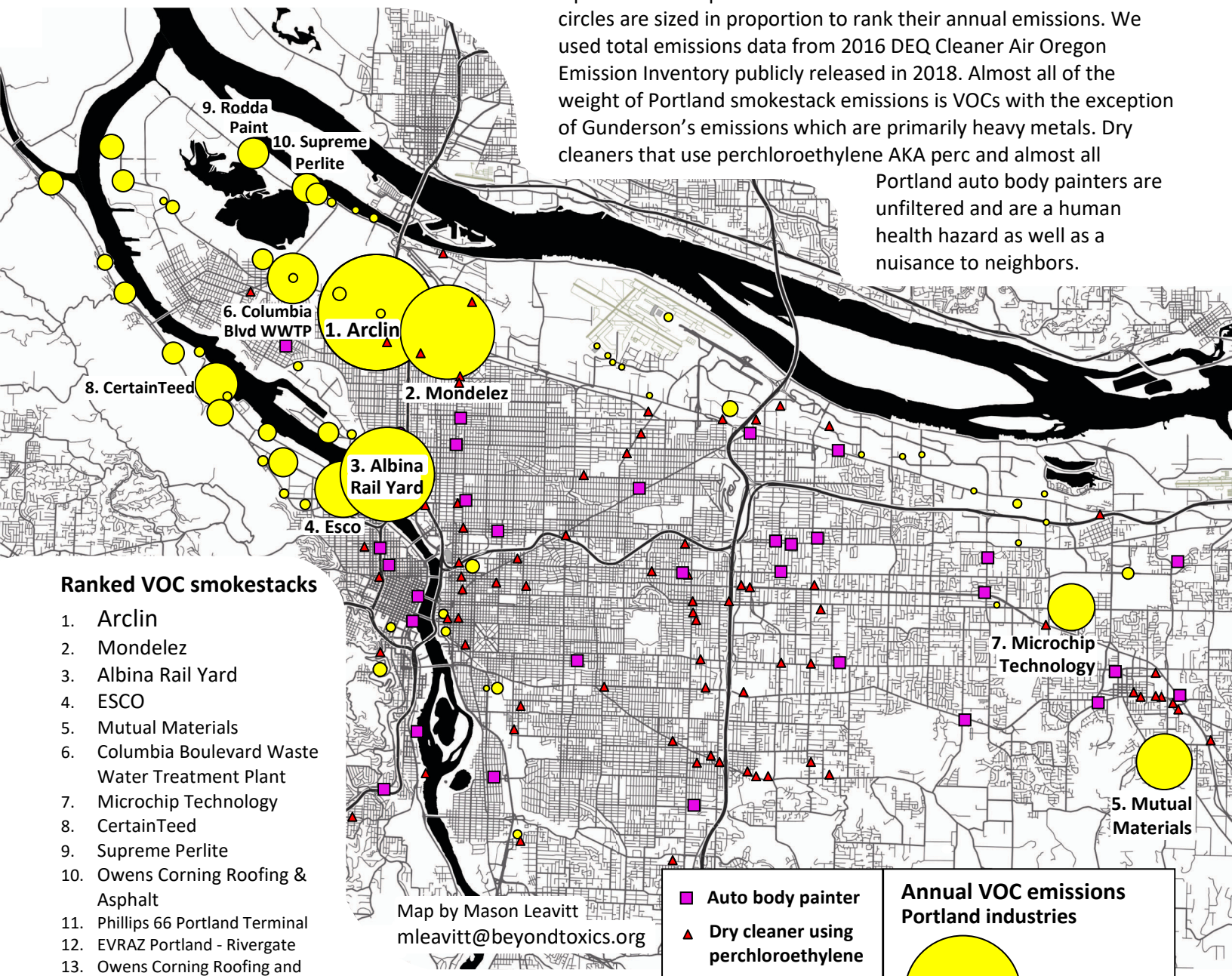
INDUSTRIAL VOC POLLUTERS

Portland smokestacks ranked by annual weight emitted

This map shows self-reported VOCs released from Portland industries. The circles are sized in proportion to rank their annual emissions. We used total emissions data from 2016 DEQ Cleaner Air Oregon Emission Inventory publicly released in 2018. Almost all of the weight of Portland smokestack emissions is VOCs with the exception of Gunderson's emissions which are primarily heavy metals. Dry cleaners that use perchloroethylene AKA perc and almost all Portland auto body painters are unfiltered and are a human health hazard as well as a nuisance to neighbors.



