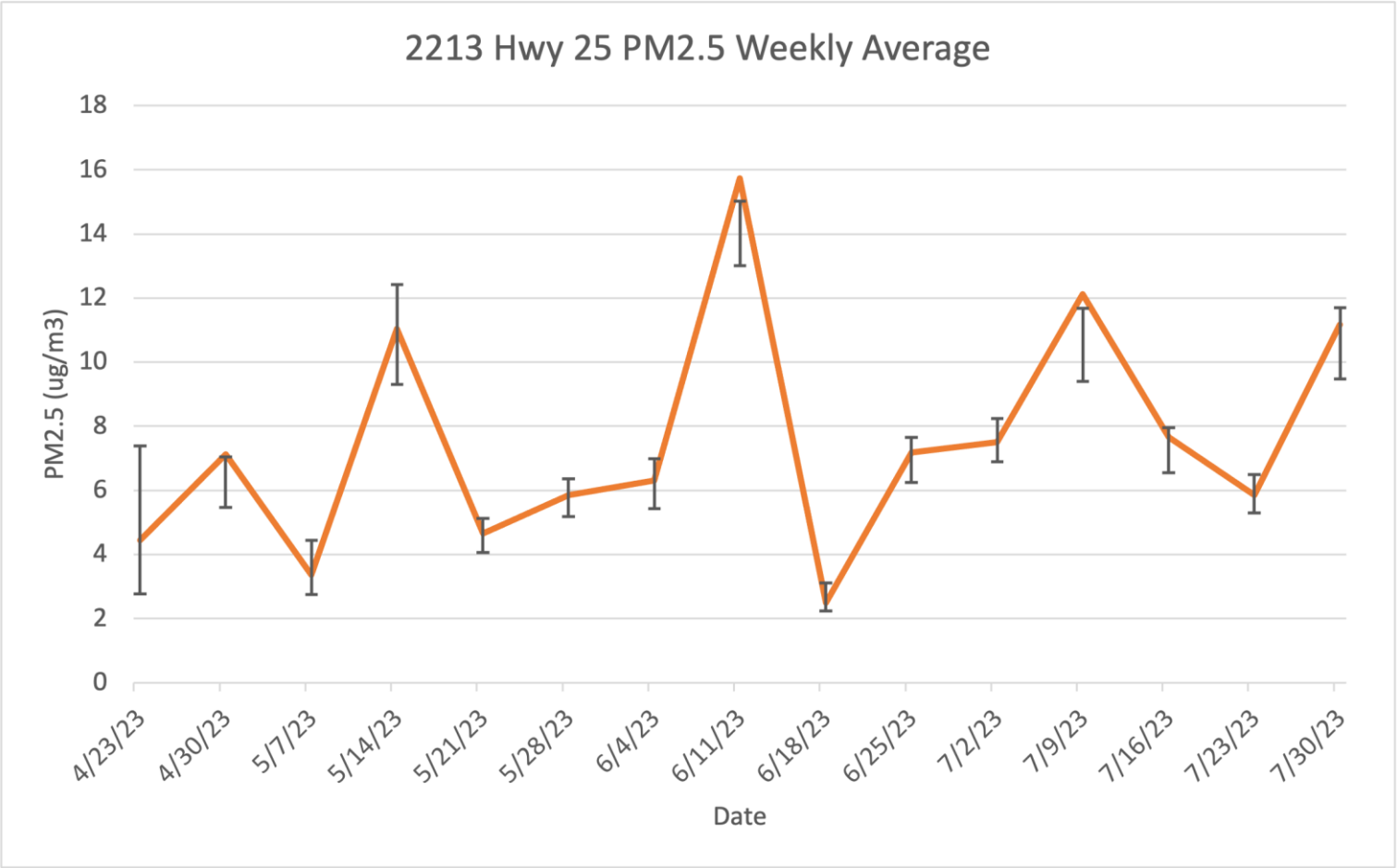
Weekly $PM_{2.5}$ from April - August 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

Wilcox Rd, Northport



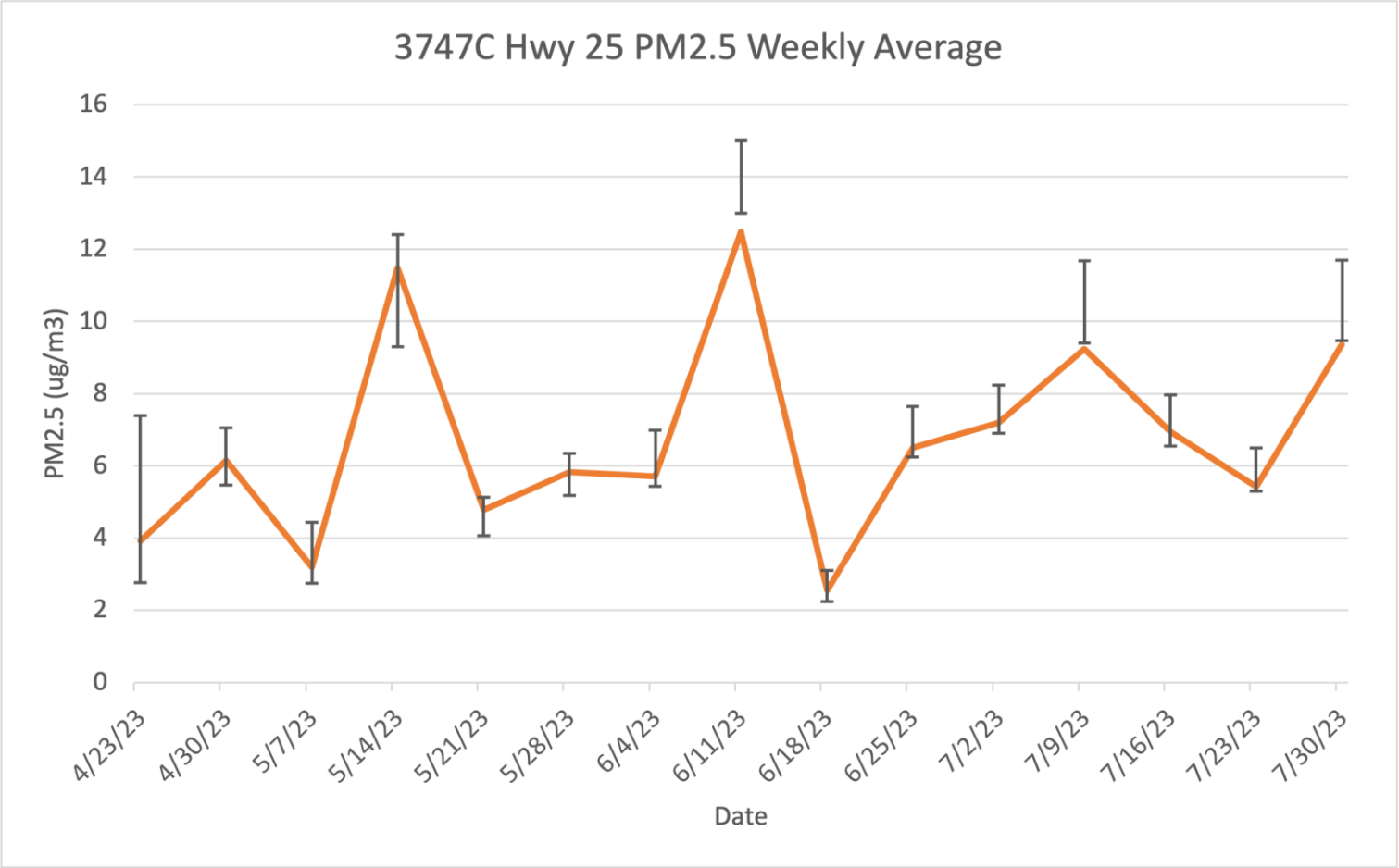
Weekly $PM_{2.5}$ from April - August 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

