Improving Air Quality in Overburdened Communities Highly Impacted by Air Pollution

2023 Report

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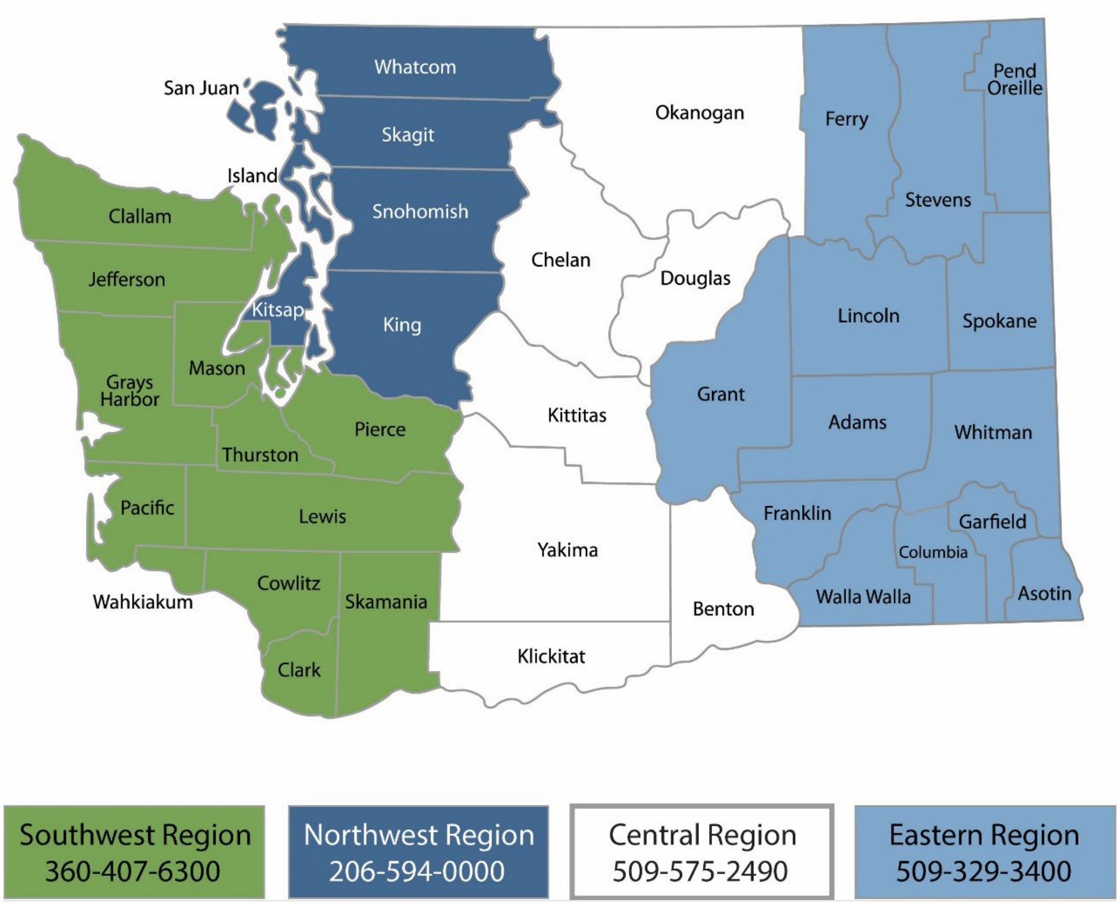
Map of Counties Served

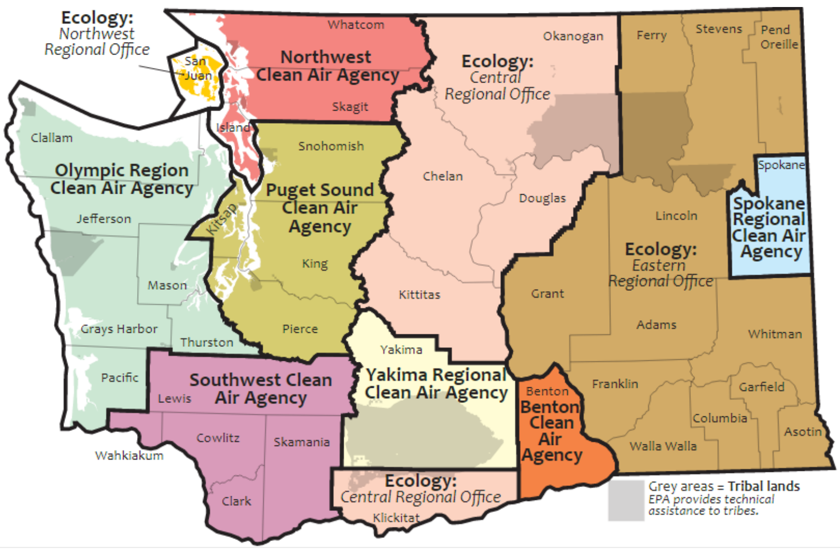


Region	Counties served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	P.O. Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	P.O. Box 330316 Shoreline, WA 98133	206-594-0000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 West Alder Street Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 North Monroe Spokane, WA 99205	509-329-3400
Headquarters	Statewide	P.O. Box 46700 Olympia, WA 98504	360-407-6000

Washington Local Clean Air Agencies

Ecology works in partnership with EPA, local clean air agencies, and Tribes in Washington to make sure we all have clean, healthy air to breathe.[1] Local clean air agencies manage most of the air quality regulation in Washington, within their respective jurisdictions. Tribal governments protect air quality within their Tribal reservations, with technical assistance from EPA. Ecology is the primary air regulator in all other areas.

Map of Counties Served



- **Benton Clean Air Agency** — Benton County
- **Ecology Central Regional Office** — Chelan, Douglas, Kittitas, Klickitat, Okanogan counties
- **Ecology Eastern Regional Office** — Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Stevens, Walla Walla, Whitman counties
- **Ecology Industrial Section** — Pulp mills, aluminum smelters
- **Ecology Northwest Regional Office** — San Juan County
- **EPA Region 10** — Tribal lands
- **Northwest Clean Air Agency** — Island, Skagit, Whatcom counties
- **Olympic Region Clean Air Agency** — Clallam, Grays Harbor, Jefferson, Mason, Pacific, Thurston counties
- **Puget Sound Clean Air Agency** — King, Kitsap, Pierce, Snohomish counties
- **Southwest Clean Air Agency** — Clark, Cowlitz, Lewis, Skamania, Wahkiakum counties
- **Spokane Regional Clean Air Agency** — Spokane County
- **Yakima Regional Clean Air Agency** — Yakima County

[1] https://ecology.wa.gov/About-us/Accountability-transparency/Partnerships-committees/Clean-air-agencies

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Climate and Health Section

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Glossary

Attainment/nonattainment – As established by EPA, if the air quality in a geographic area meets or is cleaner than the national standard, it is called an attainment area (designated “attainment/unclassifiable”); areas that don't meet the national standard are called nonattainment areas.

Biogenic carbon – natural sources and sinks of carbon in the ecosystem. Biogenic emissions may have anthropogenic drivers. For example, as anthropogenic carbon accumulates in the atmosphere, it increases warming, causing extreme heat and droughts, which in turn increases the risk of wildfires, consequently releasing more biogenic carbon into the atmosphere.

Criteria air pollutants – six pollutants that can be harmful to public health and the environment with National Ambient Air Quality Standards designated by the United States Environmental Protection Agency. The pollutants are particulate matter (PM), ground-level ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), lead (Pb), and sulfur dioxide (SO_2).

Design value – a statistic that describes the air quality status of a given monitor relative to the level of the National Ambient Air Quality Standards (NAAQS).

Environmental justice – (from RCW 70A.02.010(8)) the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, rules, and policies. Environmental justice includes addressing disproportionate environmental and health impacts in all laws, rules, and policies with environmental impacts by prioritizing vulnerable populations and overburdened communities, the equitable distribution of resources and benefits, and eliminating harm.

Ground-level ozone – Ozone is gas that is a harmful air pollutant at ground-level because of its effect on human health and the environment.

Ischemic heart disease – heart disease caused by narrowed coronary arteries, resulting in reduced blood supply to the heart. When blood flow to the heart is blocked completely, this results in a heart attack (myocardial infarction). Exposure to air pollution can contribute to the development of ischemic heart disease and increase the risk of cardiovascular events in people with heart ischemic heart disease.

Linguistic isolation – households in which no one age 14 and over speaks English "very well" or speaks English only.

Low income – the ratio of household income to federal poverty level in the past 12 months was less than 2.

Lung cancer – cancer that begins in the cells of the lungs. Exposure to air pollution may increase risk of mortality in people with lung cancer.

Mortality – death due to any cause.

National Ambient Air Quality Standard (NAAQS) – Established by the EPA under the authority of the Clean Air Act, NAAQS define the maximum amount of a pollutant averaged over a specified period of time that can be present in outdoor air without harming public and environmental health.

Non-biogenic (or anthropogenic) carbon – human caused carbon sources to the atmosphere.

Overburdened community – (From RCW 70A.65.010(54)) a geographic area where vulnerable populations face combined, multiple environmental harms and health impacts or risks due to exposure to environmental pollutants or contaminants through multiple pathways, which may result in significant disparate adverse health outcomes or effects.

Overburdened community highly impacted by air pollution – areas of the state where people who are vulnerable to health, social, and environmental inequities are also highly impacted by criteria air pollution.

Particulate matter (particle pollution) – small inhalable particles of solids or liquids (including dust dirt, soot, and smoke) in the air that can be inhaled and can cause harm to health. PM_{10} is all particulate matter less than 10 microns in diameter. $PM_{2.5}$ is all particulate matter less than 2.5 microns in diameter and is often referred to as fine particulate matter.

People of color – individuals who list their racial status as a race other than white alone and/or list their ethnicity as Hispanic or Latino. That is, all people other than non-Hispanic white-alone individuals.

Acronyms

AIAN – American Indian and Alaska Native
AQI – Air quality index
CAP – Criteria air pollutant
CCA – Climate Commitment Act
CH_4 – Methane
CO – Carbon monoxide
CO_2 – Carbon dioxide
CRF – Concentration response function
DNC – Data not collected
EPA – United States Environmental Protection Agency
GHG – Greenhouse gas
NAAQS – National ambient air quality standard
NHOPI – Native Hawaiian and Other Pacific Islander
N_2O – Nitrous oxide
NO_2 – Nitrogen dioxide
O_3 – Ozone
OFM – Office of Financial Management
Pb – Lead
PM – Particulate matter
SO_2 – Sulfur dioxide

Units of measurement:
ppb – parts per billion
ppm – parts per million
MT CO_2e – metric tons of carbon dioxide equivalent (using carbon dioxide equivalent as a measurement captures the cumulative impacts of all greenhouse gases in a single number)
$\mu g/m^3$ – micrograms per cubic meter

Executive Summary

Purpose

The Air Quality Program is working to improve air quality in Washington communities that are historically overburdened with health, social, and environmental inequities **and** are highly impacted by criteria air pollution, such as ozone and fine particles. A section of the Climate Commitment Act directs our work.

We identified 16 areas across the state as overburdened and highly impacted by air pollution as of March 1, 2023.[2] These places are a mix of numerous communities, neighborhoods, and towns, representing more than 1.2 million people or about 15.5% of Washington's population. This report is on the first review of our work in these communities, as required by the Climate Commitment Act:

> "Beginning in 2023, and every two years thereafter, the department [Ecology] must conduct a review to determine levels of criteria pollutants, as well as greenhouse gas emissions, in the overburdened communities identified under subsection (1) of this section. This review must also include an evaluation of initial and subsequent health impacts related to criteria pollution in overburdened communities. The department may conduct this evaluation jointly with the department of health." [RCW 70A.65.020(2)(a)][3]

The overall purpose of these biennial reports is to:

- Track and understand trends in air quality and greenhouse gas emissions in overburdened communities highly impacted by air pollution
- Check how we're doing in reducing differences in exposure to, and health impacts associated with, criteria air pollution
- Be open and clear, sharing important information with communities
- Help people make choices about their health and their community's health
- Support ideas for addressing ongoing challenges with air quality and climate change.