Ranked VOC smokestacks

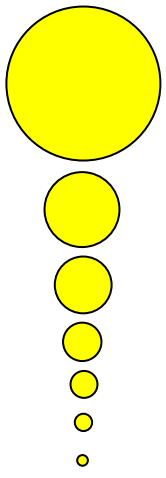
1. Arclin
2. Mondelez
3. Albina Rail Yard
4. ESCO
5. Mutual Materials
6. Columbia Boulevard Waste Water Treatment Plant
7. Microchip Technology
8. CertainTeed
9. Supreme Perlite
10. Owens Corning Roofing & Asphalt
11. Phillips 66 Portland Terminal
12. EVRAZ Portland - Rivergate
13. Owens Corning Roofing and Asphalt
14. Kinder Morgan Liquids Terminals
15. J.R. Simplot Company, Rivergate
16. Shore Terminals
17. Oil Re-Refining Company
18. Columbia Steel Casting
19. Vigor Industrial
20. Gunderson
21. BP
22. Owens-Brockway Glass Container
23. OHSU
24. Franz Bakery
25. Saint Johns Landfill
26. On Semiconductor
28. Bullseye Glass Company
29. Herbert Malarkey Roofing Company
30. Galvanizers Company
31. Siltronic Corporation
32. Lacamas Laboratories
33. The Boeing Company
34. Shell, Portland Terminal
35. Flint Group North America
36. Port of Portland
37. Arc Terminals Holdings
38. Blasen & Blasen Lumber
39. U.S. Bancorp, Columbia Center
40. Daimler Trucks
41. Gresham Wastewater Treatment Plant
42. Boeing
43. Sapa Extrusions
44. Graphic Packaging International
45. International Paper
46. Sakrete
47. Northwest Pipe
48. East Side Plating - Plant #5
49. Container Management Services
50. Oregon Air National Guard

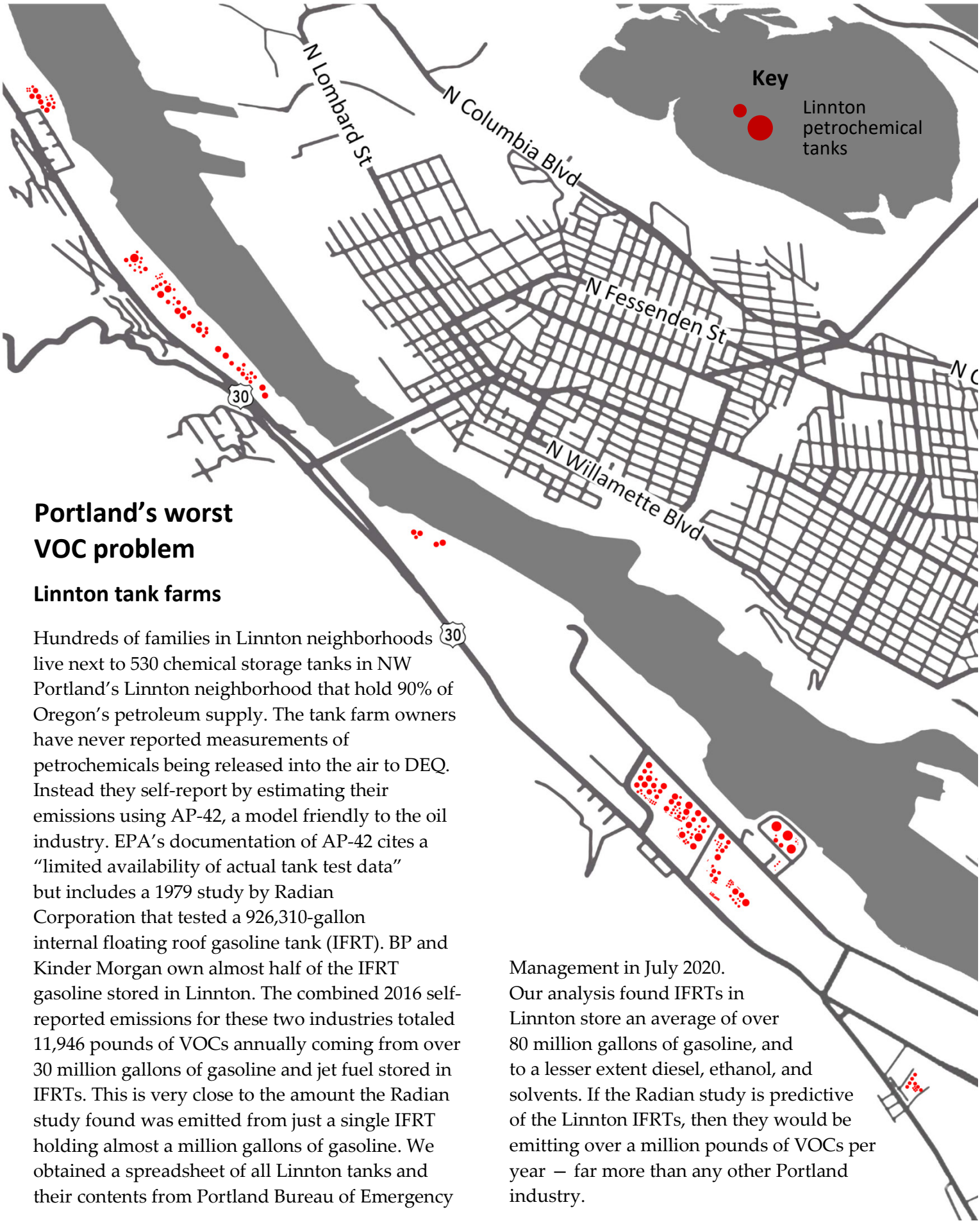
Map by Mason Leavitt
mleavitt@beyondtoxics.org