2213 Hwy 25, Evans



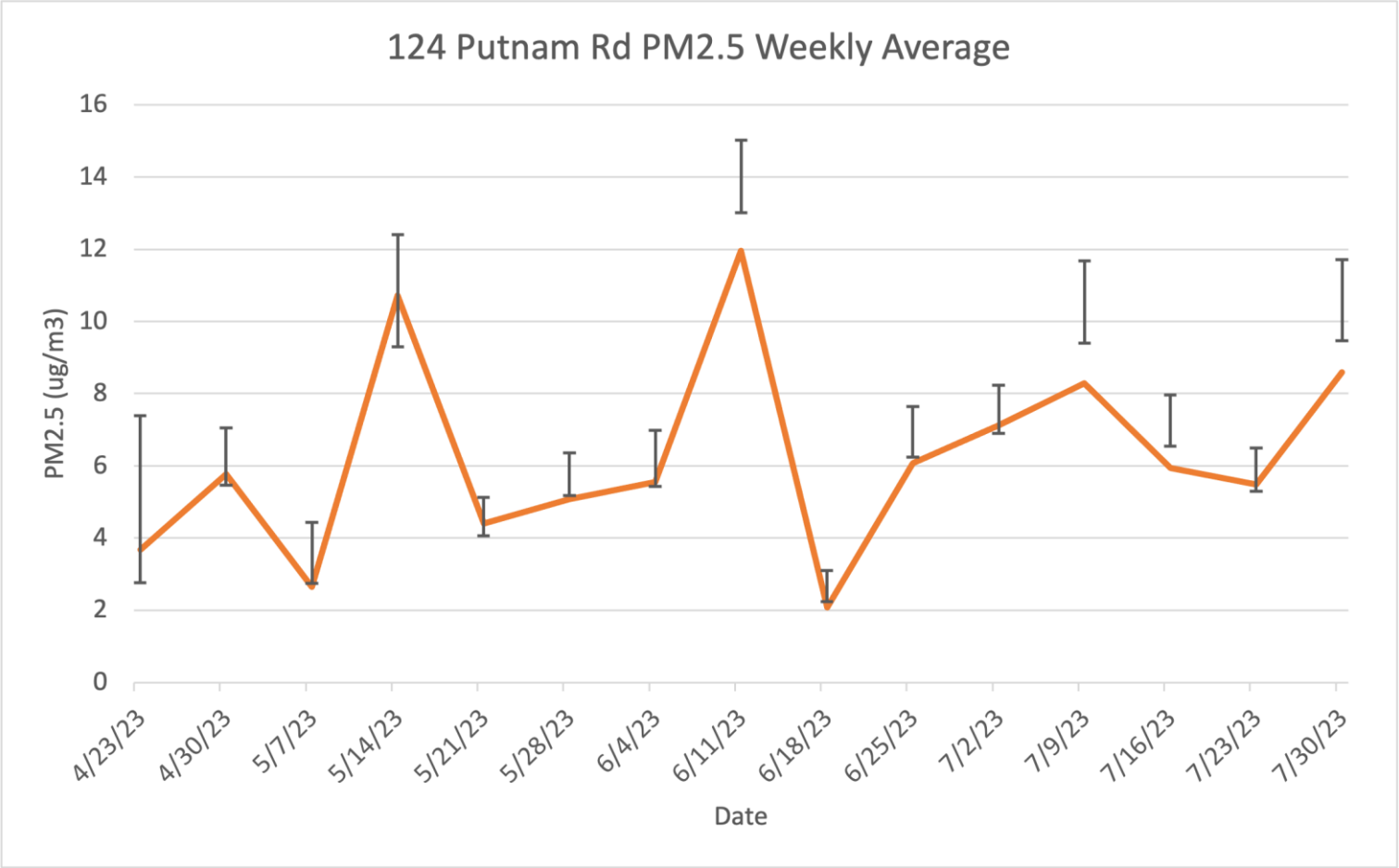
Weekly $PM_{2.5}$ from April - August 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

3747 Hwy 25, Gifford



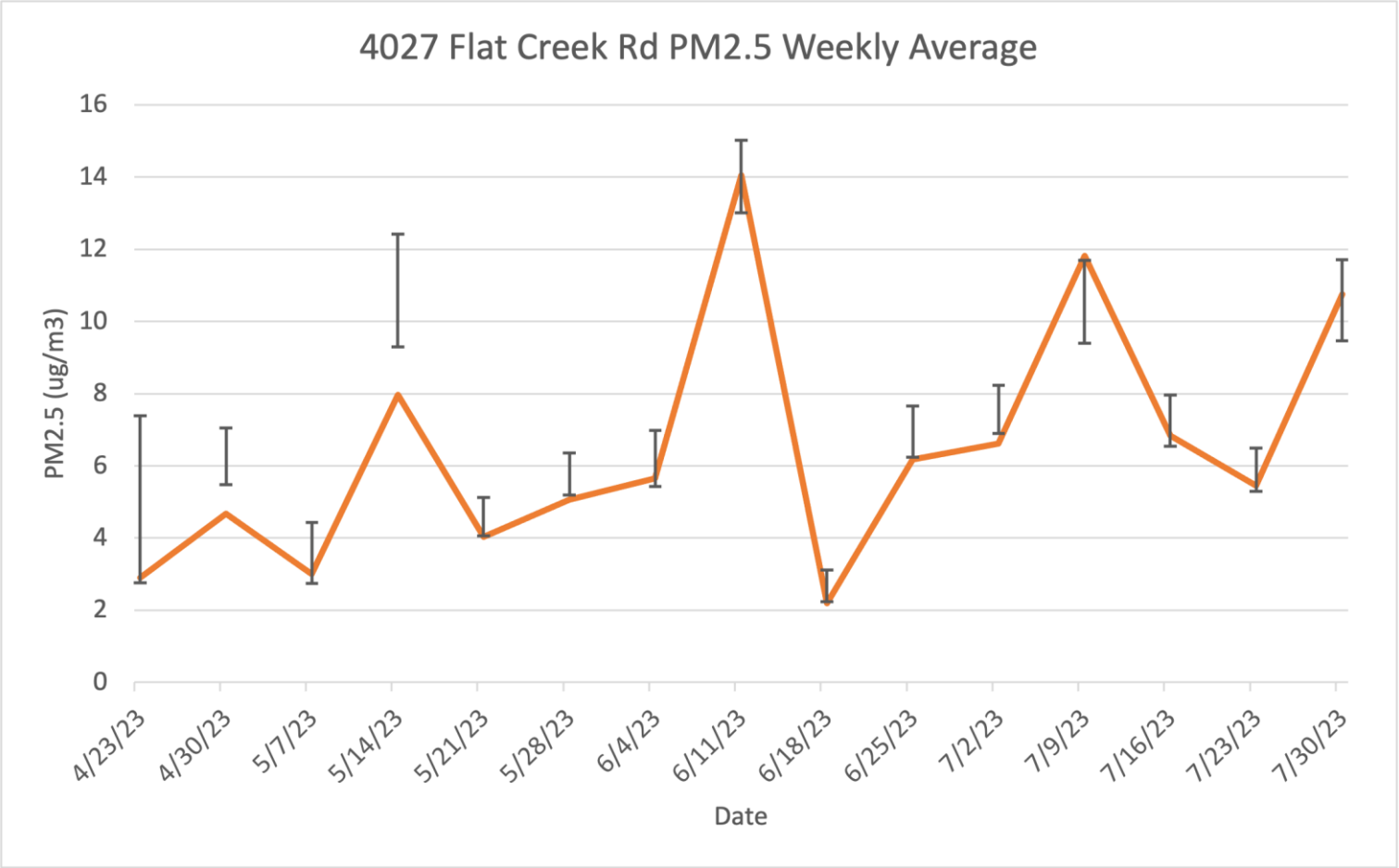
Weekly $PM_{2.5}$ from April - August 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

124 Putnam Rd, Inchelium



Weekly $PM_{2.5}$ from April - August 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

4027 Flat Creek Rd, Northport



Weekly $PM_{2.5}$ from April - August 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