The purpose of this initial report is slightly different. Since it is the first report, it outlines and provides a baseline for what we already know about criteria air pollution, certain health impacts, and greenhouse gas emissions in overburdened communities highly impacted by air pollution in Washington. Tribal communities that are highly impacted by air pollution are not yet included in this report. We are consulting with Tribal governments and looking forward to adding Tribal communities in future reports.

[2] For more information on how these communities were identified, see our StoryMap: https://arcg.is/11CfOe0
[3] RCW 70A.65.020(2)(a)

Key Findings

We analyzed state data for each of the 16 communities identified as overburdened and highly impacted by air pollution, both separately and together. We have collected the findings into three categories: 1. air pollution, 2. health impacts, and 3. GHG emissions.

Air pollution

- Between 2020 and 2022, overburdened communities highly impacted by air pollution experienced an average of 7.5 days per year with air quality that were unhealthy for sensitive groups, or worse.
  - The statewide average for this period was 6.7 days.
  - Most of the unhealthy air quality days occurred during wildfire smoke events.
- Fine particles ($PM_{2.5}$) is the greatest pollutant of concern in all overburdened communities highly impacted by air pollution.
- Fine particles ($PM_{2.5}$) measured and experienced in communities varies from year to year, mainly depending on the frequency and magnitude of exposure to wildfire smoke.
- Without considering wildfire smoke, levels of fine particles ($PM_{2.5}$) are higher during the winter, mostly due to burning wood for home heating.
- Ground-level ozone in some communities can get close to unhealthy levels, especially during heat waves and droughts.
- Nitrogen dioxide levels are expected to meet national air quality standards.

Health impacts

- People in overburdened communities highly impacted by air pollution have more health problems, including lung and heart disease, compared to the average for the state.
- People in overburdened communities highly impacted by air pollution live 2.4 years less than people in the rest of the state, on average.
- Fine particles ($PM_{2.5}$) is the main criteria air pollutant that affects people's health, both in overburdened communities and across the state.
- Older adults in overburdened communities highly impacted by air pollution were twice as likely to die from illnesses linked to breathing fine particles ($PM_{2.5}$) from human-caused sources than the statewide average.
- Older adult people of color have a higher risk of death from breathing fine particles ($PM_{2.5}$) compared to older white adults in the same area.
- Health impacts from fine particles ($PM_{2.5}$) measurably differ across overburdened communities.
- Data only tell part of the story. Additional approaches are needed for future reports to understand different ways air pollution impacts the health and wellbeing of individuals, families, and the community.

Greenhouse gas emissions

- In Washington, the main sources of greenhouse gas emissions in overburdened communities are often different than the main sources of criteria air pollutants of most concern (fine particles and ozone) statewide.
- As of 2021, 49 facilities that are required to report greenhouse gas emissions are in or near overburdened communities highly impacted by air pollution. Of those facilities, 22 (almost 45 percent) are now participating in Washington's cap-and-invest program, which requires them to acquire allowances to emit greenhouse gases or reduce their emissions.
- Washington's cap-and-invest program started on January 1, 2023. Because available data is from earlier years, it is too early to determine its impact on reducing greenhouse gas emissions and criteria air pollutants in overburdened communities.

Next steps

After this report, we plan to:

- Continue our outreach and engagement with each of the 16 identified overburdened communities highly impacted by air pollution.
- Continue expanding the state's air monitoring network in these communities to obtain more detailed data about their air quality.
- Work with Tribal governments that are interested in participating in this initiative.
- Work with partners in clean air agencies, universities, environmental justice organizations, and communities, as well as interested Tribes, to build our approach and methods, and to analyze and review trends.
- Find new ways to understand:
    - How more than one criteria air pollutant can pile up and affect human health
    - How air pollution affects people beyond what current data and methods show.

Introduction

Reviewing and Improving Air Quality in Overburdened Communities

This report is part of a larger initiative to improve air quality in Washington communities that are overburdened and highly impacted by air pollution. While the Climate Commitment Act[4] (CCA) largely focuses on reducing greenhouse gas emissions, it also requires Ecology to reduce another category of air pollution, called criteria air pollutants.[5] This law requires us to accomplish several tasks over time, outlined in Table 1 below.

Table 1. Improving air quality in overburdened communities highly impacted by air pollution: requirements and progress

Task	Status
Identify which Washington communities are overburdened and highly impacted by air pollution.	Complete (see Figure 1), except for communities on Tribal land
Analyze and identify significant sources of criteria air pollution in overburdened communities highly impacted by air pollution.	High level information in this report, with further analysis to come
Engage with communities and expand Washington's air quality monitoring network to gather more data about the criteria air pollutants that affect them.	Ongoing
Develop strategies to reduce criteria air pollutants in each community.	Ongoing
Conduct periodic analyses to make sure reduction goals for criteria air pollution are being met.	First biennial review complete; next report due 2025
Establish air quality targets to protect human health.	Not started

Over an 18-month period, Ecology conducted an analysis of air quality, socioeconomic, and health disparity data of communities in Washington, with extensive public outreach. On March 1, 2023, we identified 16 areas across Washington that are overburdened and highly impacted by criteria air pollution (Figure 1). These are areas of the state where people who are vulnerable to health and environmental inequities are also highly impacted by criteria air pollution.

We have begun work to better understand and improve air quality in these 16 areas, starting by expanding air monitoring and engaging with community leaders. Efforts to reduce air pollution in and with these communities will continue over many years. We are also conducting reviews,

[4] Engrossed second substitute senate bill 5126, chapter 316, laws of 2021

[5] https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-quality-standards#criteria

beginning with this report, to track progress and understand more about pollution and its impacts in and with these communities and other communities identified as overburdened by criteria air pollutants over time. The data reported here is also intended to ensure that our efforts and the shift to decarbonize Washington's economy do not result in unintended increases of air pollution in already overburdened communities.

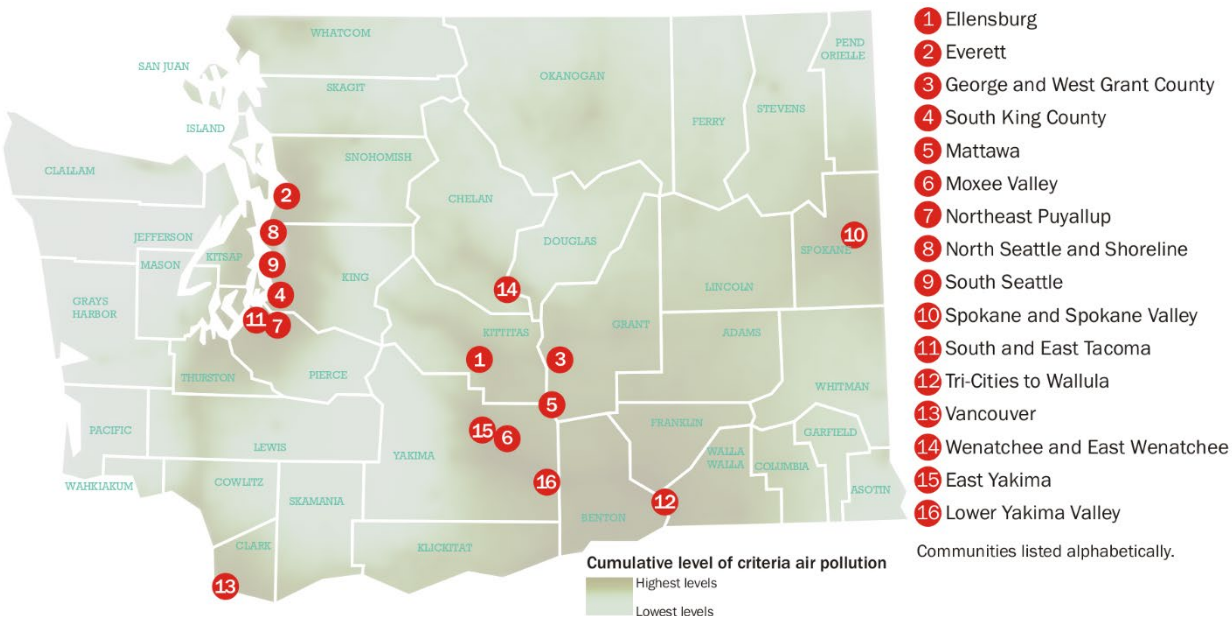

Figure 1. Statewide map of Overburdened Communities Highly Impacted by Air Pollution

Contributing to environmental justice through measurable reduction of criteria air pollution in the 16 communities identified is a central goal of this initiative. By reaching out to, and working with, community-based and serving leaders across Washington, and by utilizing the Washington Environmental Justice Council's Community Engagement Values and Guidance[6] and related resources, we are taking steps to humbly and respectfully work with those on the frontlines of addressing environmental injustice. We intend to continuously incorporate community guidance, lessons learned, and to grow this work alongside related priorities, such as the implementation of the Healthy Environment for All (HEAL) Act, to reduce disparities over time.

Criteria air pollution & health impacts

Criteria air pollutants (CAPs) are six common air pollutants that EPA has designated as causing harm to people's health and the environment. The federal Clean Air Act requires EPA to set National Ambient Air Quality Standards (NAAQS; Appendix A) for criteria air pollutants.[7]

[6] https://waportal.org/sites/default/files/team-exchanges/2023-12/2023.08.25%20ADOPTED%20Community%20Engagement%20Guidance.pdf
[7] https://www.epa.gov/criteria-air-pollutants

Ecology, local clean air agencies, and Tribes monitor these pollutants across Washington and take action to control and reduce pollution. These six criteria air pollutants are:

- Particulate matter:
    - Fine particulate matter ($PM_{2.5}$)
    - Inhalable particulate matter (PM_{10})
- Ozone (O_3)
- Nitrogen dioxide (NO_2)
- Sulfur dioxide (SO_2)
- Carbon monoxide (CO)
- Lead (Pb)

Below is a description of the major source categories, potential health effects, and the general status of each criteria air pollutant in Washington.

Particulate matter

Particulate matter (PM), also called particle pollution, is a mixture of tiny solids or liquid droplets that includes smoke, soot, dirt, and dust floating in the air. These particles come in many shapes and sizes. They can be made up of hundreds of different chemicals.

PM is usually broken into two categories:

- Fine particulate matter ($PM_{2.5}$): consists of inhalable particles that are 2.5 micrometers or smaller in diameter, including combustion particles, organic compounds, metals, etc.
- Inhalable particulate matter (PM_{10}): consists of inhalable particles that are 10 micrometers or smaller in diameter, including dust, pollen, mold, etc., together with $PM_{2.5}$.

Airborne particles can be inhaled and cause serious health problems. Smaller particles, particularly those less than 2.5 micrometers, penetrate deeper into the lungs than larger particles and some may even enter the bloodstream. Most of the health impacts across Washington from criteria air pollution are associated with exposure to $PM_{2.5}$. Almost all communities that were identified as highly impacted by air pollution were identified based on estimated or measured levels of $PM_{2.5}$. Also, while the 24-hour $PM_{2.5}$ NAAQS is a design value of 35 micrograms per cubic meter

THE RISING IMPACT OF WILDFIRES

Wildfire smoke is a major threat to human health. Smoke from wildfires is currently the largest source of particle pollution in Washington. It is also a significant source of other types of air pollution. Smoke can travel long distances both within the state and from fires in neighboring states or Canada. The frequency of wildfire smoke events in the state has been rising. As forestlands get hotter and drier from climate change, wildfire risk will continue to rise.

Wildfire smoke information resources:

- Tracking wildfire smoke[7]

(µg/m^3), Ecology has a healthy air goal (used to identify areas of concern for $PM_{2.5}$[8]) of 20 µg/m^3.

As of December 31, 2023, there are 83 $PM_{2.5}$ monitors and 7 PM_{10} monitors operated by Ecology and our partners in Washington. This number will continue to expand greatly, particularly due to the proliferation of low-cost sensors. This will increase the amount of information about particulate pollution, especially in overburdened communities highly impacted by air pollution.