Auto body painter

Dry cleaner using perchloroethylene

Annual VOC emissions
Portland industries





Portland's worst VOC problem

Linnton tank farms

Hundreds of families in Linnton neighborhoods live next to 530 chemical storage tanks in NW Portland's Linnton neighborhood that hold 90% of Oregon's petroleum supply. The tank farm owners have never reported measurements of petrochemicals being released into the air to DEQ. Instead they self-report by estimating their emissions using AP-42, a model friendly to the oil industry. EPA's documentation of AP-42 cites a "limited availability of actual tank test data" but includes a 1979 study by Radian Corporation that tested a 926,310-gallon internal floating roof gasoline tank (IFRT). BP and Kinder Morgan own almost half of the IFRT gasoline stored in Linnton. The combined 2016 self-reported emissions for these two industries totaled 11,946 pounds of VOCs annually coming from over 30 million gallons of gasoline and jet fuel stored in IFRTs. This is very close to the amount the Radian study found was emitted from just a single IFRT holding almost a million gallons of gasoline. We obtained a spreadsheet of all Linnton tanks and their contents from Portland Bureau of Emergency Management in July 2020. Our analysis found IFRTs in Linnton store an average of over 80 million gallons of gasoline, and to a lesser extent diesel, ethanol, and solvents. If the Radian study is predictive of the Linnton IFRTs, then they would be emitting over a million pounds of VOCs per year — far more than any other Portland industry.

Monitoring dangerous airborne industrial solvents in Portland neighborhoods

Industrial solvents, also known as volatile organic compounds (VOCs) are a group of thousands of chemicals containing carbon. Numerous Portland industries release dangerous VOCs into the air such as benzene, formaldehyde, toluene, and xylene which disperse into neighborhoods. These industries include oil recyclers, tank farms, auto body painters, asphalt and fiberglass manufacturers, as well as mobile sources such as trucks and ships. Forest fire smoke contains a lot of VOCs.

Short term health effects from VOCs may include:

- itchy eyes
- headaches
- fatigue
- breathing difficulties
- coughing
- burning eyes or throat
- nausea
- increased asthma attacks

These symptoms often increase based on the frequency and duration of the exposure.