April – September 2023

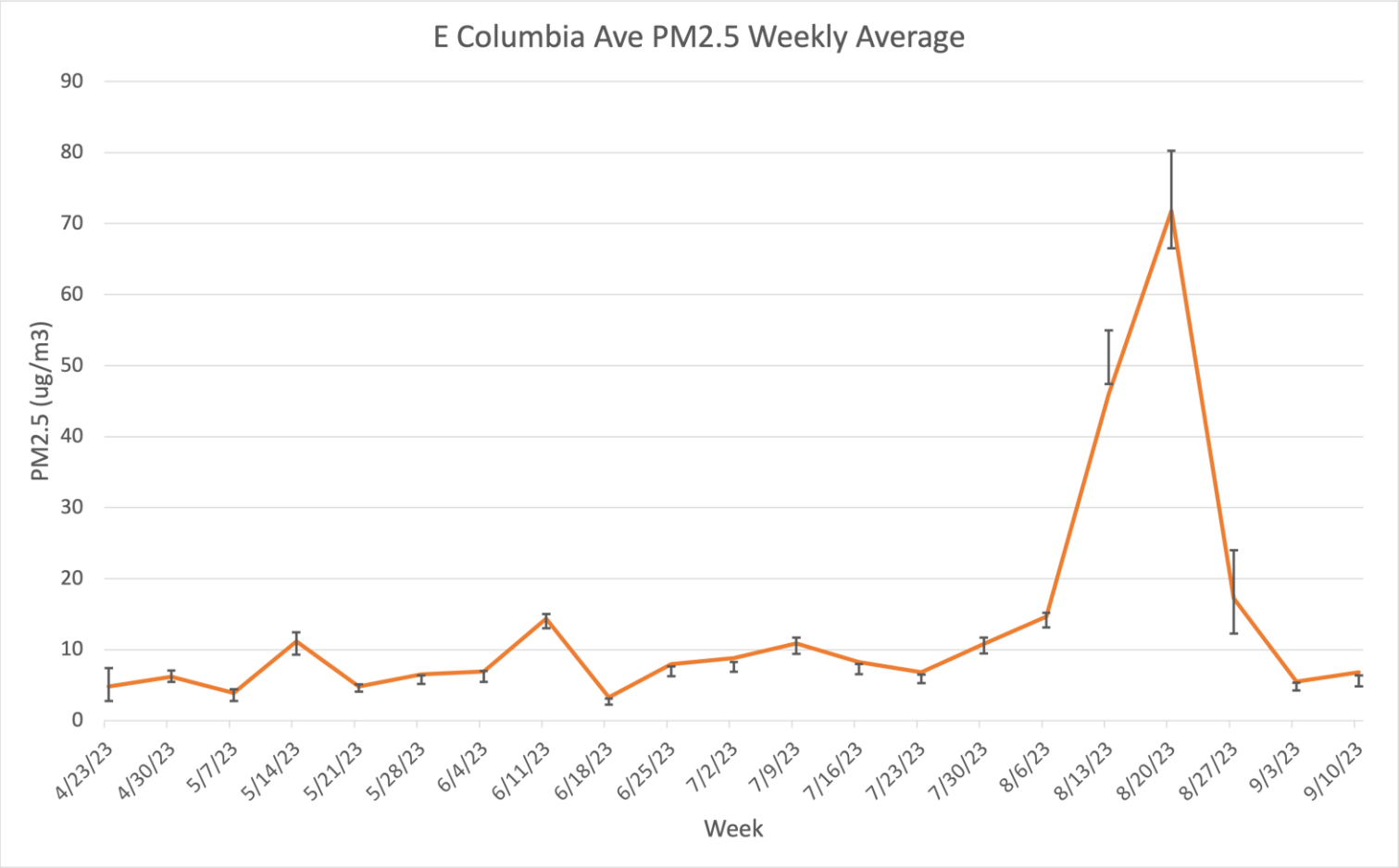
Supplemental Figures

Weekly $PM_{2.5}$ Concentrations (in ug/m^3) in Upper Columbia River Valley, Washington

Week of	4/23/23	4/30/23	5/7/23	5/14/23	5/21/23	5/28/23	6/4/23	6/11/23	6/18/23	6/25/23	7/2/23	7/9/23	7/16/23	7/23/23	7/30/23	8/6/23	8/13/23	8/20/23	8/27/23	9/3/23	9/10/23
4027 Flat Creek Rd	2.89	4.68	3.01	7.97	4.03	5.06	5.65	14.05	2.20	6.17	6.61	11.82	6.84	5.46	10.76	13.92	55.95	72.67	15.17	3.87	4.45
Wilcox Rd	3.06	6.48	2.89	9.94	4.45	5.38	5.55	14.29	2.24	6.38	6.68	12.01	7.08	5.56	10.84	14.34	54.14	73.93	37.04	4.16	4.38
Juniper St	6.26	7.83	4.62	13.07	5.35	6.85	7.93	15.28	3.47	8.13	8.71	11.29	8.42	6.72	11.07	15.72	50.25	72.22	17.52	5.29	6.61
Fumi Circle Rd	5.72	7.19	4.38	11.45	4.73	6.22	7.27	14.50	3.05	7.67	7.69	10.59	7.93	6.79	10.76	13.16	51.54	72.64	16.84	5.23	5.69
Valley Westside Rd	4.03	6.05	3.37	8.52	4.23	5.60	6.11	13.94	3.00	7.16	7.65	10.26	7.73	6.36	10.44	13.86	51.75	71.14	16.86	4.54	5.79
E Hawthorne Ave	4.79	5.81	3.60	10.90	4.57	6.34	6.13	13.64	2.65	7.02	7.65	10.11	7.30	5.88	9.94	13.77	45.76	71.81	15.67	4.34	5.30
E Columbia Ave	4.80	6.20	3.87	11.18	4.80	6.52	6.93	14.34	3.26	7.94	8.79	10.87	8.21	6.78	10.83	14.65	45.95	71.81	17.23	5.47	6.82
Brooks Rd	11.79	5.94	5.44	9.73	5.07	5.17	5.60	14.09	2.95	6.25	7.05	10.99	6.89	5.28	9.95	14.11	52.11	93.79	20.39	5.15	6.03
2213 Hwy 25	4.45	7.13	3.36	11.04	4.66	5.85	6.31	15.73	2.48	7.18	7.51	12.11	7.65	5.85	11.17	15.53	57.74	78.95	17.43	4.74	5.11
124 Putnam Rd	3.68	5.78	2.65	10.72	4.40	5.08	5.55	11.95	2.09	6.07	7.13	8.29	5.94	5.49	8.59	12.25	46.99	65.31	14.45	4.47	5.39
39 Short Cut Rd	6.61	6.41	3.83	11.69	5.32	5.85	6.52	13.49	2.49	7.42	8.03	9.35	6.89	5.96	10.51	14.09	51.64	70.28	15.83	5.47	6.36
3747C Hwy 25 S	3.93	6.15	3.19	11.48	4.77	5.83	5.70	12.48	2.56	6.50	7.20	9.24	6.94	5.43	9.36	12.85	47.64	68.13	14.84	4.49	5.71
Riverview Lane	3.95	5.77	2.46	13.43	3.38	5.23	5.35	14.37	2.32	6.39	7.61	10.10	6.46	5.06	13.40	15.44	53.99	71.54	16.64	5.12	4.93
Average	5.07	6.26	3.59	10.85	4.60	5.77	6.20	14.01	2.67	6.94	7.56	10.54	7.25	5.89	10.59	14.13	51.19	73.40	18.15	4.80	5.58
Standard Deviation (1 σ)	2.31	0.79	0.84	1.56	0.53	0.58	0.78	1.01	0.43	0.70	0.67	1.15	0.71	0.60	1.12	1.04	3.78	6.87	5.88	0.52	0.76

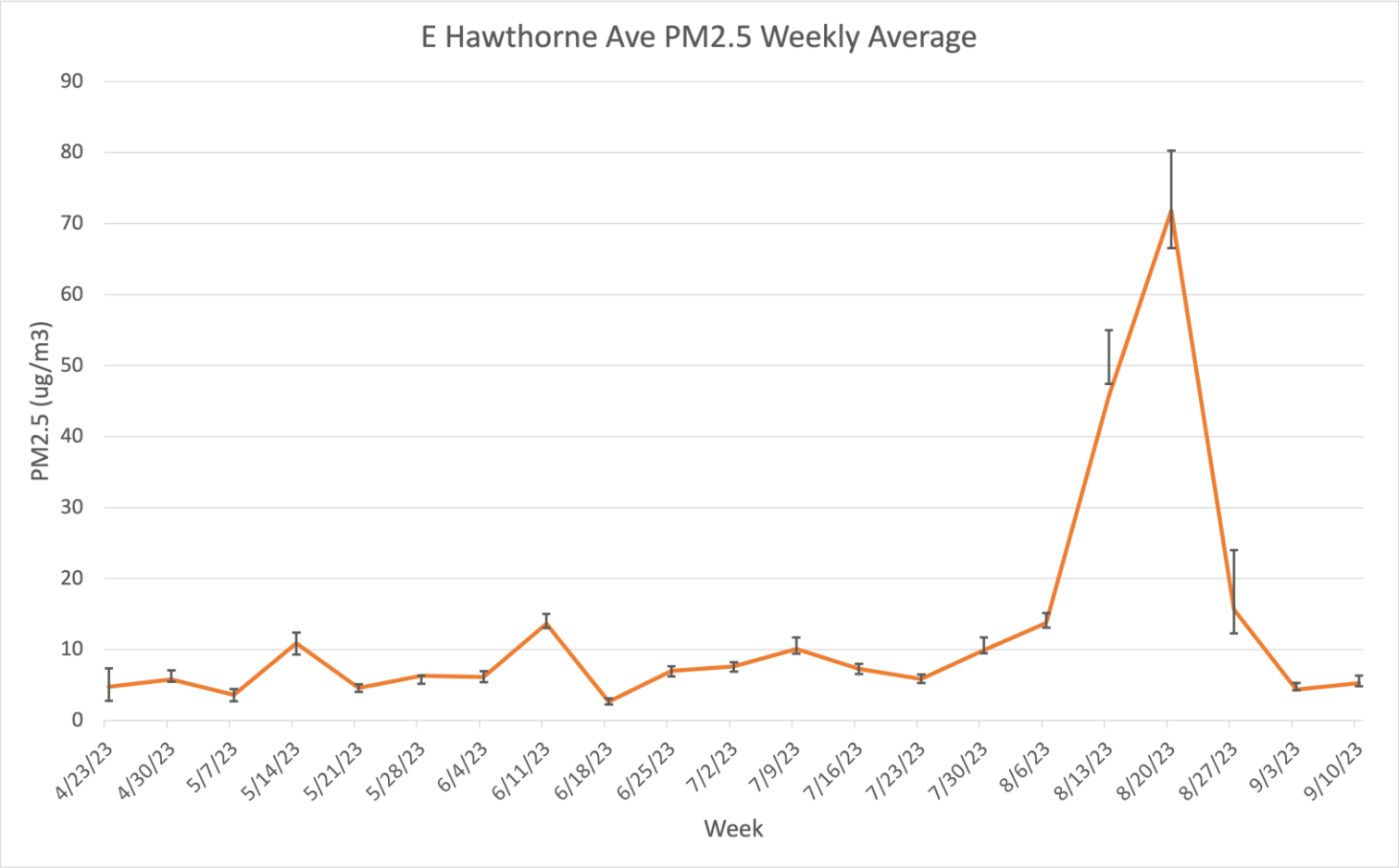
From the week of April 23, 2023, through through the week of September 10, 2023, for 13 PA sensors placed in Upper Columbia River Valley. Average and one standard deviation were calculated using values from all locations during the given week.