Wildfire is the dominant source of $PM_{2.5}$ emissions in the state. The 2020 state air emissions inventory reported that 39% of $PM_{2.5}$ emissions in the state were from wildfire. Wildfire smoke is also transported over long distances, including over state and national borders, which is not reflected in the statewide emissions inventory. Wildfire smoke exposure is usually limited to the summer and fall.[9] The next major source of $PM_{2.5}$ across the state is residential woodsmoke for home heating (15%). These emissions are primarily during the colder months, usually October-March. Other significant sources of $PM_{2.5}$ and PM_{10} include dust from agriculture and construction, outdoor burning (agricultural, residential, or prescribed), commercial cooking, and industrial facilities.[10]

Ozone

The second most significant criteria pollutant of concern in Washington is ground-level ozone (O_3). Unlike stratospheric ozone, which protects us from radiation from the sun, ground-level ozone is harmful because it can trigger a variety of health problems when inhaled. Ozone forms in the atmosphere on hot summer days when two forms of air pollution – nitrogen oxides (NO_x) and volatile organic compounds (VOCs) – react with sunlight. NO_x and VOCs come from many sources, including vehicles, industry, and even natural sources like plants. The highest concentrations of ozone are often downwind of urban areas and occur in the summer when

[8] https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-quality-standards/Particle-pollution

[9] Wildfire smoke information resources: https://ecology.wa.gov/air-climate/responding-to-climate-change/wildfire-risks

[10] For more information on sources, see the Air Emissions Inventory webpage: https://ecology.wa.gov/air-climate/air-quality/air-quality-targets/air-emissions-inventory

sunlight is stronger. In Washington, the "ozone season" designated by the EPA is from May-September, when ozone concentrations are highest. The concentration of ground-level ozone is often higher in the Western U.S. compared to other regions due to wildfires and ozone transported over long distances from out of state.[11]

Currently, there are 13 O_3 monitors operated by Ecology and our partners in Washington. Ozone monitoring is conducted year-round at three monitoring sites, and during ozone season only (May-September) at the remaining 10 sites. We expect that more will be added following community engagement on monitoring next year.

Nitrogen dioxide

Nitrogen dioxide (NO_2) is harmful to the lungs. It can worsen asthma symptoms and long-term exposure may also cause asthma to develop in children. It is primarily produced from the combustion of fossil fuels. In Washington, motor vehicles (37%) and major point sources (16%; e.g., power plants, paper mills, and oil refineries) are the dominant sources of NO_x. Other significant sources include ships, locomotives, and residential fuel use (e.g., natural gas).[10] Generally, ambient NO_2 concentrations are far lower than the NAAQS in Washington, even at the sites located next to high-traffic areas of Interstate 5 in Seattle and Tacoma. Although

[11] https://www.jpl.nasa.gov/news/nasa-background-ozone-a-major-issue-in-us-west

current NO_2 levels in Washington meet the NAAQS, we are still concerned about emissions of nitrogen oxides (NO_x) because these pollutants contribute to other pollution problems, including ozone and fine particles. Ecology and our partners currently monitor NO_2 in four locations, including in Seattle and Tacoma, representing urban and near-road conditions where we have determined NO_2 to be highest.

Sulfur dioxide

Sulfur dioxide (SO_2) is a pollutant that irritates the respiratory system and causes inflammation of the airways. Sensitive populations like children, older adults, and people with asthma are at increased risk of health effects from SO_2 exposure. Sulfur-containing compounds can also contribute to the formation of particle pollution. The major sources of SO_2 in Washington are industrial facilities like paper mills, power plants, and oil refineries.[10] Improved air pollution controls and facility closures have resulted in dramatic decreases in SO_2 in recent decades. Commercial ships are also now required to use ultra-low sulfur fuels and are no longer a significant source of SO_2. In 2020, a small portion of Whatcom County was designated as a “nonattainment area,” or not meeting the 1-hour SO_2 federal standard. This was due to an aluminum smelter that had insufficient controls. The aluminum smelter stopped operating in 2020 and is now permanently shut down. SO_2 in the area has since returned to healthy levels and the air quality index for SO_2 in the area is consistently good. Ecology and our partners currently operate five SO_2 monitoring sites, including around the now-closed smelter, as well as near other industrial and urban areas in the state.

Carbon monoxide

Exposure to carbon monoxide (CO) interferes with the blood's capacity to carry oxygen. People with existing heart problems may be more at risk of carbon monoxide's effects. The greatest sources of CO to outdoor air are cars, trucks, and other vehicles or machinery that burn fossil fuels. Thanks to cleaner cars, Washington's CO levels have decreased significantly over the last several decades. Today, CO levels in Washington remain much lower than the NAAQS. Ecology and our partners still monitor CO in three locations in Seattle, representing urban and near-road conditions where it is likely to be highest.

Lead

There is no known safe level of exposure to lead. Children are most at risk and even low levels can damage children's nervous systems. Lead emission levels in Washington decreased dramatically when leaded gasoline was phased out in the 1970s and decreased further as several large smelters ceased operation. Today, the largest source of lead in the air is from leaded aviation fuel used in small aircraft. Ecology conducted a 2012 lead study at two small airports selected because of higher lead emissions.[12] The study showed lead levels were less than 50% of the NAAQS for lead. In 2020, EPA released its study of lead concentrations from small aircrafts and found that lead levels dissipate quickly from aircraft exhaust and were uniformly below the standard within 50 meters of the runway.[13] However, they are concerned about the aggregate exposure from all sources of lead. The Federal Aviation Administration is working to eliminate lead in aviation fuel by 2030.[14] Lead levels throughout Washington meet current NAAQS. Ecology continues to collect lead emissions data and monitor and study lead air pollution at Beacon Hill in Seattle.

[12] https://apps.ecology.wa.gov/publications/SummaryPages/1302040.html
[13] https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100YG46.pdf
[14] https://www.faa.gov/unleaded

Meteorology and topography

Meteorology (climate and weather) and topography (physical features and surfaces) are natural factors that play an outsized role in the formation and distribution of air pollution across an area. Two different areas with similar pollution emissions can experience vastly different concentrations of pollutants depending on these factors. For example, air pollution concentrations are likely to be consistently higher in a valley with stagnant air than on a windy coast, regardless of emissions.

There are currently 15 meteorological monitoring sites in Ecology’s network, measuring wind speed, wind direction, and temperature. Select sites also measure ambient pressure, relative humidity, precipitation, and mixing height. This meteorological data helps us to understand the physical and chemical processes of air pollutants in the atmosphere. The physical processes mainly involve the transport and dispersion of air pollutants and pollution precursors. While the chemical processes involve the formation and modification of air pollutants and their precursors. These data are also used in permitting and planning applications.

Cumulative criteria air pollution

Under the federal Clean Air Act, criteria air pollutants are regulated individually. There is currently no standard method to account for the cumulative level and impacts of criteria air pollution. However, we developed and included a measure of cumulative criteria air pollution to identify communities highly impacted by air pollution in response to concerns about the impact of lower levels of multiple pollutants on communities. Many communities were identified as highly impacted by air pollution based on having the highest estimated cumulative levels of criteria air pollution in the state. While all pollutants for which we have statewide monitoring/modeling data (CO, NO_2, O_3, $PM_{2.5}$, SO_2) were included in this measure, it was primarily driven by three main criteria air pollutants: $PM_{2.5}$, O_3, and NO_2. CO and SO_2 generally have a lower potential health impact in Washington communities. Measuring cumulative impacts from multiple pollutants and sources is an ongoing area of scientific inquiry. We will continue to learn and grow our methods to account for cumulative impacts and how they fit into the larger picture of reducing disparities from pollution exposure, vulnerability, and health impacts.

Health impact

Air pollution is one of the greatest environmental risks to health. Both short- and long-term pollution exposure to air pollution can contribute to a wide range of diseases and health outcomes. Health impacts associated with each individual criteria air pollutant are described above. Some health outcomes, like asthma, are more easily linked to pollution, whereas others, like impacts on mental health and quality of life, are more difficult to measure and quantify. See EPA's Eco-Health Relationship Browser for more information about the many ways in which air quality can impact health (Figure 2).

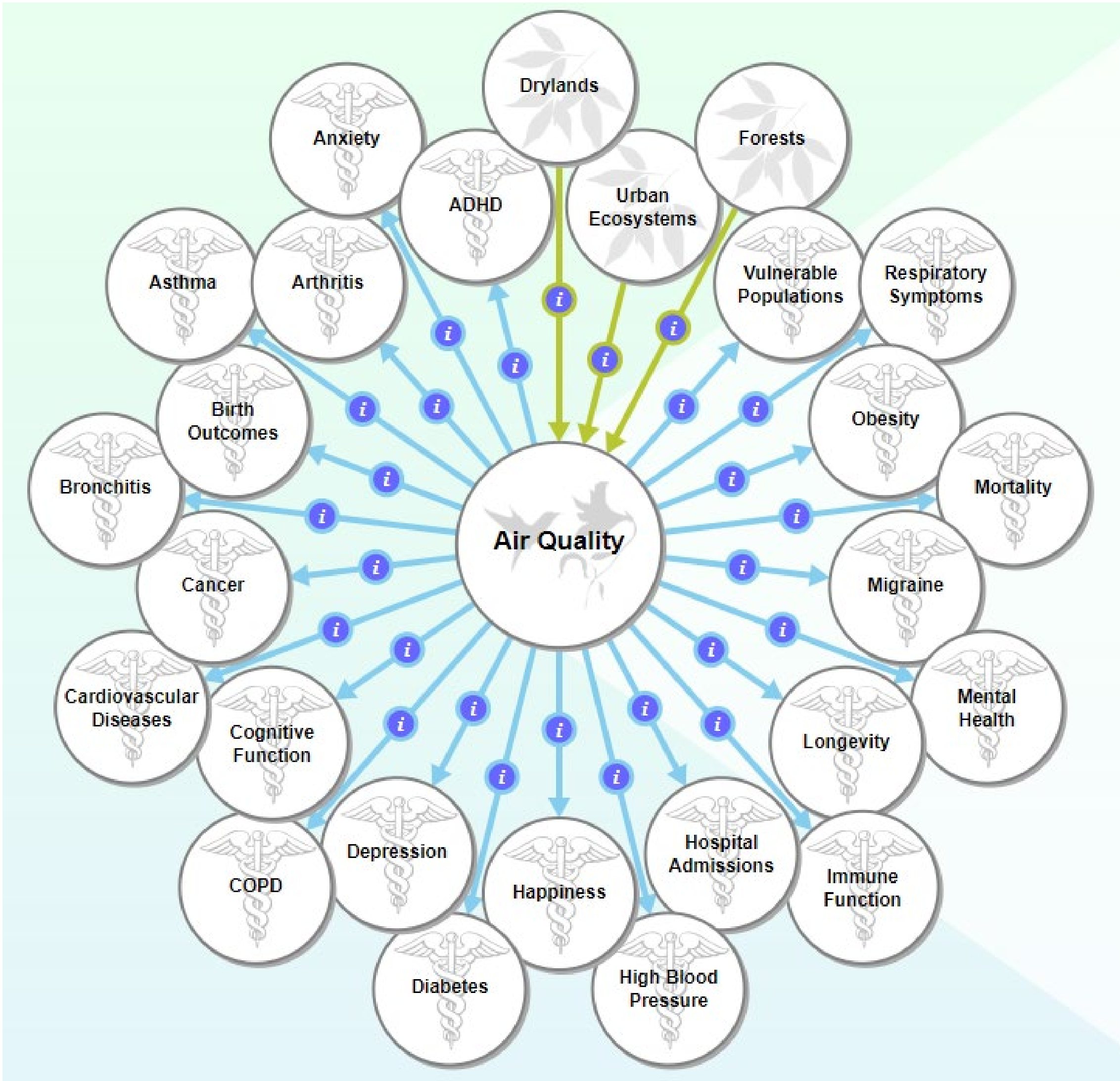

Figure 2. Linkages between air quality and health outcomes (blue arrows) and ecosystems (green arrows). Source: EPA Eco-Health Relationship Browser[15]

Air pollution is just one risk factor of many that contribute to disparate health outcomes. It can be difficult to quantify air pollution risk compared to other factors like genetics, smoking, access to healthcare, or exposure to other types of pollution. University of Washington's Institute for Health Metrics and Evaluation conducted a Global Burden of Disease study where they synthesized hundreds of thousands of data sources to estimate mortality, health outcomes and risks for different geographies.[16] Some 2019 estimates for the health impacts of air pollution[17] in Washington include:

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[15] enviroatlas.epa.gov/enviroatlas/Tools/EcoHealth_RelationshipBrowser/index.html#airquality
[16] https://www.healthdata.org/research-analysis/gbd
[17] In this study, air pollution includes ambient $PM_{2.5}$, ambient O_3, and household air pollution from solid fuels.