Long-term health effects from VOCs may include:

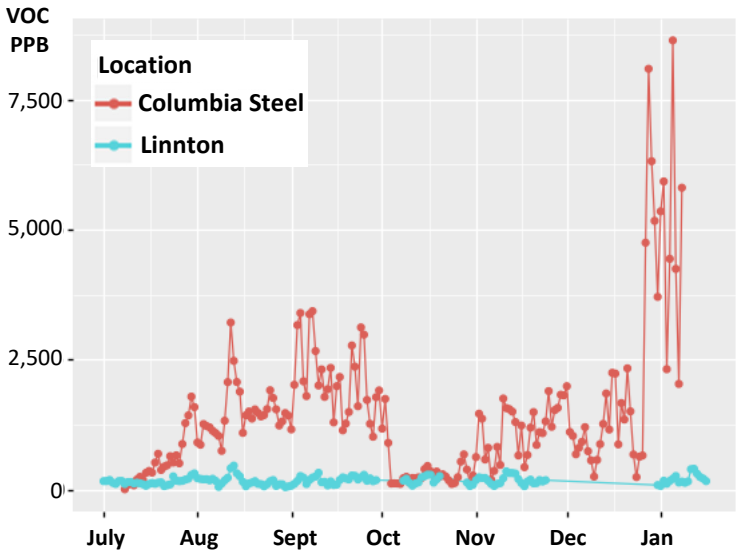
- persistent headaches
- dizziness, difficulty concentrating
- nausea
- breathing problems or lung cancer
- liver or kidney damage
- central nervous system conditions

VOCs are often, but not always, accompanied by an odor that people may recognize, such as scents related to paint, cleaning products, new cars, and petrochemicals. These can be a health threat and/or a continual nuisance in Portland neighborhoods.

Our VOC monitor results

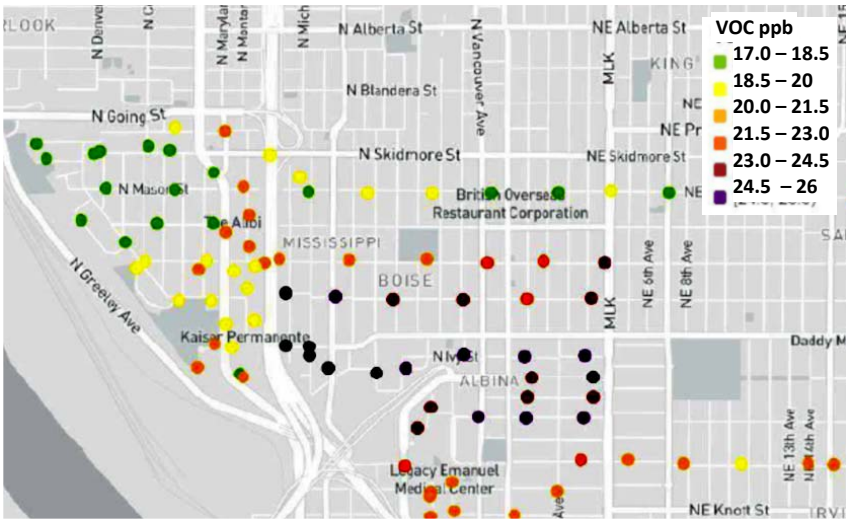
Starting in 2021, we used Atmotube VOC monitors. We switched to Flow VOC monitors in 2022. Both of these devices are no longer available and we only use PurpleAir now to collect VOC data. The graph below shows Atmotube data for two Portland residential areas. The Linnton site is near the tank farms and a stinky asphalt roofing plant. The North Portland site was next door to Columbia Steel's unfiltered paint emissions.

Atmotube VOC July 2021 – January 2022

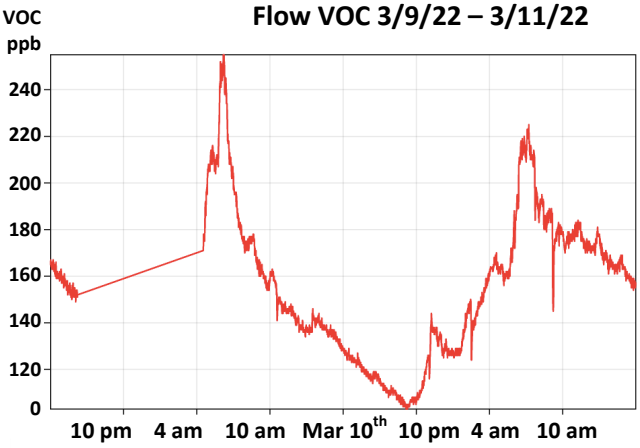


Now we map VOC data that we collect with an electric rental scooter. The map below shows Flow data collected during a two-hour bicycle ride in the residential area east of the Albina Rail Yard. We believe the purple dots on the map below show a VOC plume emanating from the Albina Yard, the largest source of VOCs in the NW industrial area. industrial area.