E Columbia Ave, Colville



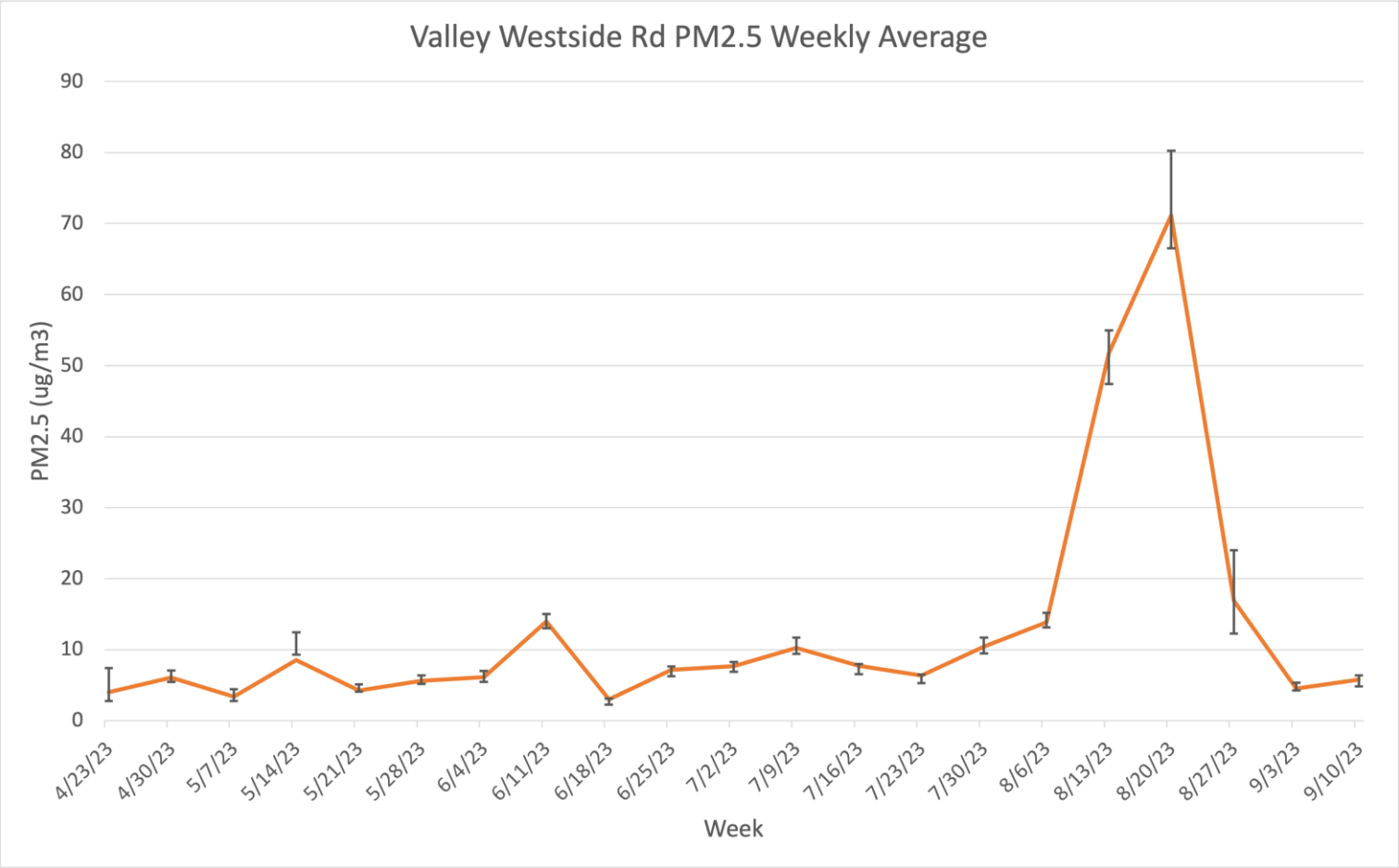
Weekly $PM_{2.5}$ from April - Sept 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

E Hawthorne Ave, Colville



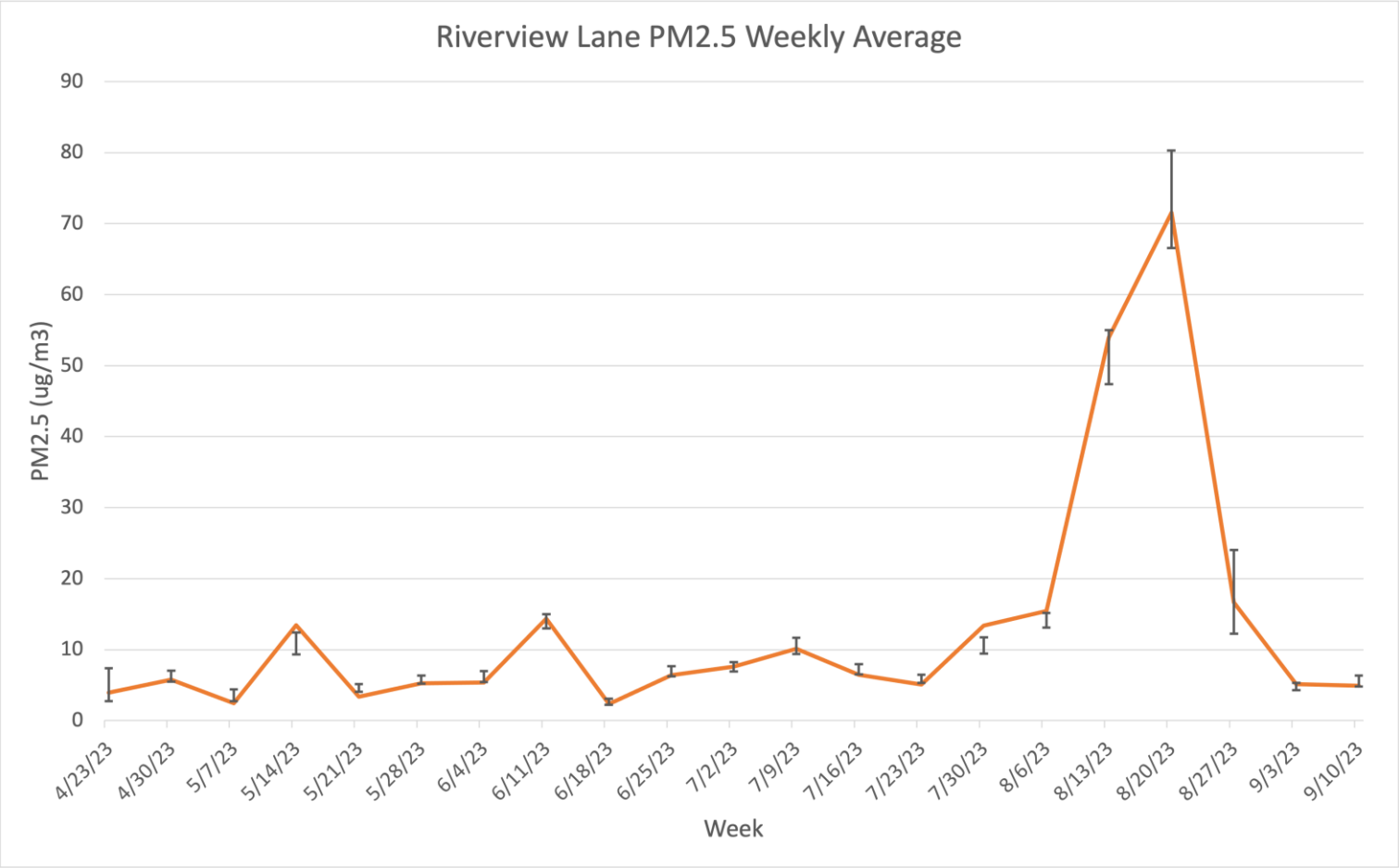
Weekly $PM_{2.5}$ from April - Sept 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