- Air pollution was the 12th (out of 20) highest risk factor for death.
    - This is lower than factors like smoking (1st) or occupational risks (11th), and higher than factors like low physical activity (14th) or unsafe water and sanitation (19th).
- An estimated 728 (1.3%) deaths were attributable to air pollution in Washington in 2019.
- There was an estimated 13,316 (1.2%) years of life lost from air pollution in Washington in 2019.
- An estimated 3.5% of disability-adjusted life years (DALYs)[18] and 5.6% of deaths from chronic respiratory diseases in Washington were attributable to air pollution in 2019.

Sensitive groups and vulnerable populations with increased risk

Exposure to criteria air pollutants does not impact everyone equally. Certain groups in Washington are at higher risk of experiencing negative health impacts. This includes people with respiratory or cardiovascular conditions, children, older adults, and pregnant people, as well as populations more vulnerable to impacts due to institutional and structural racism and systems of power and oppression. This includes people of color, Tribal and Indigenous people, people with low socioeconomic status, and outdoor workers. Many individuals and communities fall into multiple groups, increasing risk even further due to the intersectional compounding impacts of air pollution. Communities with more people in these groups may experience higher rates of health impacts from air pollutants.

People with respiratory or cardiovascular conditions: Many people in Washington live with chronic respiratory or chronic conditions and are at greater risk of negative health impacts from exposure to air pollution. Exposure to $PM_{2.5}$ and ozone in particular lead to systemic inflammation and other impacts in the body that can worsen symptoms, lead to an increase in medication use, or more frequent visits to the emergency room or hospital for this group.

Children: Children have developing lungs and breathe in more air for their body weight compared to adults, putting them at higher risk of negative health impacts from air pollution. Long-term exposure to $PM_{2.5}$ has been linked with reduced-lung growth and function, and long-term exposure to ozone has been linked with the development and exacerbation of asthma in children.

Older adults: Older adults naturally experience diminished lung function as they age and are more likely to have chronic conditions compared to the general population. These risk factors together make older adults more susceptible to negative impacts from air pollution. Indeed, most premature deaths due to air pollution are among older adults.

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[18] Disability-adjusted life years (DALYs) is an epidemiological method to measure the overall burden of a health condition by considering both its impact on the length and quality of life.

Pregnant people: Pregnant people experience many physical changes throughout pregnancy, making them and the fetus more susceptible to negative impacts from air pollution. Additionally, exposure to ozone and fine particulate matter is associated with premature birth and lower birth weight.

People of color: Due to the long history of racist legislation and policies in the U.S., including redlining and siting of roads and waste sites, communities of color are more likely to be closer to sources of air pollution, and thus are often exposed to high levels of pollutants. Additionally, the impact of living in a racist society increases the stress on the body, often leading to higher rates of chronic conditions and thus higher susceptibility to the negative impacts of air pollution.

Tribal and Indigenous people: Tribal and Indigenous people in Washington have been disproportionately impacted by air pollution due to the long history of settler-colonialism. Ongoing colonialism and displacement of Tribal and Indigenous people from traditional homelands often means that Tribes are denied access to environmental assets, including culturally relevant foods, compounding environmental disparities. One study found the declines in $PM_{2.5}$ in Tribal and Indigenous communities have been slower than in other communities in the United States.[19] Also, outdoor cultural activities such as food harvesting may coincide with high air pollution levels and time frames. The burden of chronic conditions is generally higher in Tribal and Indigenous communities, due to a wide range of long-standing harmful societal, political, and environmental factors, increasing overall susceptibility to the negative impacts of air pollution.

People with low income: People with low income in Washington are more likely to live in areas with higher levels of air pollution due to historical redlining and current siting of roads and waste sites near low-income and communities of color, for example, making them more vulnerable to the negative impacts of exposure to air pollutants. They also are more likely to experience homelessness and are less able to afford measures to mitigate exposure to air pollution, such as installing high-quality air filtration systems or leaving town during unhealthy air pollution events.

Outdoor workers: Persons who work outside (e.g., farm workers, construction workers, etc.) are exposed to air pollution during their working hours and are thus exposed to air pollution for longer periods than the general population. The main pollutants of concern for this population in Washington are fine particulate matter and ozone, though additional pollutants may be of concern depending on the nature and location of the work.

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[19] Air Pollution in American Indian Versus Non–American Indian Communities, 2000–2018 | AJPH | Vol. 112 Issue 4 (aphapublications.org)

Additionally, everyone, not just those in sensitive groups, may experience minor impacts from exposure to air pollutants.

Greenhouse gas emissions

The Climate Commitment Act largely focuses on reducing greenhouse gas (GHG) emissions throughout the state. Because the Cap-and-Invest program is statewide and does not have source-specific or community-specific emission limits, RCW 70A.65.020 is needed to ensure pollutant reductions are occurring in overburdened communities highly impacted by air pollution. Criteria air pollutant reductions may or may not be linked to greenhouse gas reductions. We identified where people were highly impacted by criteria air pollution based on several factors.[20] GHG information was not required for the identification of overburdened communities, however, we are required to determine GHG emissions in these communities every two years.

Ecology is responsible for tracking statewide GHG emissions, as both a historical record of Washington's contribution to climate change and to measure our progress towards meeting our GHG emission limits (Table 2).[21]

Table 2. Washington greenhouse gas emission limits, set by legislation in 2020

Year	Greenhouse Gas Emission Limits
2020	Reduce to 1990 levels of 93.3 million metric tons of carbon dioxide equivalent
2030	45% below 1990 levels
2040	70% below 1990 levels
2050	95% below 1990 levels and achieve net zero emissions

Ecology publishes the Washington Statewide GHG emissions inventory every two years. The most recent statewide data is from 2019 (see Figure 3), with GHG emissions totaling 102.1 million metric tons of carbon dioxide equivalent (MMT CO_2e). While GHG emissions are reported statewide, there are currently no reporting requirements for smaller geographies, such as counties or cities. Some local governments produce their own GHG inventories.

[20] Improving air quality in overburdened communities https://ecology.wa.gov/Air-Climate/Climate-Commitment-Act/Overburdened-communities

[21] Washington's greenhouse gas inventory https://ecology.wa.gov/air-climate/reducing-greenhouse-gas-emissions/tracking-greenhouse-gases/ghg-inventories

Washington requires state agencies and applicable[22] facilities, fuel suppliers, and electric power entities that produce over 10,000 metric tons of carbon dioxide equivalent (MT CO_2e) per year to annually report their GHG emissions to Ecology's Greenhouse Gas Reporting Program. This program allows us to track emissions and reduction progress from businesses covered under the CCA over time. Businesses are required to report their GHG emissions until they emit less than 10,000 MT CO_2e per year for five consecutive years, as required by WAC 173-441-030(6).

The CCA builds upon the existing GHG reporting framework, but also has its own specific reporting requirements. With some exceptions, a business is covered by the CCA if it emits more than 25,000 MT CO_2e annually. [23] Businesses have a compliance obligation to report their GHG emissions for a full compliance period of four years, even if they report below 25,000 MT CO_2e in a calendar year.[24]

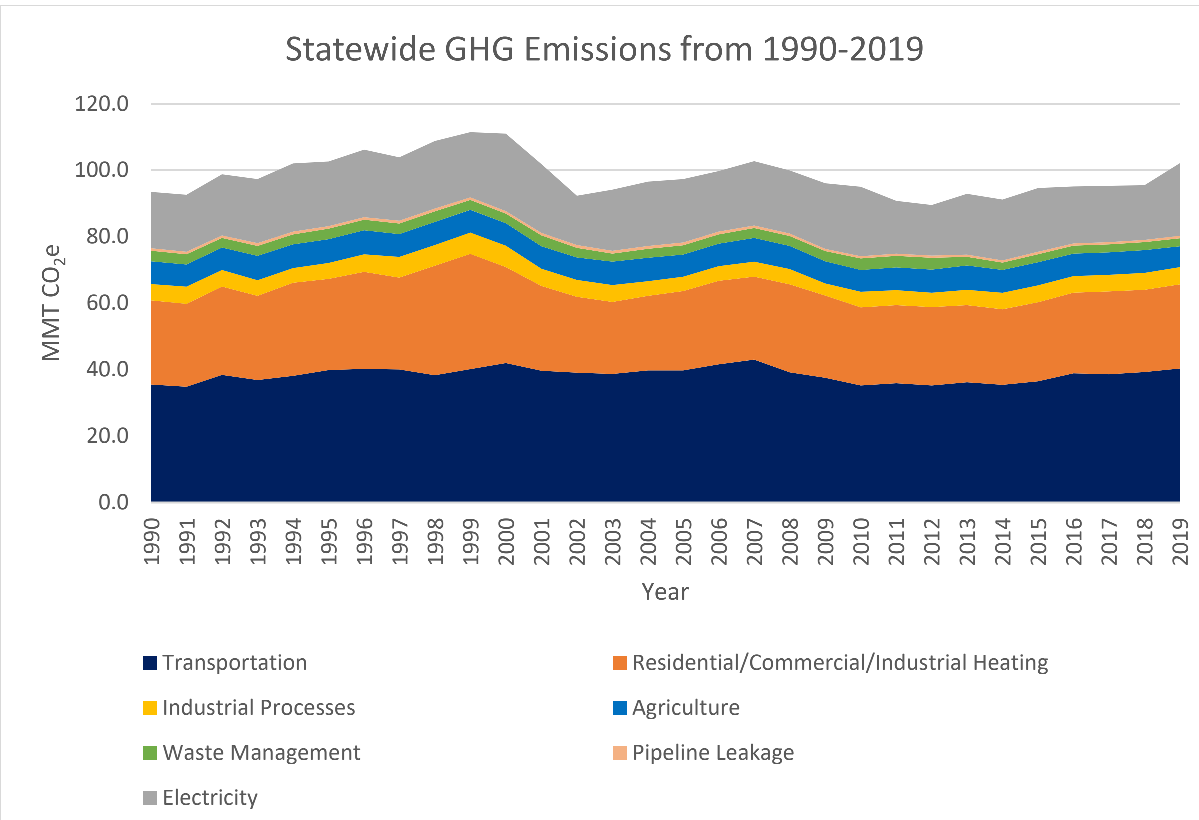

Figure 3. Washington's total greenhouse gas emissions by inventory sector from 1990-2019 in millions of metric tons (MMT) of carbon dioxide equivalent (CO_2e)

[22] GHG reporting applicability, WAC 173-441-030 https://app.leg.wa.gov/WAC/default.aspx?cite=173-441-030
[23] Washington State Cap-and-Invest Program https://ecology.wa.gov/Air-Climate/Climate-Commitment-Act/Cap-and-invest
[24] Climate Commitment Act Program Rule, exiting the program WAC 173-446-070 https://app.leg.wa.gov/WAC/default.aspx?cite=173-446-070

In 2019, Washington's Statewide GHG Emissions Inventory Report[25] showed that the three highest emitting sectors were transportation,[26] residential/commercial/industrial heating (RCI),[27] and electricity.[28] For this report, we considered GHG sources by sector such as transportation, industry, and electric power. We refer to transportation as "mobile sources" (on-road and non-road) and industry and electric power as "facility emissions" from stationary industrial processes, natural gas transmission systems, and electricity generation.[29] Focusing on these sectors is in part due to already having a GHG reporting program and a way to estimate mobile source emissions.