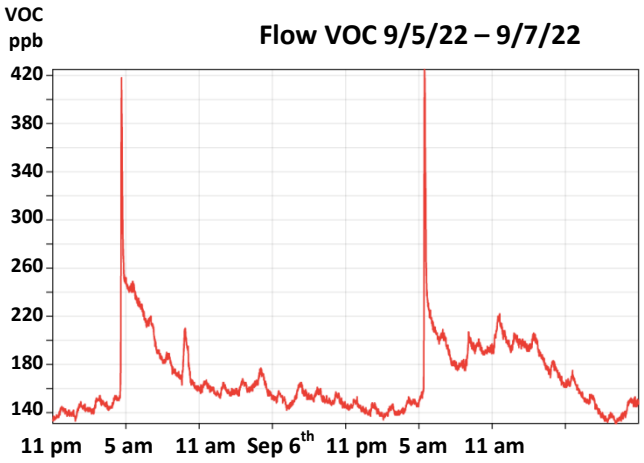
Flow VOC April 1st, 7 – 8:45 am



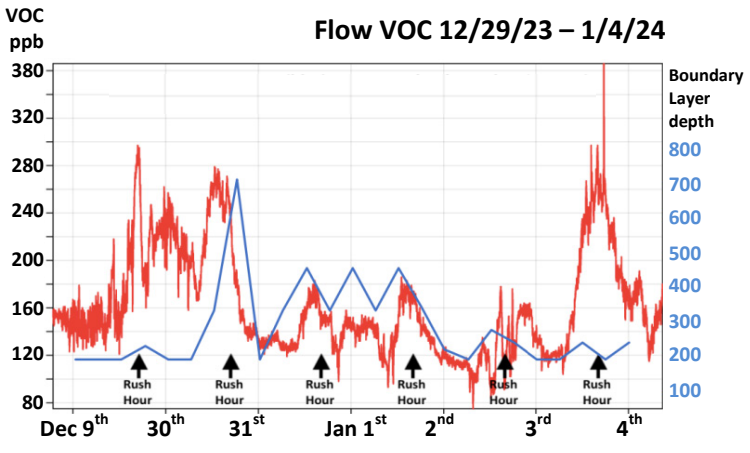
We set up a stationary Flow to monitor VOCs at a house near the Albina Rail Yard, located in the plume on the previous page. VOCs spiked at 1 pm and 5 pm in March:



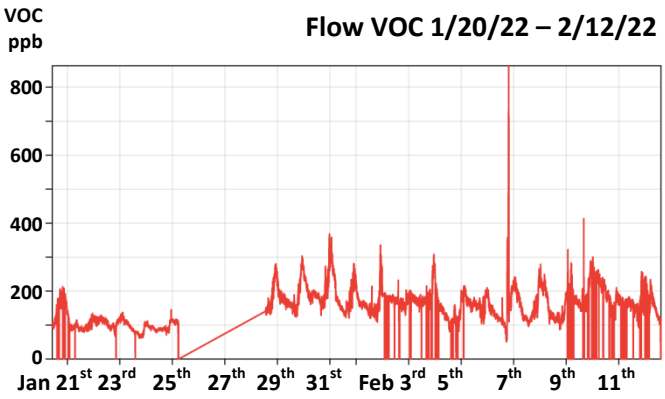
In September 2022, the same monitor spiked at 6 am daily. These spikes appear to come from truck-to-train transfers of VOCs without a control device.