Valley Westside Rd, Colville



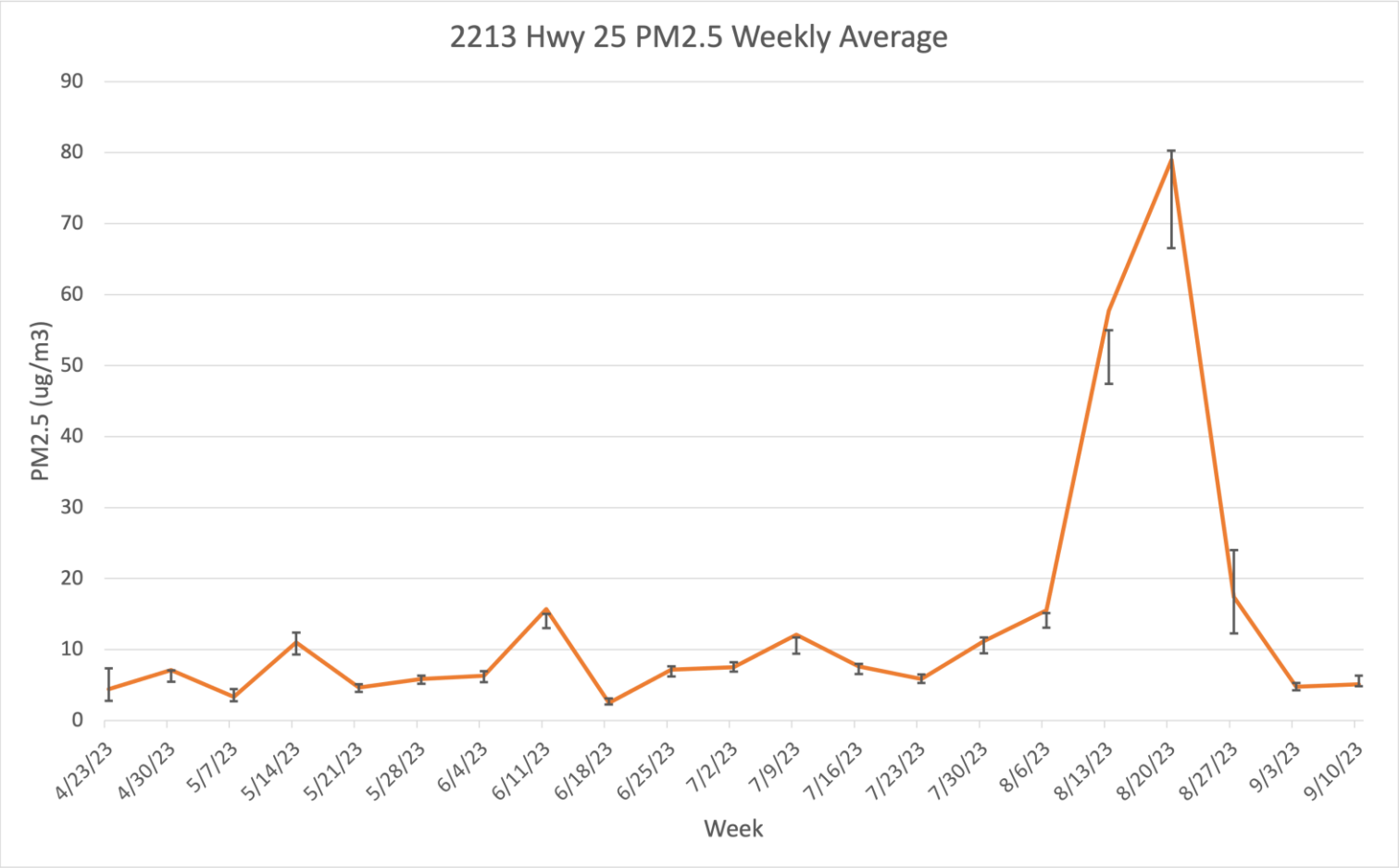
Weekly $PM_{2.5}$ from April - Sept 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

Riverview Lane, Curlew



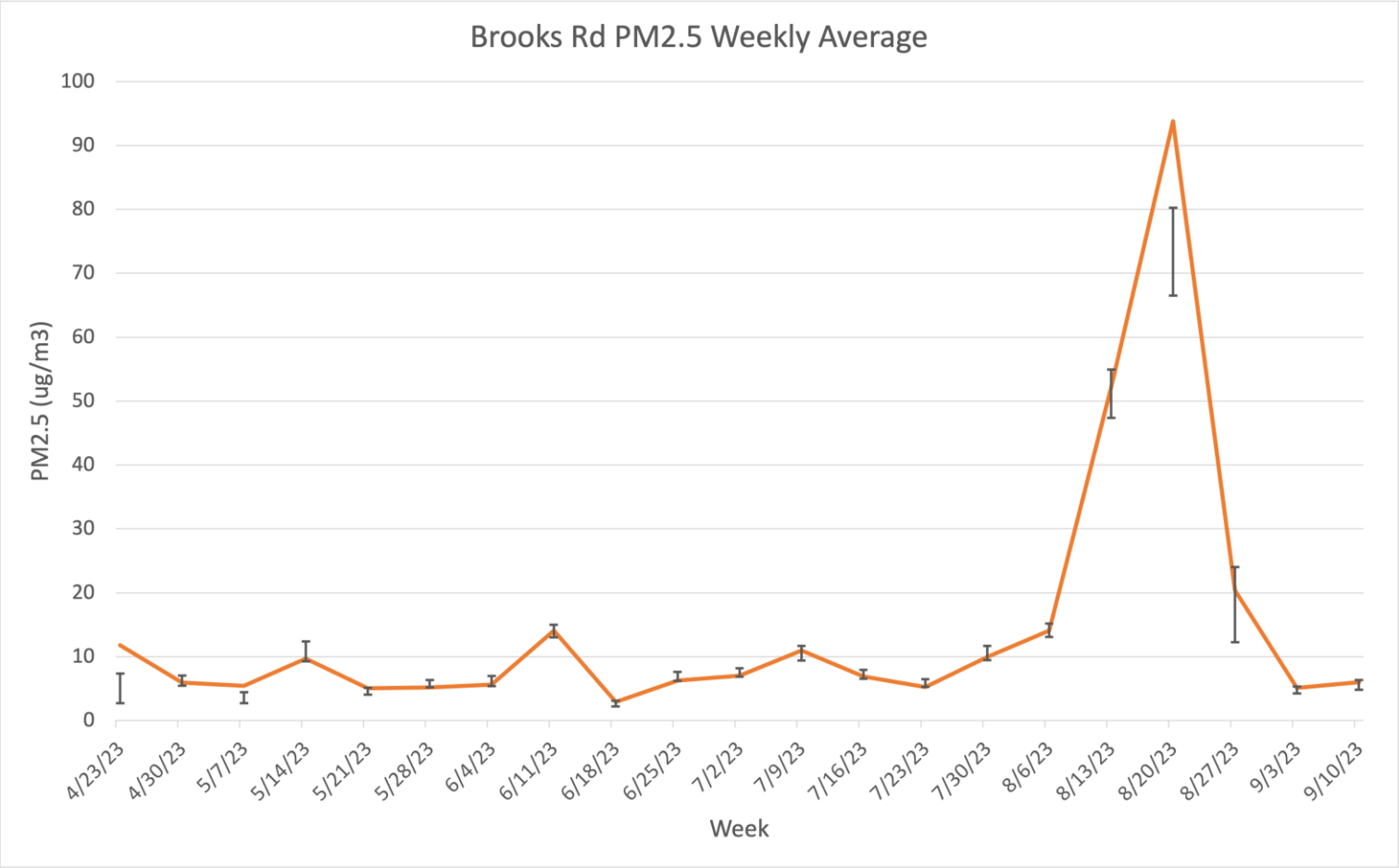
Weekly $PM_{2.5}$ from April - Sept 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

2213 Hwy 25, Evans



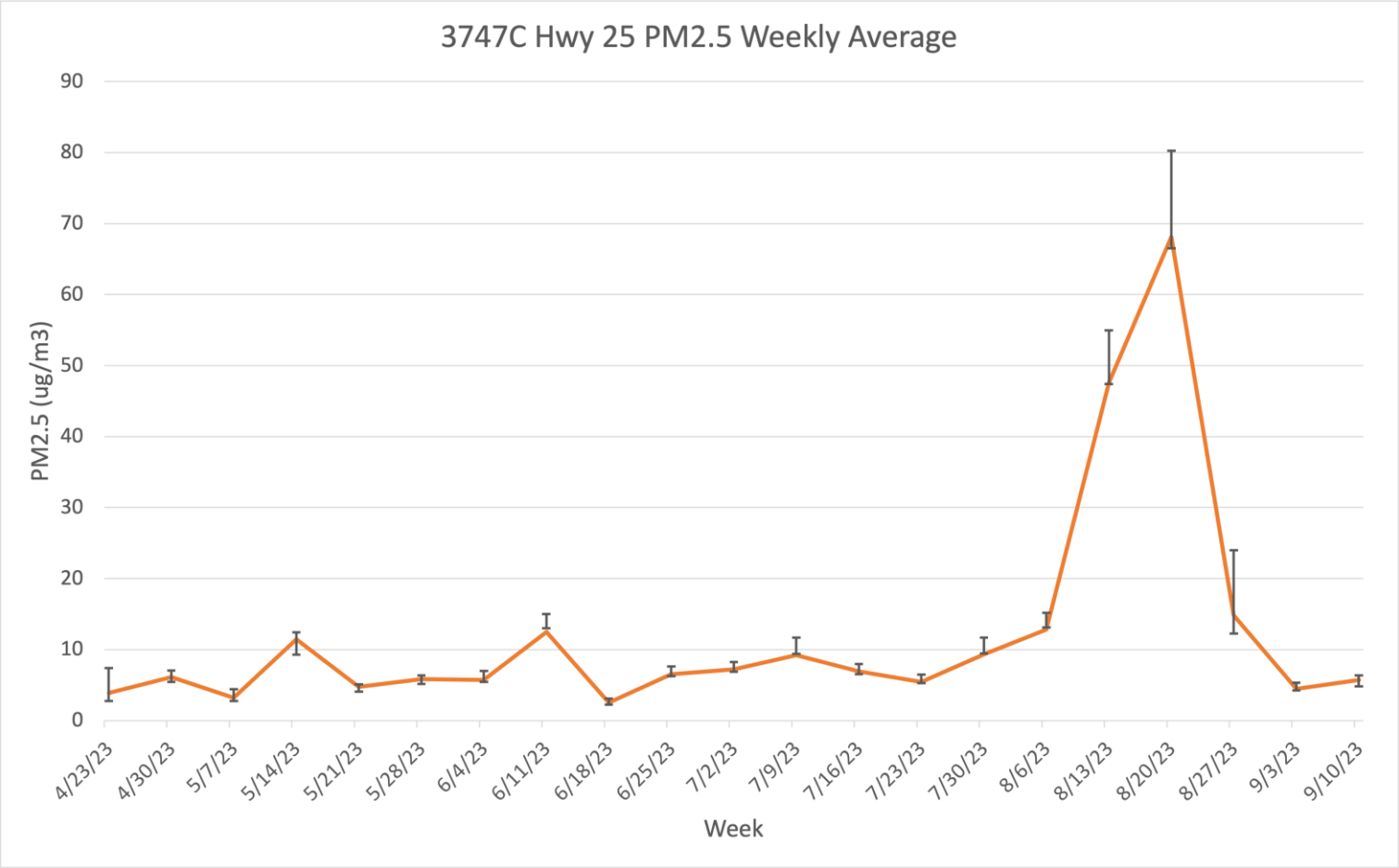
Weekly $PM_{2.5}$ from April - Sept 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