Currently, there is not enough disaggregated data to capture GHGs from all emission sources within the identified overburdened communities.

Greenhouse gas reductions and co-benefits for reducing criteria air pollution

Criteria air pollutants and greenhouse gases are both considered types of air pollution. Unlike criteria air pollutants, greenhouse gases are not directly harmful to health, but their climate impacts (heatwaves, droughts, floods, wildfires, etc.) are.[30] Exposures to criteria air pollutants and adverse climate impacts can harm people in overburdened communities more severely relative to other communities.

Criteria air pollutants like particulate matter (PM), sulfur dioxide (SO_2) and nitrogen oxides (NO_x) are often considered co-pollutants with greenhouses gases, particularly from sources like fossil fuel combustion. These sources are often concentrated in overburdened communities because of environmental racism. For example, the development of highway systems and zoning decisions for industrial areas that were made in communities of color. However, the primary sources of each individual greenhouse gas[31] (CO_2, CH_4, N_2O, etc.) and criteria air pollutant (CO, NO_2, PM, etc.) sometimes differ.

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[25] Washington State Greenhouse Gas Emissions Inventory Report: 1990-2019 https://apps.ecology.wa.gov/publications/documents/2202054.pdf

[26] Transportation includes on-road combustion of gasoline, diesel, and non-road use of both. Non-road emissions are from fuels (primarily diesel) consumed by aviation, boats and ships, trains, agricultural and construction equipment.

[27] Residential/Commercial/Industrial (RCI) emissions are only from on-site fuel combustion for heating/energy use. The electricity consumed by these sectors is counted separately in the electricity sector.

[28] Electricity includes in-state generation and consumption-based emissions.

[29] For this report, "mobile sources" includes cars, trucks, motorcycles, buses, locomotives, aviation, ships, etc. "Facility emissions" include industrial on-site fuel combustion for heating/energy use, WA State electricity generation, compressor stations for natural gas transmission systems, and other facilities that report to the WA GHG reporting program. Facility sectors include chemicals, food production, livestock, manufacturing, metals, minerals, natural gas systems, refineries, power plants, pulp and paper, landfills, etc.

[30] EPA Report on the Environment https://www.epa.gov/report-environment/greenhouse-gases

[31] Reducing greenhouse gas emissions https://ecology.wa.gov/air-climate/reducing-greenhouse-gas-emissions/tracking-greenhouse-gases

As GHG emissions are intended to be reduced through laws and policy efforts like Cap-and-Invest and others,[32] *where* those greenhouse gas emissions and co-pollutants are reduced depends on how and where these policies are implemented. For example, vehicle electrification generally reduces both CO_2 emissions and co-pollutants like NO_2 and particulates whereas technologies that rely on biomass energy reduce overall CO_2 but can produce localized increases in co-pollutants like particulates. One study on U.S. climate policy also found that, while GHG emissions reduction is expected to reduce total air pollution, using cost and income as criteria for emissions reduction can exacerbate pollution disparities for communities of color.[33]

Burning fossil fuels emits both greenhouse gases and criteria air pollutants, and measures to reduce greenhouse gases will likely have co-benefits for reducing criteria air pollutants. Future biennial reports will include an analysis of changes in both GHG emissions and criteria air pollutant levels in overburdened communities highly impacted by air pollution, and if disparities in both are reduced over time.

Methods

Level of criteria air pollutants

Monitoring

Ecology, EPA, Tribes, and local clean air agencies maintain a network of air monitoring stations to measure criteria air pollution and meteorology in Washington (Figure 4). The monitoring network supports many goals, including informing the public about current air quality conditions, supporting compliance with federal air quality standards and development of pollution control strategies, and supporting air quality research. As of December 2023, there were 85 monitoring sites in the network. Most of these sites capture neighborhood-scale pollution concentrations where people live, work, and play. Other sites capture regional transport of pollution or impacts of specific pollution sources. A few sites capture background concentrations in remote areas. Together, these sites provide a comprehensive picture of air quality across the state. We are expanding our monitoring network in overburdened communities highly impacted by air pollution to get more granular information in these areas. The expanded monitoring network will provide critical data needed to conduct future reviews.

[32] Zero-emission vehicles (ZEV) law, Clean Fuel Standard, Clean Energy Transformation Act, Hydrofluorocarbons Emissions Reduction

[33] Polonik, P., Ricke, K., Reese, S., & Burney, J. (2023). Air quality equity in US climate policy. *Proceedings of the National Academy of Sciences*, *120*(26), e2217124120.

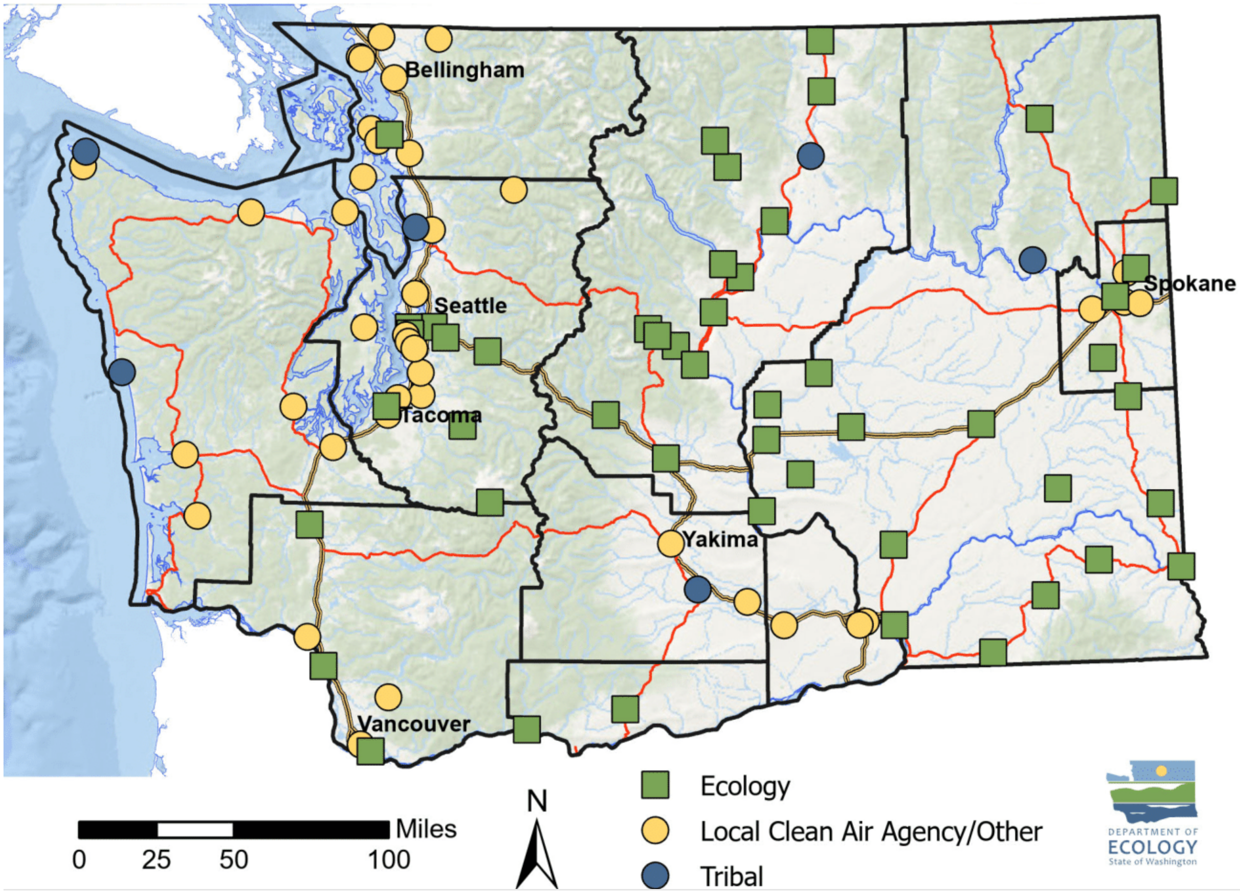

Figure 4. Map of ambient air monitoring sites across Washington. Sites are color-coded by which agency or jurisdiction owns and operates the monitoring site.

Current air monitoring data is available on our online map.[34] Monitoring data can also be summarized in several ways, described below, to track trends in air quality over time.

Summary statistics

Each criteria air pollutant has one or more NAAQS set by EPA to protect public health and the environment (Appendix A). Pollutant monitoring data are summarized in a statistic called a "design value," which describes the air quality status of a given location relative to the NAAQS.

For each monitoring site in or nearby to an overburdened community highly impacted by air pollution, the following statistics are reported, as available:

All monitored criteria air pollutants:

- 3-year 2022 design values (covering 2020-2022)
- Annual components of design value calculations for 2020-2022

[34] https://enviwa.ecology.wa.gov/home/map

Particulate matter:

- Summary statistics with wildfire days >35.4 µg/m^3 removed
- Seasonal means:
    - Cold season (October-March) – also considered the home heating season because this is when people most need to heat their homes, often by burning wood.
    - Warm season (April-September) – this includes the period when wildfires are most likely to occur (these dates are adjusted for years when wildfires occurred later than September 30).

Ozone:

- Ozone season (May-September) mean

Note that summary statistics presented here are the shorter averaging time only (1-24 hours). Summary statistics and design values that exceed their corresponding NAAQS are marked in a red-shaded box. We also included the summary statistics for $PM_{2.5}$ with wildfire days removed to demonstrate the relative impact of wildfire on $PM_{2.5}$ levels. Additional monitoring information is provided for particulate matter and ozone. Both pollutants tend to vary seasonally, more so than other pollutants.

The only exceptions are for the Mattawa and George and West Grant County communities, both of which had $PM_{2.5}$ sensors installed in 2023. For those two communities, monitoring results from the time of installation to October 31, 2023, are included.

Number of days with unhealthy air quality

EPA establishes an air quality index (AQI) for five of the criteria air pollutants regulated by the Clean Air Act (Table 3). The AQI is divided into six categories. Each category corresponds to a different level of health concern. Each category also has a specific color. The color makes it easy for people to quickly determine whether air quality is reaching unhealthy levels in their communities.

Each community with existing air monitoring has a calendar plot showing the air quality index for each day from 2020-2022 (or 2023 for Mattawa and George and West Grant County). If there are multiple monitoring sites in or near the community, the site and pollutant with the highest AQI for each day was selected.

The number of days with recorded air pollution in the AQI category “Unhealthy for Sensitive Groups” or higher in each community was summarized in Table 5 and in bar plots in Appendix B. Table 5 below provides a summary of criteria air pollution in the 16 identified overburdened communities already shown to be places where there are a greater proportion of demographic groups shown to be vulnerable to air pollution (Table 4 above).

Table 3. Air Quality Index (AQI) for criteria air pollutants

Air Quality Index Level	24-hour $PM_{2.5}$ concentration	24-hour PM_{10} concentration	8-hour Ozone concentration	8-hour Carbon Monoxide concentration	1-hour Sulfur Dioxide concentration	1-hour Nitrogen Dioxide concentration
Good (Green)	0-12 µg/m^3	0-54 µg/m^3	0-54 ppb	0-4.4 ppm	0-35 ppm	0-53 ppb
Moderate (Yellow)	12.1-35.4 µg/m^3	55-154 µg/m^3	55-70 ppb	4.5-9.4 ppm	36-75 ppm	65-100 ppb
Unhealthy for Sensitive Groups (Orange)	35.5-55.4 µg/m^3	155-254 µg/m^3	71-85 ppb	9.5-12.4 ppm	76-185 ppm	101-360 ppb
Unhealthy (Red)	55.5-150.4 µg/m^3	255-354 µg/m^3	86-105 ppb	12.5-15.4 ppm	186-304 ppm	381-649 ppb
Very Unhealthy (Purple)	150.5-250.4 µg/m^3	355-424 µg/m^3	106-200 ppb	15.5-30.4 ppm	305-604 ppm (24-hour)	650-1249 ppb
Hazardous (Maroon)	≥250.5 µg/m^3	≥425 µg/m^3	≥200 ppb	≥30.5 ppm	≥605 ppm (24-hour)	≥1250 ppb

PM= particulate matter, ppb = parts per billion, ppm = parts per million, µg/m^3 = micrograms per cubic meter

Dominant pollutant & dominant site in overburdened communities highly impacted by air pollution

For communities with multiple pollutants monitored, we created additional bar plots showing the number of days each pollutant had the highest daily recorded AQI between 2020-2022.