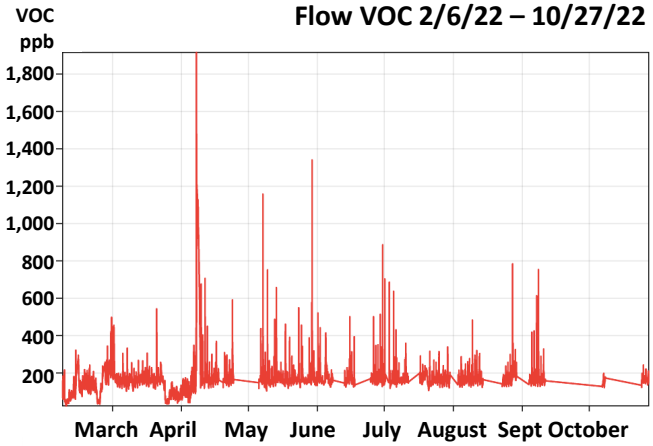


The graph below shows Flow data at a residential site close to Intel, a major VOC emitter. VOCs are generally around 120 ppb, and may be spiking either from rush hour traffic or Intel pollution concentrated due to inversions, shown in blue.



The next two graphs compare the same site in Linnton with a residential site near Albina Rail Yard. The Linnton site is in the 150 ppb range; the Albina site is generally 200 ppb and spikes higher.





Wind direction and atmospheric inversion data is needed when taking VOC samples. Airborne industrial pollution moves in the direction of the wind and tends to rise and dissipate quickly into the upper atmosphere unless an inversion is present. We use data from about nine wind monitors called anemometers and software from the National Oceanic and Atmospheric Administration to determine inversion. We found that the real time PM2.5 data on the PurpleAir website is also necessary to determine inversion.

We explain how to determine and document wind direction and inversion here: portlandcleanair.org/files/reports/How%20to%20Map%%20Particulate%20in%20Neighborhoods.pdf

A drawback of using the Atmotube, Flow, and PurpleAir VOC monitors is that results are shown as TVOC which means total VOCs — the combined reading of all VOCs present in the air. Some VOCs

like formaldehyde are dangerous to human health. Other airborne industrial VOC emissions, such as ethanol, pose a much lower risk to human health. The Aeroqual 900 can differentiate among the hundreds of possible VOCs and costs $1,825. However, the Aeroqual is not designed to collect and store data. Doing so requires another $850 for a wireless data logging kit and an attached laptop.

We used Summa canisters to sample airborne VOCs concentrations with regulatory-grade accuracy. The table below shows the results of five 2022 Portland Summa samples analyzed by an EPA-certified lab in California.

Summa canister results

Linnton CEI Hub

1. Near Kinder Morgan Linnton	**VOCs Detected**	**ppbv**	**ug/m^3**
Sample Date: 4/5/2022	Ethanol	8.4	16
Location: 45.60241, -122.78689	Acetone	15	36
~100ft from tanks / fenceline	2-Propanol	8.4	21
Stability: E – Slightly Stable	Hexane	0.96	3.4
	Toluene	0.82	3.1

2. Near Kinder Morgan Linnton	**VOCs Detected**	**ppbv**	**ug/m^3**
Sample Date: 11/12/22	Toluene	0.94	3.5
Location: 45.604, -122.79			
~100ft from tanks / fenceline			
Stability: G - Extremely Stable			

3. Near Linnton Community Center	**VOCs Detected**	**ppbv**	**ug/m^3**
Sample Date: 11/12/22	Ethanol	23	60
Location: 45.599, -122.785			
~1600ft from LCC			
Stability: E - Slightly Stable			

4. Near Chevron, Kinder Morgan,	**VOC's Detected**	**ppbv**	**ug/m^3**
Phillips 66, McCall, & Zenith Energy.	Ethanol	19	36
Sample Date: 3/6/22	Hexane	2.8	9.8
Location: 45.561429, -122.735815	Cyclohexane	0.96	3.3
~ 300ft from tanks / fencelines.	isooctane	1.2	5.7
Stability: E - Slightly Stable	Benzene	0.69	2.2
	Heptane	0.71	2.9
	Toluene	2.2	8.4
	m,p-Xylene	1.1	4.9

Columbia Steel Mill

St. Johns Near Columbia Steel	**VOCs Detected**	**ppbv**	**ug/m^3**
Sample Date: 2/9/22	Ethanol	93	180
Location: 45.596, -122.729	2-Propanol	2.6	6.3
~ 500ft from main building.	Toluene	2.2	8.2
Stability: D - Neutral	m,p-Xylene	1	4.5

Cascadia Action has worked with Linnton Neighborhood Association for six years. The Problem with the Linnton tanks is explained here: http://portlandcleanair.org/files/reports/Tank%20Farm%20v8%20web.pdf