Brooks Rd, Evans



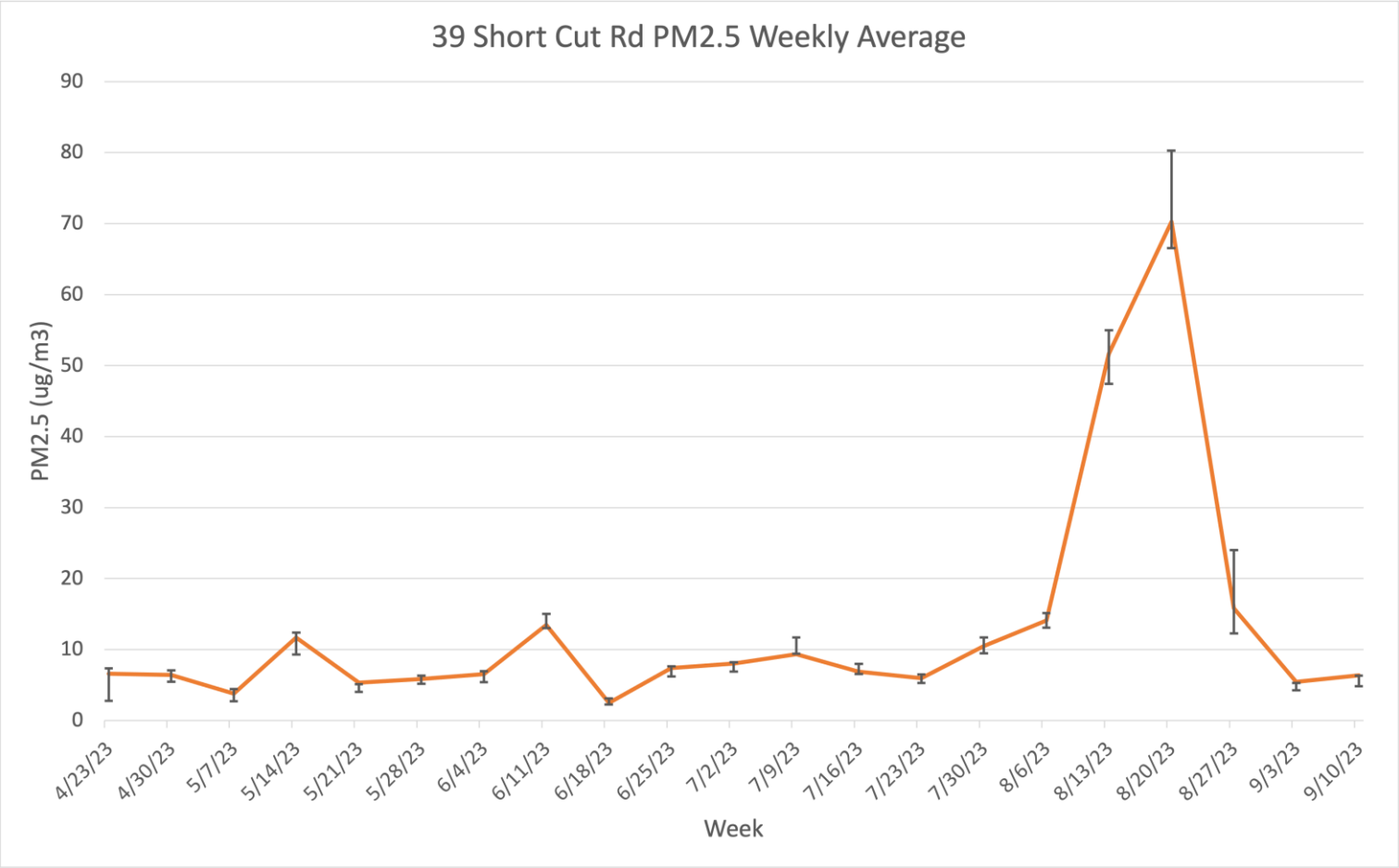
Weekly $PM_{2.5}$ from April - Sept 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

3747 Hwy 25, Gifford



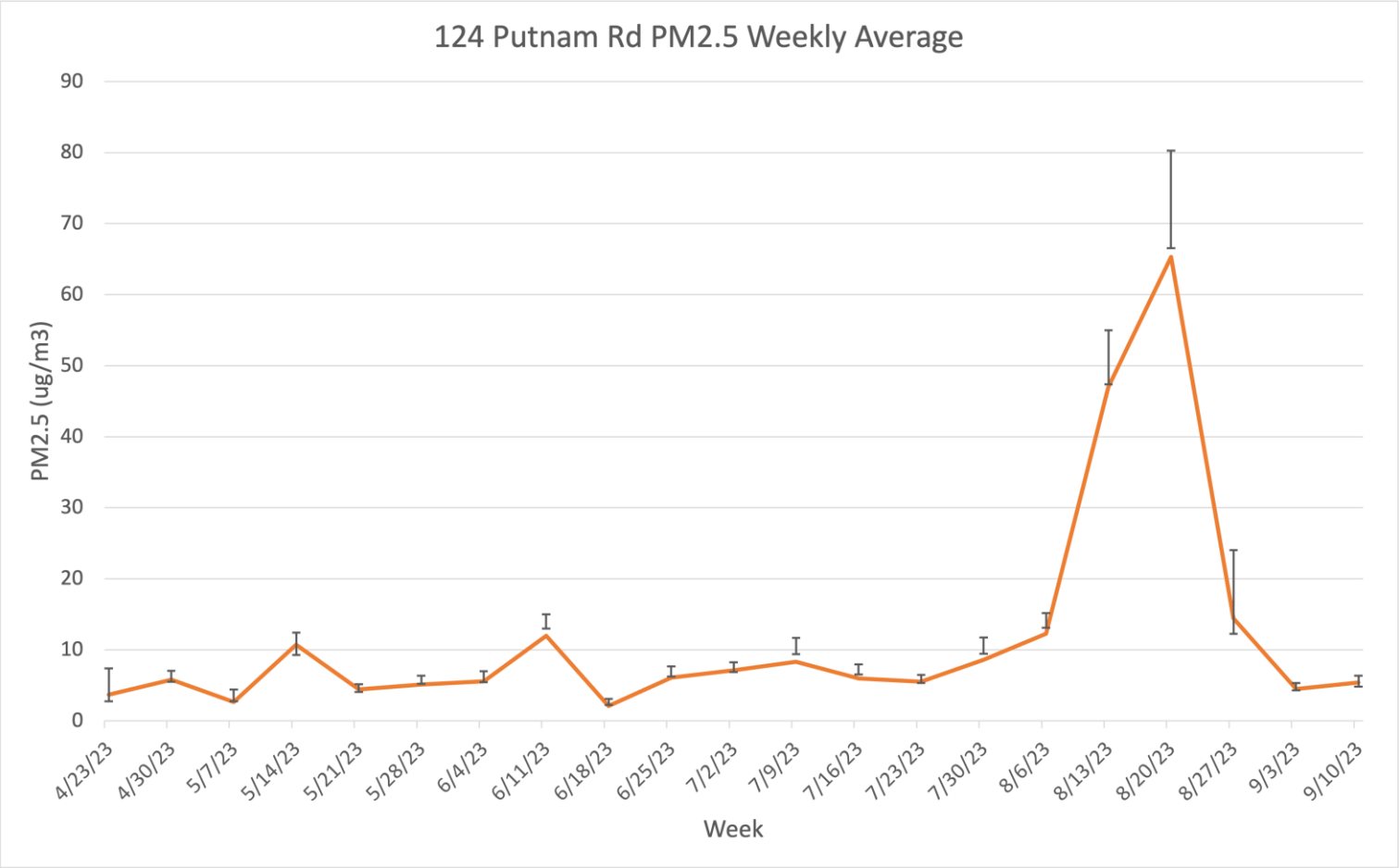
Weekly $PM_{2.5}$ from April - Sept 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