Additionally, for communities with multiple monitoring sites, we created bar plots showing the number of days each site had the highest daily recorded AQI between 2020-2022. These plots are in Appendix B.

Air quality modeling

Ozone

Ozone is considered a regional pollutant and varies across a coarser geographic scale than other criteria pollutants. Most ozone monitors in Washington are considered urban scale, each representing a broad area up to 50 km in diameter. In addition, since ozone is a secondary pollutant formed downwind from urban areas, locations with elevated ozone are often separate from areas where the precursors to ozone formation and other criteria pollutants are emitted. Most ozone monitors are in areas with the highest expected concentrations, which are typically lower-population areas downwind from urban cores and in many cases downwind from overburdened communities highly impacted by air pollution.

Due to the limited availability of O_3 monitoring data within overburdened communities highly impacted by air pollution, many communities were assigned the nearest O_3 monitoring site outside of the community boundary if that site was considered reasonably representative of ozone concentrations in or downwind of the community. For communities with no representative or downwind O_3 monitoring site, O_3 monitoring data were supplemented with estimated 8-hour O_3 design values from the NW-AIRQUEST Regional Background Design Values map.[35] For this dataset, model and monitoring data from July 2014 through June 2017 were used to estimate background concentrations of criteria air pollutant design values on a 4 km x 4 km grid scale. For more information on the methods used to derive these estimates see the methodology document. These data were included for overburdened communities that were identified as having elevated levels of cumulative criteria air pollution that do not currently have O_3 monitors. For each community, all grid cells with the centroid in the community boundaries were averaged.

Roadway NO_2

Nitrogen dioxide monitoring is not widely conducted in Washington due to its resource-intensive nature and low expected concentrations. Monitoring is only conducted at select near-road and urban-scale monitoring sites, as concentrations are expected to be a small fraction of the NAAQS outside of urban areas. Due to its limited availability, monitoring data were supplemented with model output in this report to summarize NO_2 concentrations across

[35] https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe

overburdened communities that were identified as having elevated levels of cumulative criteria air pollution.

The Community-LINE (C-LINE) model is a freely available web-based tool that estimates emissions and dispersion of primary mobile source pollutants to investigate the impact of air pollution on communities located near roadways.[36] C-LINE is a screening tool and simulates mobile source pollutants based on changes in traffic behavior at different times of the day. C-LINE uses road data from the 2013 Highway Performance Monitoring System (HPMS) data from the Federal Highway Administration for Washington State. It models the dispersion of criteria pollutants such as nitrogen dioxide and other mobile pollutants.

C-LINE is run for a representative short-term concentration (one hour) using a combination of selected conditions for meteorology, season, traffic density, etc., for the area of interest. We selected model conditions based on the maximum NO_2 concentrations produced from the model. For each community we calculated the average concentration across the whole area, and within each census block group. To represent peak near-road NO_2 concentrations and remove model outliers (NO_2 concentrations in the middle of roadways), we derived the spatial 98th percentile within community boundaries, as well as the average across the whole area and mapped within each census block group. A full description of model conditions is included in appendix C.

Challenges

The model performance of C-LINE is influenced not only by vehicular and roadway data, but also by the meteorological variables and topographic structures. From the tens of runs performed, the wintertime stable atmosphere was selected, which is characterized by a cold, dry and heavy air. A region with a complex topography in a wintertime stable atmosphere downwind of a busy roadway can be expected to amass NO_2 pollution. This is because an advected stagnant air settles from hours to days due to calm or no winds in a convergence zone. For this reason, the model may show overestimated NO_2 results compared to real-world concentrations from roadways in some areas. However, since the model includes only on-road mobile sources of NO_2, it may also underestimate NO_2 concentrations compared to monitored results.

Model results at the nearest points to the NO_2 monitoring sites were compared to annual maximum hourly NO_2 concentrations measured in winter over the 2016-2022 period for which monitoring data were available. At Seattle-10th & Weller, the modeled concentration of 53 ppb fell within the range of monitored maximums of 51-83 ppb. At Tacoma-S 36th, the modeled concentration of 51 ppb also fell within the range of monitored maximums of 44-55 ppb. At Seattle-Beacon Hill, the modeled concentration of 31 ppb underestimated peak monitored concentrations, which ranged from 44-58 ppb. These results indicate that while the C-LINE model was able to reasonably estimate peak NO_2 conditions in the near-roadway environment,

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[36] https://www.epa.gov/healthresearch/community-line-source-model-c-line-estimate-roadway-emissions

it did not fully capture NO_2 concentrations at broader spatial scales away from major roadways, where additional sources are expected to influence ambient concentrations.

Health impacts

To estimate health impacts from $PM_{2.5}$, we used EPA's Benefits Mapping and Analysis Program, Community Edition (BenMAP-CE) version 1.5.8.[37] BenMAP-CE uses four key sources of data: (1) baseline mortality rates, (2) census population data, (3) baseline $PM_{2.5}$ concentration and natural background $PM_{2.5}$ concentration (3.07 µg/m^3 measured at Cheeka Peak, Washington as the control scenario), and (4) health impact functions from literature (Figure 5). For more information about the model inputs and conditions used for this report, see Appendix C.

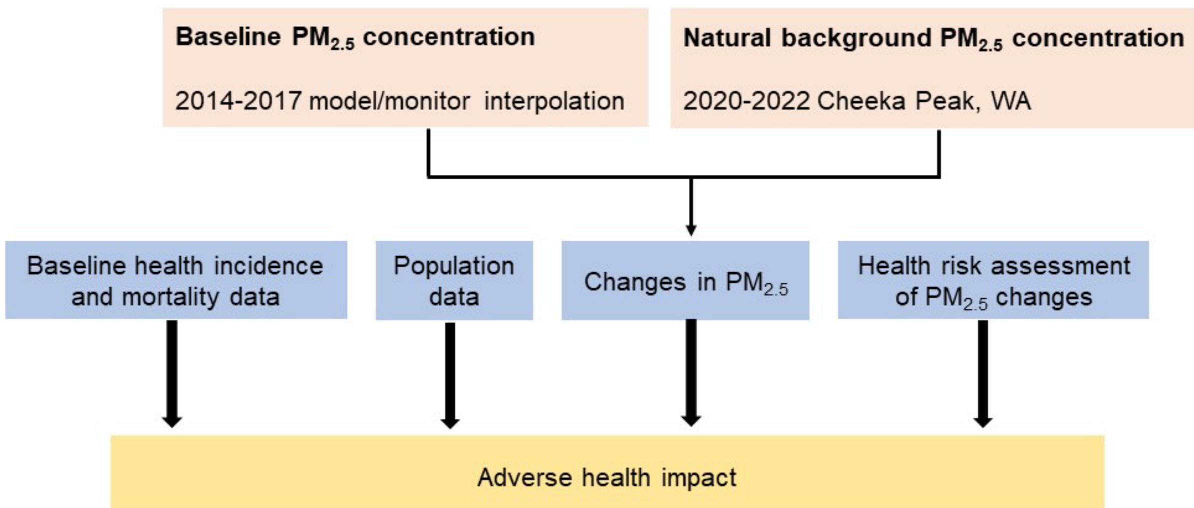

Figure 5. Flow chart illustrating the analysis of health impact associated with $PM_{2.5}$ changes

Challenges

Uncertainty exists in the inputs and outputs of BenMAP-CE modeling. First, different time periods and geographical resolution of BenMAP-CE inputs for estimating annual deaths could lead to minor inconsistency of model results. We used the best available annual average $PM_{2.5}$ concentration dataset that covers the whole state at the census tract level. This data is from June 2014-July 2017 due to issues with more recent modeling results accounting for wildfire smoke and topography. This is a different time period than other model inputs and pollution data presented in this report. Since it excludes wildfire smoke, modeling results represent health impacts from anthropogenic sources. The control scenario that represents the natural background level without sources of air pollution from human activity is the three-year average of $PM_{2.5}$ concentration at the Cheeka Peak monitoring site in northwest Washington for years 2020-2022.

[37] https://www.epa.gov/benmap

Moreover, there are inherent limitations in the mortality and population data. Causes of death were assigned based on diagnosis codes, and it's possible that these codes did not completely capture specific causes death in some instances. Additionally, deaths were geocoded to the census-tract geography, and incomplete, inaccurate, or missing residential address at death could have impacted geocoding. There are also some limitations outlined by Washington Office of Financial Management (OFM) for use of their small areas estimates. Small area estimates are subject to errors that can arise from census count errors, incomplete or inaccurate source data, and modeling error. Additionally, we used OFM's 2020 population estimates with 2010 census tracts because the 2020 Census data were not available when OFM created the small area demographic estimates. Population distributions may have changed since 2010.

We calculated two-year average death rates for years 2020-2021, and many counts used to calculate these rates were small, which could yield unreliable rates. In future BenMAP-CE iterations, we plan to use death rates averaged over more years. Due to time constraints in the current analysis, we used crude mortality rates instead of age-adjusted rates, which do not adjust for the potential impact that differences in age distributions across race/ethnicity groups and geographic populations can have on mortality rates. In the studies that stratified by race and ethnicity, from which we derived concentration-response functions (CRFs), age-adjusted death rates among Black people and Hispanic people were higher than for other racial groups and non-Hispanic people (see Appendix C, Table C5 for more information).

Furthermore, CRFs we used in this study were based on pollution-associated effects observed in populations in other parts of the United States and other time periods. Therefore, our estimates for specific populations in this study, based on these CRFs, have a lot of uncertainty. However, we assume the populations are similar enough that our estimates are reasonably accurate.

Last, the health impacts of short-term $PM_{2.5}$ exposure are not included in this report. The $PM_{2.5}$ concentration formatted by BenMAP-CE differs from the format required by the CRFs found in the literature. For example, Liu et al.[38] used a moving average of lag 0–2 days to estimate daily deaths due to short-term $PM_{2.5}$ exposure. However, BenMAP-CE's input is daily average $PM_{2.5}$ concentration associated with outcomes on the same day as exposure, without consideration of a lagged effect. This could lead to incorrect estimates of daily deaths from BenMAP-CE. Consequently, further investigations are needed to use BenMAP-CE in estimating the health effects of short-term $PM_{2.5}$ exposure. We plan to include these estimates in a future report.

[38] Liu, Rongqi Abbie, Yaguang Wei, Xinye Qiu, Anna Kosheleva, and Joel D. Schwartz. "Short term exposure to air pollution and mortality in the US: a double negative control analysis." *Environmental Health* 21, no. 1 (2022): 1-12.

Greenhouse gas emissions

To analyze greenhouse gas emissions in each overburdened community highly impacted by air pollution, we considered different emission sources by sector. We looked at transportation, industry, and electric power.

For industry and electric power, stationary source emission totals from various industrial processes, natural gas transmissions systems, and electric power generation are included. Washington requires certain facilities to report their GHGs to Ecology as part of the GHG Reporting Program. The GHG Reporting Program uses the reported information to understand the amount and sources of carbon pollution in Washington, and to support the cap-and-invest program established by the CCA.

We estimated GHG emissions from on-road and non-road mobile sources using existing data from EPA's National Emissions Inventory (NEI), Washington's statewide GHG emissions inventory, and census population data.

We were unable to provide estimates from the buildings sector which includes consumption-based residential and commercial heating. We intend on including this information in future reports.

Facilities

We used Esri ArcGIS to spatially determine which stationary source locations were within overburdened communities highly impacted by air pollution using reported facility data from 2020 and 2021. We also included facilities in neighboring communities that were within a three-mile proximity to each community. Facilities that produce over 10,000 MT CO_2e per year are required to report their GHG emissions to Ecology's GHG Reporting Program, as well as businesses that emit less than 10,000 MT CO_2e per year until they do so for a consecutive five years (additional information is in the "Introduction" section of this report). CCA-covered entities are listed in the tables for each community summary and whether it is a major source of criteria air pollutants as designated in the Air Operating Permit program.[39]

Electric bulk power transmission and natural gas distribution locations are shown in Figure 6. GHG emissions from these sources are only calculated statewide so they are excluded from facility totals in Table 11, but they are described in the "Results and Discussion" sections of this report.