Linnton keeps asking DEQ to monitor the tank farms and surrounding neighborhoods. DEQ has refused annually since 2021. More online here: http://portlandcleanair.org/files/reports/2023%20LNA%20Letter%20to%20DEQ%20re%20CEI%20Hub%20emissions%202.22.23.pdf
and here:
http://portlandcleanair.org/files/reports/Tank%20Farm%20v8%20web.pdf

We studied tank farm monitor results by the Maine Department of Environmental Protection (DEP) at South Portland Maine at a similar tank farm which has a total capacity of 279,671,489 gallons, close to Linnton's total tank capacity of 232,371,100 gallons. Of the 13 total Summa sample canisters Cascadia Action deployed in 2022, five had valid results, shown at left, eight came back from the lab as "No VOCs detected," Of the 72 total grab sample canisters made deployed by DEP, 56 had valid results, 13 did not. Our monitor results for Linnton are here:
http://portlandcleanair.org/files/reports/Linnton-CEI-Hub-Report%2003-30-23.pdf

The Linnton tanks are surely the largest VOC emitters in Portland. Arclin is likely the second largest, emitting 44,463 pounds of VOCs annually according to their 2016 emissions inventory which includes 13,588 pounds of formaldehyde, a dangerous carcinogen. Arclin's wastewater evaporator is entirely unfiltered and the source of most of their emissions.

All emissions for each smokestack are listed in map on portlandcleanair.org by clicking on each industry and following the link. Besides smokestacks, sources of strong VOC smells in neighborhoods include leaking underground residential fuel tanks and mobile roofing tar trailer kettles.

Low-cost VOC monitoring

The DEQ lab staffed by experts, rarely, if ever, deploys their state-of-the-art VOC monitors in the Portland neighborhoods most affected by dangerous industrial air pollution. This compelled Portland neighborhood associations to start citizen monitoring.

Starting in 2018, Cascadia Action began purchasing consumer-grade monitoring equipment to measure industrial pollution. At that time, affordable and reasonably accurate air pollution monitors started entering the consumer market for the first time. Instead of thousands of dollars per device, these new devices were approximately $100 per unit.

If you can smell VOCs outside your home regularly, then similar concentrations are present indoors as well. The human nose rapidly desensitizes to odors. Scent habituation is also known as olfactory fatigue or "nose blindness." To detect odors in your home, the United States Consumer Product Safety Commission recommends leaving your house for a few minutes and then reentering. The neighbors of some industries may need to leave their neighborhood and then return to notice VOC odors.

Using a human nose can be an effective way to determine the occurrence and source of airborne VOCs but there are some drawbacks. Human nose sampling must be limited to only a few readings a day, and data may be considered too subjective when obtained from untrained volunteers. Vigor, a Portland shipbuilding and fabrication company, elected to end a $1M waste treatment program in 2017 due to several studies, including a year-long sulfur dioxide odor study by University of Portland students and faculty. Undergraduate students were trained in the ASTM E544-10 method which is critical to correctly identify odor concentrations. They sorted ten unlabeled flasks of the reference odorant 1-butanol and water from the lowest to highest concentration. To avoid olfactory fatigue, odor data was collected only three times per day – morning, midday, and evening; odors were sampled from 12/1/14 through 11/30/15 at 19 NE Portland locations.

VOC monitoring devices can record sample data every two seconds without the need for special training. We began using a $79 Atmotube Plus to monitor homes and neighborhoods. This portable, battery powered monitor was used to locate the source of airborne VOCs by walking or bicycling toward the area corresponding to greater total VOC (TVOC) numbers displayed on a smartphone.

Atmotube Plus uses a Sensirion SGPC3 gas sensor, a heated metal oxide sensor located between two electrodes. Using high temperatures, the sensor creates oxygen ions that react with VOCs in the sample. These reactions change the electrical resistance between the electrodes, measuring the ambient gas concentration. Because humidity interferes with accuracy, the device automatically corrects the VOC reading based on its humidity sensor.

The stated accuracy of the Sensirion gas sensor is +/- 15%. This is not clear from reading the sensor datasheet. Upon request, Sensirion provided the standard of deviation which compares the device to regulatory-grade VOC analysis such as gas chromatography–mass spectrometry (GC–MS).