39 Short Cut Rd, Inchelium



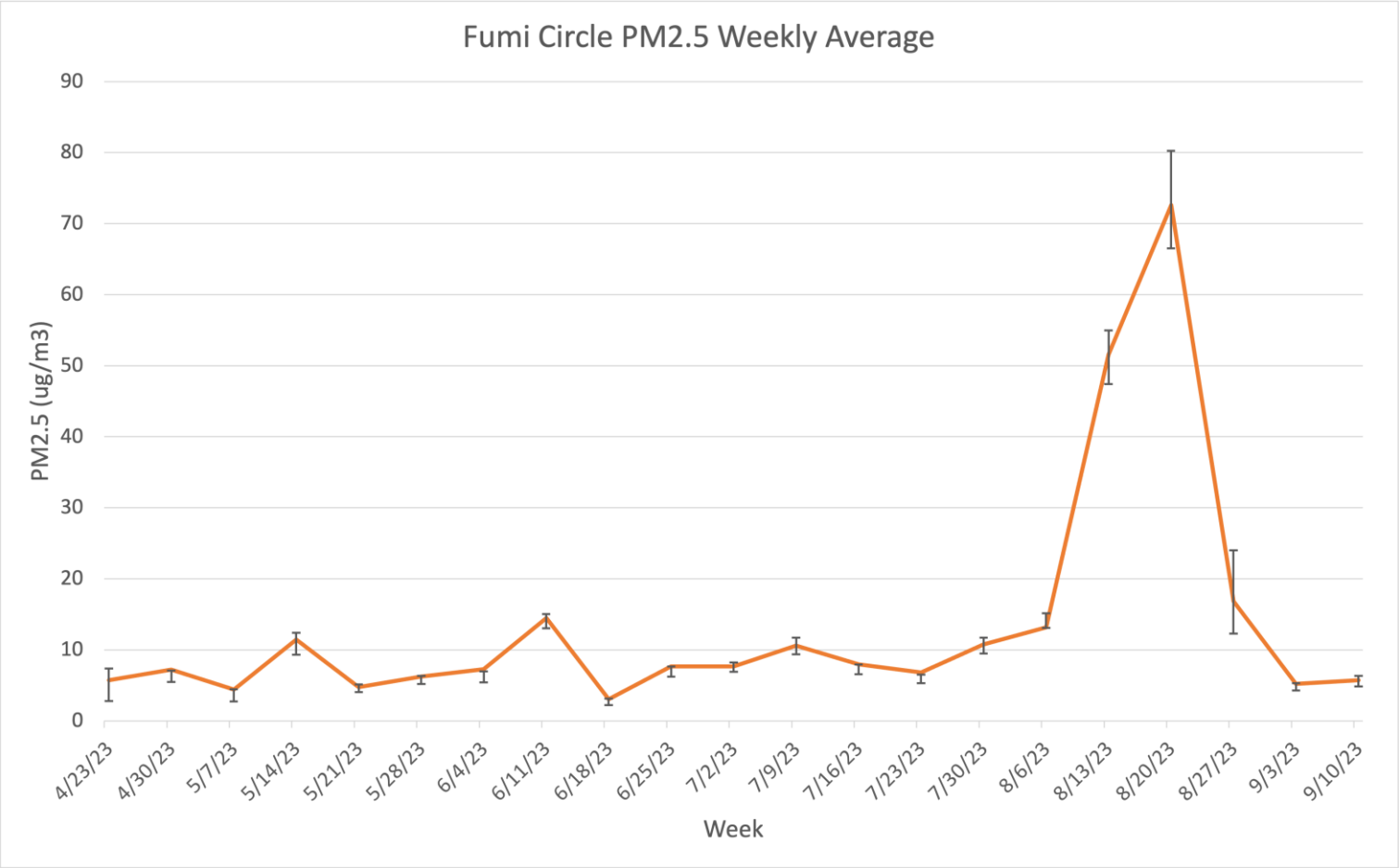
Weekly $PM_{2.5}$ from April - Sept 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

124 Putnam Rd, Inchelium



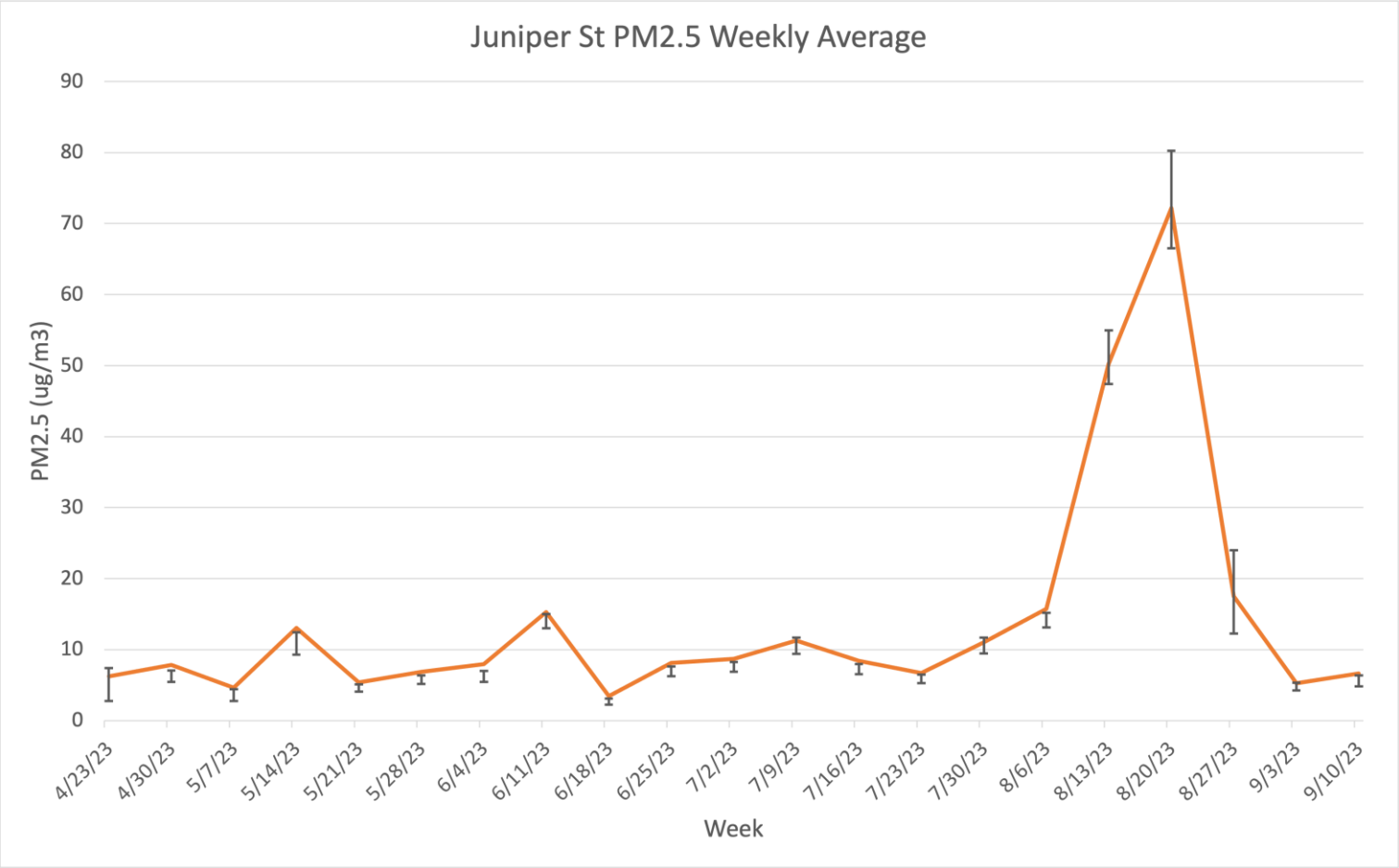
Weekly $PM_{2.5}$ from April - Sept 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