[39] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant, including criteria air pollutants. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

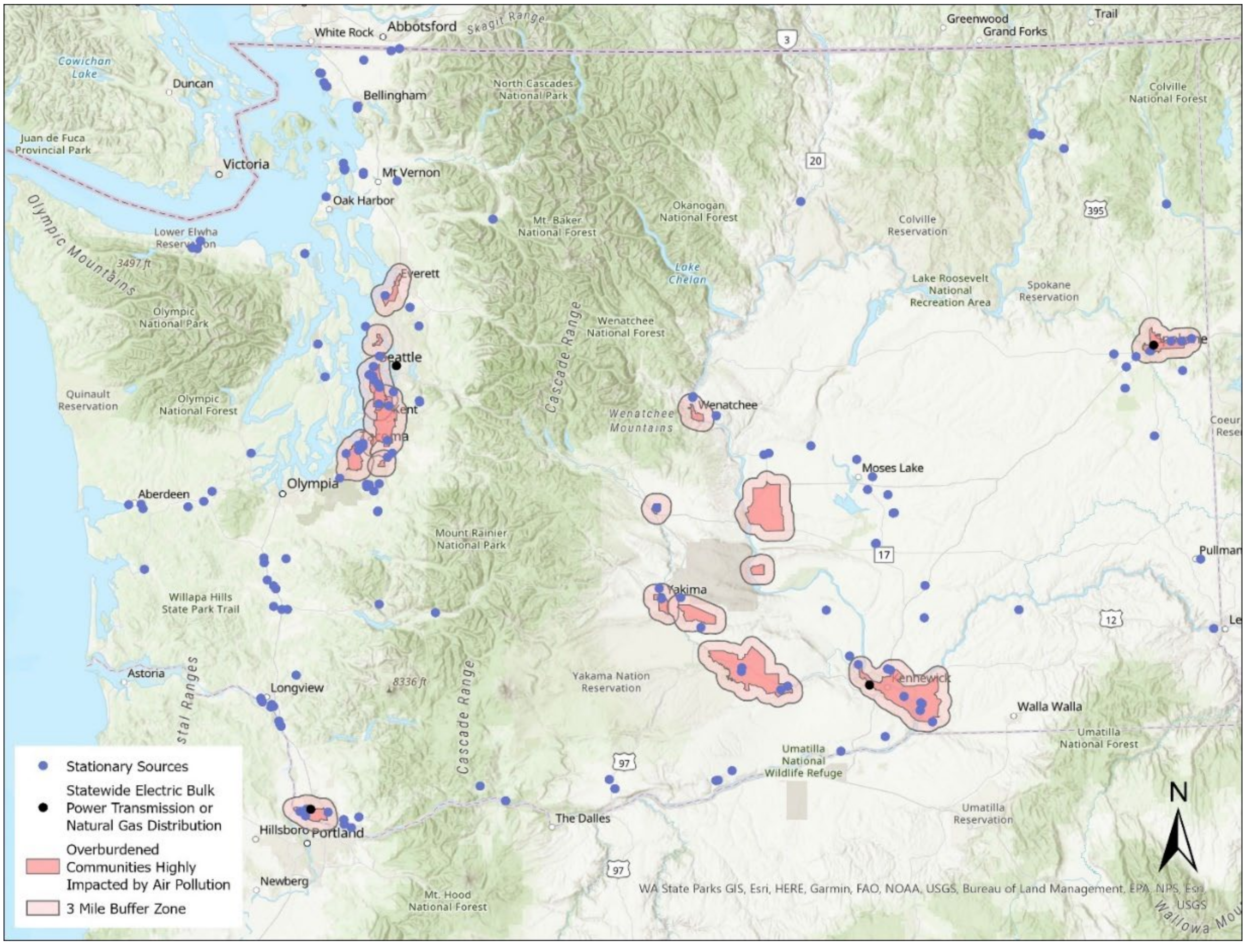

Figure 6. Locations of facilities that reported GHG emissions in 2021 in relation to overburdened communities highly impacted by air pollution

Mobile Sources

We estimated greenhouse gas emissions from mobile sources in each overburdened community highly impacted by air pollution using the following data sources:

- The 2020 EPA National Emissions Inventory (NEI) published every three years, which uses EPA's Motor Vehicle Emission Simulator (MOVES) and other tools that report activity for ships, trains, and airplanes[40]
- The 2019 Washington State Greenhouse Gas Emissions Inventory[41]
- 2020 Census Bureau county population and block groups[42]

[40] 2020 National Emissions Inventory (NEI) Data, U.S. EPA https://www.epa.gov/air-emissions-inventories/2020-national-emissions-inventory-nei-data
[41] GHG Inventories, Washington State Department of Ecology https://ecology.wa.gov/air-climate/reducing-greenhouse-gas-emissions/tracking-greenhouse-gases/ghg-inventories
[42] Washington 2020 Census https://www.census.gov/library/stories/state-by-state/washington-population-change-between-census-decade.html

The mobile source greenhouse gas emissions estimates (called “Transportation” in the Washington State GHG Emissions Inventory) are based on fuel tax receipt data from the Department of Revenue and the NEI uses process-based emissions calculators that rely on local fuel, fleet, and travel information.

We used EPA’s 2020 NEI greenhouse gas data from mobile sources for MT CO_2e (CO_2, CH_4, N_2O) in each county. We used a ratio to allocate the 2019 statewide GHG emissions inventory total to county-level MT CO_2e:

County CO_2e = County CO_2e from NEI ÷ Statewide CO_2e from NEI × 2019 Statewide GHG Emissions Total

The 2020 census population data was used to determine the population within each overburdened community highly impacted by air pollution. We used the ratio of population in each community to the county population, to estimate a per capita MT CO_2e value:

MT CO_2e in each Community = MT CO_2e Per County ÷ County Population × Community Population

Per Capita Rate = MT CO_2e in each Community ÷ Each Community Population

Challenges

It is important to note that 2020 Vehicle Miles Traveled (VMT),[43] an input in MOVES, reflects COVID-19’s impact on modeled transportation emissions. We compared Washington State Department of Transportation’s (WSDOT) 2019 and 2020 statewide VMT estimates, which showed a 15% drop.[44] This drop in VMT estimates shows that there were less miles driven on public roadways, contributing to a reduction of GHG gases from 2019 to 2020. Due to the impacts of COVID-19, the emission reductions in 2020 are considered abnormal. Since we allocated the 2019 statewide transportation inventory to the 2020 MOVES county-level proportions, it doesn’t reflect the change.

Census population data was used in this analysis to go from county CO_2e to community CO_2e. However, for future reports we plan to have access to more local fuel consumption data needed to better capture and reflect changes over time in each area.

Limitations

There are many limitations to be aware of while reading and interpreting the results of this analysis. First, we were limited in our ability to collect new data and information for this initial report, which is the first of its kind in Washington state. Datasets related to pollution, health,

[43] VMT are used in MOVES to calculate emissions while the vehicle is in motion or during short periods of idling on public roadways. WSDOT makes estimates of county VMT by functional roadway classification using the national Department of Transportation’s Highway Performance Monitoring System (HPMS) data.
[44] WSDOT annual mileage and travel information Annual mileage and travel information | WSDOT (wa.gov)

and greenhouse gases are more commonly available at larger geographic scales like county or state, which are less relevant to a community-level analysis. As such, many of the results in this report are based on models or other estimation techniques to get finer scale estimates that are more representative of the overburdened areas we have identified. Second, time periods for data sources in different sections of this report vary based on availability and alignment with the analytics needs. For example, health impacts were estimated from different pollution data than those presented in the "levels of criteria air pollutants" sections, which represent different years. Therefore, caution should be taken when connecting results from different types of analysis.

Data and modeling may not fully capture on-the-ground impacts and experiences, especially at a very local or neighborhood level. When we conduct more extensive monitoring and data analysis in these communities, we may find that pollution concentrations and related health impacts are lower or higher than previously understood. For greenhouse gas emissions, we were only able to collect data on stationary sources that report to Ecology and estimate mobile source emissions at a high-level based on state-level emissions data, county-level modeling, and population. We would like to be able to include more GHG emission sectors in the future.

Lastly, we were limited to quantitative methods and information for this first report. This report is not comprehensive and does not encompass all the pollution or health impacts that a community experiences. It also does not reflect the knowledge systems and assets, creativity, and progress that is an inherent part of each community. We will continue to develop our methodology to overcome these limitations in future biennial reports. We will also continue to coordinate with other state, local, and federal agencies as well as with communities directly on data collection, analysis, and information-sharing.

Results and Discussion

Summary of all overburdened communities highly impacted by air pollution

As of December 2023, we have identified 16 overburdened communities highly impacted by air pollution, with more to come following Tribal consultation.[45] These communities are geographic areas of the state that often include multiple smaller communities, neighborhoods, and towns. Collectively, they include about 1.2 million people, or about 15.5% of the population of Washington. We have included a demographic analysis to better understand who lives in these communities and who is more likely to be overburdened and highly impacted by air pollution in Washington (Table 4). More people may work in or visit these areas. Data is limited for these populations.

[45] For more information on how these communities were identified, see our StoryMap: https://arcg.is/11CfOe0

Demographic data were also used to help identify overburdened communities, through the use of environmental justice mapping tools like EJScreen and the Washington Environmental Health Disparities Map. These results confirm that we have identified areas where there are a greater proportion of people who may be more vulnerable to the impacts of air pollution, such as people of color and low-income populations. But it also highlights that there may be gaps for certain sensitive populations, such as older adults, as well as gaps due to limitations of the current data which render the location-specific geographic boundaries. We would like to underscore that there are additional, vulnerable individuals and populations at smaller scales and in all parts of the state. As data is updated and new information is gathered through continued engagement with stakeholders, communities, and Tribes, we may identify new overburdened communities highly impacted by air pollution in the future.

Table 4. Demographic data of overburdened communities highly impacted by air pollution compared to statewide, 2020 estimates from the American Community Survey

Demographic	Statewide [% of population]	Census block group fully or partially identified as overburdened [% of identified population]
Total population	7,512,465	1,185,585
Age		
Under age 5	454,612 [6.1%]	81,784 [6.9%]
Under age 18	165,3469 [22%]	278,490 [23%]
Over age 64	1,160,604 [15%]	148,220 [13%]
People of color	2,444,556 [33%]	600,364 [51%]
American Indian and Alaska Native	91,766 [1.2%]	15,160 [1.3%]
Asian	662,902 [8.8%]	110,530 [9.3%]
Black or African American	290,245 [3.9%]	95,412 [8%]
Hispanic or Latino (any race)	971,522 [13%]	307,220 [26%]
Native Hawaiian and Pacific Islander	51,117 [0.7%]	18,036 [1.5%]
Some other race	360,578 [4.8%]	127,987 [10.8%]
Two or more races	531,976 [7.1%]	98,711 [8.3%]
Linguistically isolated	110,655 [1.5%]	36,941 [3.1%]
Low income	1,780,174 [24%*]	443,532 [38%*]
Below federal poverty level	751,044 [10%*]	190,196 [16%*]
No health insurance coverage	458,228 [6.2%*]	119,857 [10.3%*]

*Percentage calculated based on different total population, in accordance with the American Community Survey results

Criteria air pollution

Air pollution concentrations can vary minute to minute, day to day, and year to year. Air pollution comes from both human-caused sources, and from natural events, such as wildfires, volcanic eruptions, and dust storms. Concentrations are also influenced by weather patterns and variations.