The only low-cost VOC monitor we found for monitoring airborne formaldehyde was the Temtop M10 that uses a Dart WZ-S sensor. We purchased two for $90 each.

Cascadia Action has switched to $300 PurpleAir for low-cost VOC monitoring because Atmotube and Flow are no longer available. PurpleAir is better because it's waterproof and can log data internally without an additional smartphone. Internal data logging makes stationary monitoring easier when graphing long-term exposure. We collect thousands of TVOC readings within a two-hour period to map VOCs in entire neighborhoods. PurpleAir can be used for bicycle and electric scooter collection because it can be powered via USB with an external phone charger.

We use the Strava app on our smartphones for GPS because PurpleAir does not have GPS. Our Airmap software automatically makes a GIS map of the PurpleAir and Strava data. This shows a bullseye of

TVOC airborne concentrations with the highest concentration at the center. This can identify the industry or source causing the problem. We limit data collection to two hours for accurate comparisons. The best map would include several devices collecting data during that time.

While new consumer-grade hardware is impressive, it lacks easy ways to visualize the data collected and setup is often not well explained by the manufacturer. Our data collection with Flow monitors required working with GIS mapping technicians, Excel specialists, and computer programmers to view our results. In 2020, we began creating automated computer programs so our neighbors would not need multiple specialists to monitor industries.

It was expensive and tedious to use GIS mapping every time we did a bike ride for data collection. A volunteer from Mapbox automated our mapping on their platform so we would no longer need to use ArcGIS to visualize the data. A web engineer volunteered and scripted a web interface which automatically maps the results from each type of monitor in Mapbox. Now, we just load the data onto the page and instantly get mapped results.

Higher-cost VOC monitoring

Oregon DEQ uses GC-MS for VOC analysis at Portland air monitor sites. Air samples are gathered in a Summa canister and analyzed at the DEQ Lab. The DEQ Lab has agreed to allow us to colocate our VOC monitors at DEQ monitoring locations to measure the standard of deviation for ourselves.

The Aeroqual Series 900 Controller fitted with a Aeroqual VOC photoionization detector (PID) Sensor Head is a battery powered device that can be bike mounted to collect data for GIS mapping. This costs $1,825 for the device and an additional $850 and $39/year for the required wireless data logging kit, all from the GasSensing website. Aeroqual 900 PID uses high-energy photons to break a small percentage of VOC molecules in the sample into positively charged ions. The ions produce an electric current, measured and reported by the detector. This device takes a reading every ten minutes. Note that PID sensors can't measure formaldehyde, which requires a different Aeroqual sensor attachment. Aeroqual's accuracy is +/- 10% of the measured value obtained by a regulatory-grade instrument.

We worked with Eurofins, an EPA and Oregon-certified lab. Eurofins mailed us $800 Summa canisters and charged about $250 per sample for canister rental and analysis. Summa canisters are spherical, six-liter stainless steel containers about the size of a basketball and weigh about six pounds each. They have a nearly chemically inert interior surface manufactured for air sampling. Summa canister lab analysis can detect approximately 60 VOCs and their airborne concentrations.

VOC analysis with Easy-VOC is $840 for a kit from the Markes website, which includes the pump, 10 sample sorbent tubes, and other required hardware. The equipment is much easier to transport than Summa canisters. Easy-VOC analysis includes hundreds of VOCS, a much wider range than Summa canisters. The device looks like a large syringe and can easily fit in a backpack. However, we couldn't find a lab willing to analyze the sorbent tubes.

Two Summa canisters or Easy-VOC samples are best when bicycle mapping with a low-cost monitor – one near the source and one further away to determine which airborne VOCs are at the site and their accurate concentration gradients.

Another option for regulatory-grade accuracy, ideal for people living near oil refineries and tank farms, is an EPA 325 fenceline study. This study uses small sorbent tubes that are left at the sample site for 28 days and then analyzed at a lab. Each sample costs $75 to report the results for just one VOC, such as benzene. EPA 325 can be extended to additional VOCs of concern including 1,3-butadiene, toluene, ethylbenzene, xylenes, and other chemicals with known sampling rates. A single study may include as many as 20 to 30 sample sites. The cost for three rounds of 30 tubes totaling 90 samples in a three-month study, for a single VOC is about $7,000 through Beacon Labs in Maryland.

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