Fumi Circle Rd, Kettle Falls



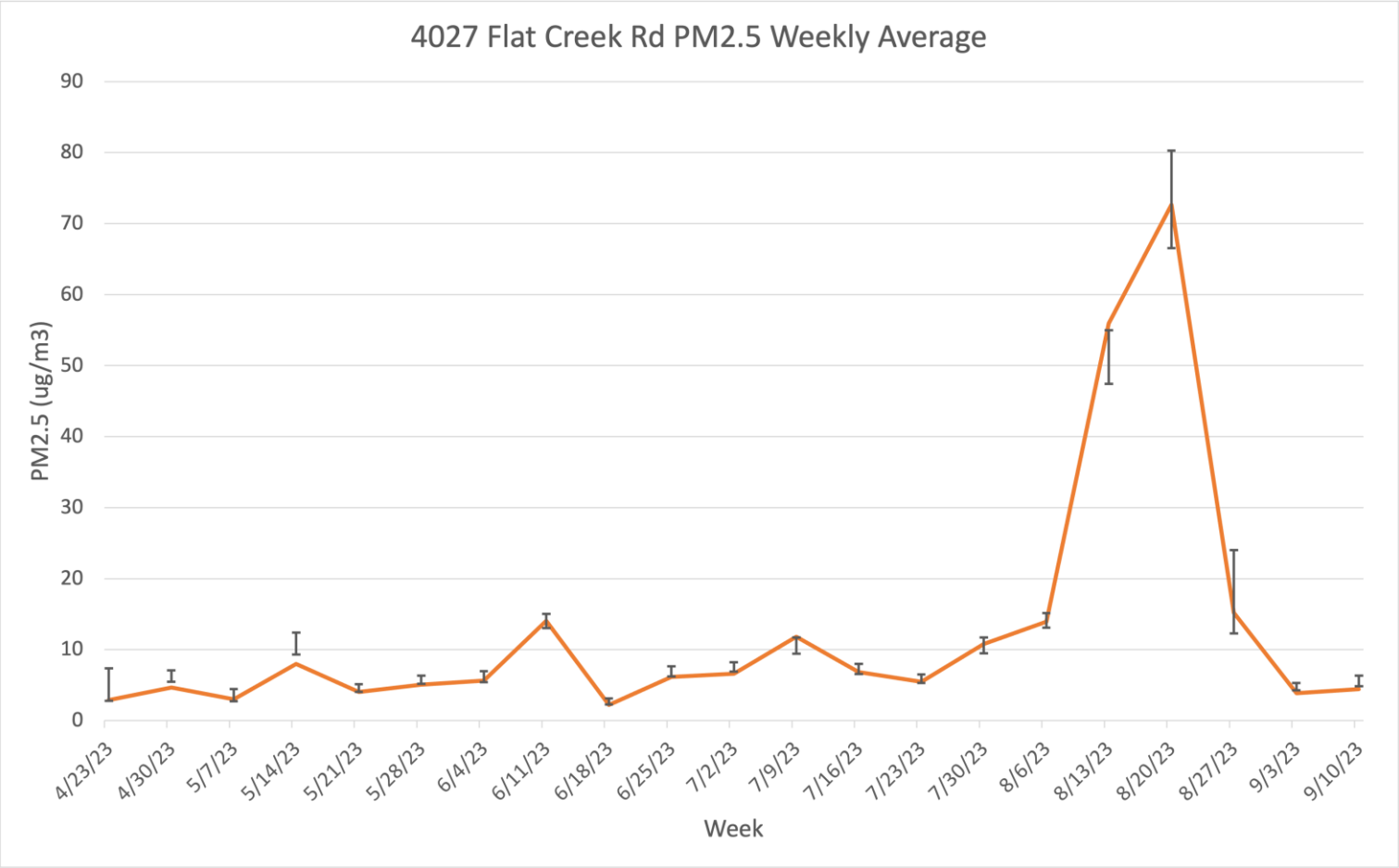
Weekly $PM_{2.5}$ from April - Sept 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

Juniper St, Kettle Falls



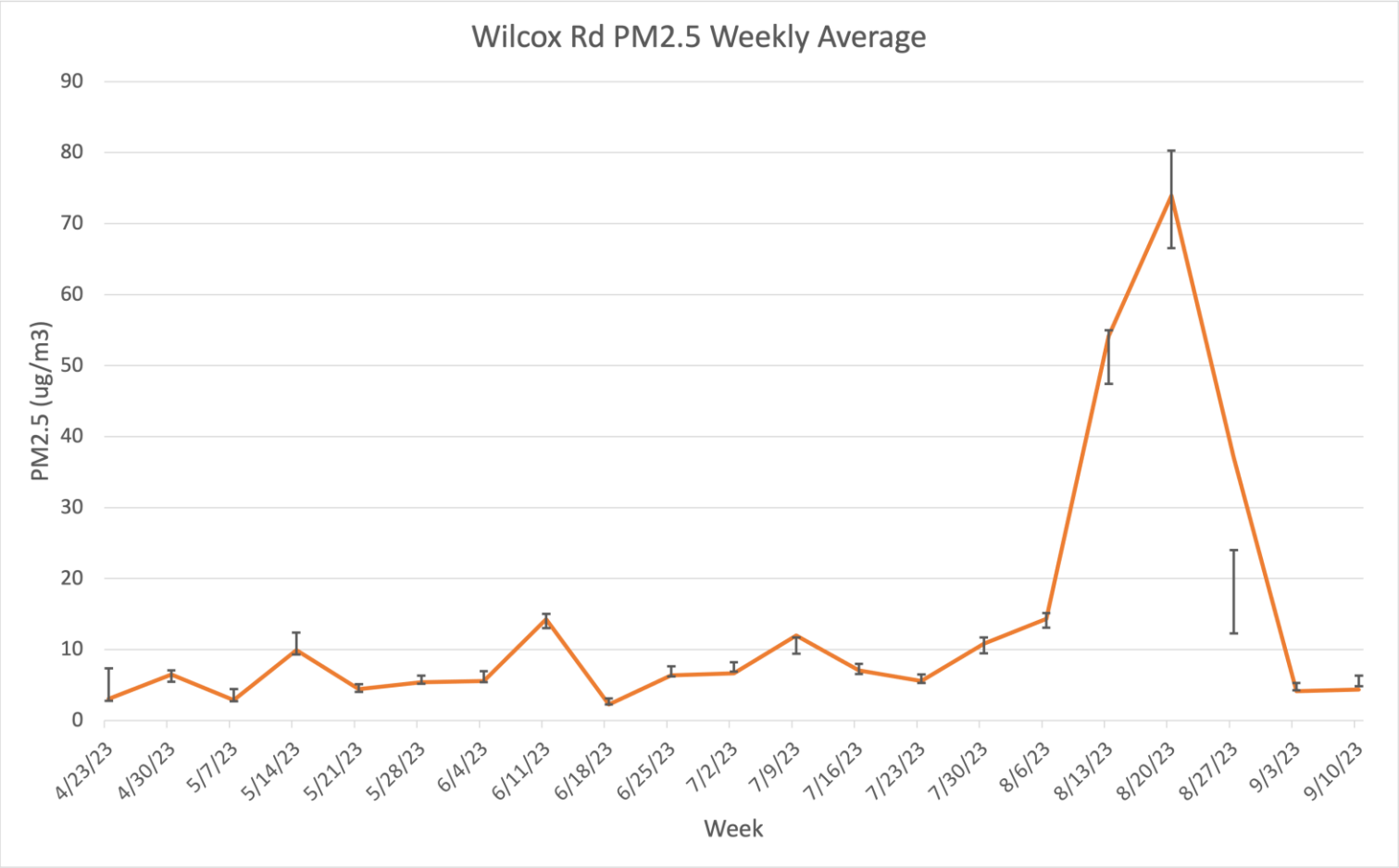
Weekly $PM_{2.5}$ from April - Sept 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

4027 Flat Creek Rd, Northport



Weekly $PM_{2.5}$ from April - Sept 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

Wilcox Rd, Northport



Weekly $PM_{2.5}$ from April - Sept 2023. One standard deviation from the mean $PM_{2.5}$ of all locations is given at each of the weekly points.

PurpleAir Sensors Used

Sensor Name	Sensor Index	Location
Colville High School*	96109	Colville
E Columbia Ave	148785	Colville
E Hawthorne Ave	148773	Colville
Valley Westside Rd	148755	Colville
Riverview Lane	148751	Curlew
Brooks Rd	148757	Evans
Evans wa	148741	Evans (2213 Highway 25)
Gifford	148775	Gifford
Inchelium Clinic	148759	Inchelium
Inchelium School District*	94671	Inchelium
Putnam Re	148791	Inchelium
940 Juniper St	148793	Kettle Falls
Fumi Circle Rd	148783	Kettle Falls
Kettle Falls District Office*	105470	Kettle Falls
Kettle Falls Library*	117911	Kettle Falls
Flat Creek Rd	148747	Northport (4227 Flat Creek Rd)
Natchos	149001	Northport (4027 Flat Creek Rd)
Wilcox Rd	148745	Northport
Sunningdale Smoke Eaters	90699	Trail
TRL5938A	104066	Trail
Onion Creek School District*	102428	Colville
Western Spokane/Riverside State Park*	6784	Spokane
Park Ave*	119003	Yakima
North Central District*	83633	Seattle
Darrington Elementary School*	15229	Darrington

*Used for wintertime monthly average comparison

References

- Barkjohn, K.K., Gantt, B., and Clements, A.L.: Development and applications of a United States-wide correction for $PM_{2.5}$ data collected with the PurpleAir sensor, Atmos. Meas. Tech., 14, 4617-4637, https://doi.org/10.5194/amt-14-4617-2021, 2021.
- Air Emissions Inventory . Washington State Department of Ecology. [accessed 2023 Jul 14]. https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory#:~:text=A%20point%20source%20emissions%20inventory.