The main criteria air pollutant of concern contributing to unhealthy air quality across the state is PM2.5. Most days with unhealthy air quality in overburdened communities highly impacted by air pollution occurred during wildfires or dust events during 2020-2022 (see Table 5). Due to these events, a number of monitors across Washington reported concentrations above the $PM_{2.5}$ and PM_{10} NAAQS. In overburdened communities highly impacted by air pollution, there were an average of 7.5 days per year of air quality that was recorded as unhealthy for sensitive groups, or worse. In comparison, the average for all monitors statewide during that same period was 6.7 days. Note that all of Washington is currently considered by EPA as “in attainment” with national PM standards because periods of high concentration did not coincide with the timing of past EPA nonattainment designations. Ecology monitors and provides daily information about air pollution, recognizing that people face exposure to and health impacts from wildfire smoke and dust. We work with health agencies to inform people about options to reduce exposure when air quality is poor. We will continue to expand air monitoring and communicate about air pollution as we work in partnership with air agencies and communities to reduce air pollution.

The overburdened communities that are included in this initiative, when compared to the rest of the state, consistently experience elevated levels of criteria air pollution. This is true whether wildfire smoke is included in the analysis or not. For each community, this report provides a closer look at levels of criteria air pollution. In the future, we will do further analysis on the sources of pollution and, together with each community, will develop a community-specific pollution reduction strategy.

Table 5 below provides a summary of criteria air pollution in the 16 identified overburdened communities already shown to be places where there are a greater proportion of demographic groups shown to be vulnerable to air pollution (Table 4 above).

Table 5. Summary of criteria air pollution in overburdened communities highly impacted by air pollution.

Name	Local clean air authority	Pollutant(s) of concern[46]	Current monitor(s)	Average annual days with recorded unhealthy air quality (2020-2022)[47]
Spokane and Spokane Valley	Spokane Regional Clean Air Agency	$PM_{2.5}$ 24-hour; $PM_{2.5}$ annual; Cumulative criteria air pollution	2 O_3 (nearby); 2 $PM_{2.5}$; 2 PM_{10}	7.33
Tri-Cities to Wallula	Benton Clean Air Agency; Ecology Eastern Regional Office	Ozone; $PM_{2.5}$ 24-hour; PM_{10}; Cumulative criteria air pollution	1 O_3 (nearby); 3 $PM_{2.5}$ (1 nearby); 2 PM_{10}	8.33
East Yakima	Yakima Clean Air Agency	$PM_{2.5}$ 24-hour; $PM_{2.5}$ annual; Cumulative criteria air pollution	1 $PM_{2.5}$; 1 PM_{10}	11
Lower Yakima Valley	Yakima Clean Air Agency; Benton Clean Air Agency	$PM_{2.5}$ 24-hour; $PM_{2.5}$ annual; Cumulative criteria air pollution	2 $PM_{2.5}$	10.67
Moxee Valley	Yakima Clean Air Agency	$PM_{2.5}$ 24-hour; Cumulative criteria air pollution	None	DNC
George and West Grant County	Ecology Eastern Regional Office	$PM_{2.5}$ 24-hour	1 $PM_{2.5}$ (new)	DNC
Mattawa	Ecology Eastern Regional Office	$PM_{2.5}$ 24-hour	1 $PM_{2.5}$ (new)	DNC
Ellensburg	Ecology Central Regional Office	$PM_{2.5}$ 24-hour; Cumulative criteria air pollution	1 $PM_{2.5}$	5.67

[46] The pollutant(s) listed are based on thresholds used for identifying each area as overburdened and highly impacted by air pollution. The pollutant(s) of concern identified for each area may change in the future following engagement with communities.
[47] Number of days the air quality index was in the "unhealthy for sensitive groups" category or above.

Name	Local clean air authority	Pollutant(s) of concern[46]	Current monitor(s)	Average annual days with recorded unhealthy air quality (2020-2022)[47]
Wenatchee and East Wenatchee	Ecology Central Regional Office	$PM_{2.5}$ 24-hour	1 $PM_{2.5}$ (nearby)	12
Everett	Puget Sound Clean Air Agency	$PM_{2.5}$ 24-hour	1 $PM_{2.5}$ (nearby)	5.67
North Seattle and Shoreline	Puget Sound Clean Air Agency	$PM_{2.5}$ 24-hour; Cumulative criteria air pollution	1 $PM_{2.5}$ (nearby)	5.33
South Seattle	Puget Sound Clean Air Agency	$PM_{2.5}$ 24-hour; $PM_{2.5}$ annual; Cumulative criteria air pollution	2 CO; 1 lead; 2 NO_2; 1 O_3; 5 $PM_{2.5}$; 1 PM_{10}; 1 SO_2	6.67
South King County	Puget Sound Clean Air Agency	$PM_{2.5}$ 24-hour; Cumulative criteria air pollution	2 $PM_{2.5}$	6.33
Northeast Puyallup	Puget Sound Clean Air Agency	Cumulative criteria air pollution	1 $PM_{2.5}$ (previously nearby)	DNC
South and East Tacoma	Puget Sound Clean Air Agency	$PM_{2.5}$ 24-hour; Cumulative criteria air pollution	1 NO_2; 3 $PM_{2.5}$	7
Vancouver	Southwest Clean Air Agency	$PM_{2.5}$ 24-hour; Cumulative criteria air pollution	1 O_3 (nearby); 1 $PM_{2.5}$	4.33

CO = carbon monoxide, DNC = data not collected, O_3 = ozone, NO_2 = nitrogen dioxide, PM = particulate matter, SO_2 = sulfur dioxide

Health impacts

People in overburdened communities bear a greater burden of health impacts compared to the state as a whole. This is due to living in areas with more environmental hazards and socioeconomic vulnerabilities. The communities that are included in this initiative are specifically at greater risk of health impacts from criteria air pollution. People in these communities may also have less access to mitigation measures, like indoor air filtration or greenspaces.

Table 6 shows, on average, communities that are overburdened and highly impacted by air pollution tend to have higher rates of chronic conditions compared to the statewide population. There is some evidence that long-term exposure to air pollution may contribute to development of disease – for example, asthma development in children or chronic cardiovascular conditions in adults. Further, short-term exposure to air pollution is associated with exacerbations in existing conditions like asthma or COPD. It may also increase the likelihood of heart attack or stroke in a person who is at elevated risk.

Deaths from cardiovascular disease are also higher and life expectancy is 2.4 years shorter on average in these communities. Air pollution is associated with various causes of mortality. Effects are seen with long-term exposure and with short-term increases in pollution levels.

Table 6. Estimated health measures for overburdened communities highly impacted by air pollution compared to statewide.[48]

Health measure	Statewide	Census tracts fully or partially identified as overburdened	Data source and year(s)
Asthma prevalence among adults (%)	10.9	11.6	CDC PLACES (2021)[49]
Chronic obstructive pulmonary disease prevalence (COPD) among adults (%)	5.6	6.2	CDC PLACES (2021)[49]
Coronary heart disease prevalence among adults (%)	4.8	4.9	CDC PLACES (2021)[49]
Diabetes prevalence among adults (%)	8.7	9.7	CDC PLACES (2021)[49]
Stroke prevalence among adults (%)	2.7	2.9	CDC PLACES (2021)[49]
Cardiovascular disease deaths (age adjusted rate per 100,000)	194	229	WTN (2016-2020)[50]
Life expectancy at birth (years)	80.4	78.0	WTN (2016-2020)[51]

While looking at health data in Table 6 related to disease prevalence, mortality, and other adverse health outcomes can show the health disparities among different communities, it does not explain the causes or factors that led to those health outcomes. To understand the impact of air pollution, we used BenMAP-CE to estimate disparities in mortality rates specifically related to ambient $PM_{2.5}$ exposure (Table 7). For most of the different outcomes and age groups, modeling results suggest that the mortality rates associated with $PM_{2.5}$ in overburdened communities highly impacted by air pollution are likely to be higher than the statewide average. This is especially true for older adults (age 65-99) where mortality rates are expected to be about twice as high in overburdened communities highly impacted by air pollution compared to statewide.

[48] Each of these estimates have a range of uncertainty (not calculated for this report).
[49] CDC PLACES data is based on modeled census tract estimates: https://data.cdc.gov/500-Cities-Places/PLACES-Local-Data-for-Better-Health-Census-Tract-D/cwsq-ngmh
[50] Washington Tracking Network: https://fortress.wa.gov/doh/wtn/WTNPortal/#!q0=821
[51] Washington Tracking Network: https://fortress.wa.gov/doh/wtn/WTNPortal/#!q0=655

Table 7. Estimated $PM_{2.5}$-related crude annual death rates for overburdened communities highly impacted by air pollution compared to statewide. Uncertainty range is in [] brackets.

Cause of death	Age group	Statewide (Crude rate per 1,000 people) [uncertainty]	Census tracts fully or partially identified as overburdened (Crude rate per 1,000 people) [uncertainty]	Study
Ischemic heart disease	30 to 99	0.07 [0.06 to 0.09]	0.09 [0.07 to 0.10]	Krewski et al. [52]
Lung cancer	30 to 99	0.03 [0.01 to 0.05]	0.03 [0.01 to 0.05]	Krewski et al.[52]
All-causes	30 to 99	0.18 [0.12 to 0.24]	0.28 [0.19 to 0.37]	Krewski et al.[52]
All-causes	18 to 84	0.25 [0.12 to 0.37]	0.40 [0.34 to 1.09]	Pope et al. [53]
All-causes	65 to 99	0.36 [0.33 to 0.39]	0.69 [0.63 to 0.75]	Di et al. [54]

Table 8 summarizes the annual $PM_{2.5}$-related mortality in communities that are overburdened and highly impacted by air pollution, based on a study by Krewski et al[52].[52] This study investigated deaths from all causes, ischemic heart disease, and lung cancer, among people ages 30 to 99, for all ethnicity and race groups combined. The annual average number of estimated deaths associated with $PM_{2.5}$ pollution in all overburdened communities highly impacted by air pollution is 203 for all causes of death, 63 for ischemic heart disease, and 25 for lung cancer.

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[52] Krewski, D., Jerrett, M., Burnett, R. T., Ma, R., Hughes, E., Shi, Y., ... & Tempalski, B. (2009). *Extended follow-up and spatial analysis of the American Cancer Society study linking particulate air pollution and mortality* (Vol. 140). Boston, MA: Health Effects Institute.
[53] Pope III, C. A., Lefler, J. S., Ezzati, M., Higbee, J. D., Marshall, J. D., Kim, S. Y., ... & Burnett, R. T. (2019). Mortality risk and fine particulate air pollution in a large, representative cohort of US adults. *Environmental Health Perspectives*, *127*(7), 077007.
[54] Di, Q., Wang, Y., Zanobetti, A., Wang, Y., Koutrakis, P., Choirat, C., ... & Schwartz, J. D. (2017). Air pollution and mortality in the Medicare population. *New England Journal of Medicine*, *376*(26), 2513-2522.

Table 8. Annual number of deaths associated with $PM_{2.5}$ air pollution in census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]
Krewski et al.	30 to 99	All	All-causes	203 [137 to 268]
Krewski et al.	30 to 99	All	Ischemic heart disease	63 [51 to 74]
Krewski et al.	30 to 99	All	Lung cancer	25 [10 to 38]

Table 9 summarizes the annual $PM_{2.5}$-related all-cause mortality by race and ethnicity groups among people ages 18 to 84 based on a study by Pope et al.[53] The annual average number of estimated deaths associated with $PM_{2.5}$ pollution in overburdened communities highly impacted by air pollution was about 400. Non-Hispanic white people and non-Hispanic Black people had the highest rate of death. The estimated annual death rate is highly influenced by age, as older adults are the most at risk. Within overburdened communities highly impacted by air pollution, non-Hispanic white adults skew oldest with about 23% age 65 or older, while Hispanic adults skew youngest with about 6% age 65 or older. Future analyses will include age-adjusted rates to better account for the influence of age on mortality.

Table 9. Annual number and rate of all-cause deaths by race and ethnicity groups associated with $PM_{2.5}$ air pollution in census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity	Race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al.	18 to 84	Hispanic	All	All-causes	80 [45 to 113]	0.38 [0.22 to 0.54]
Pope et al.	18 to 84	Non-Hispanic	AIAN	All-causes	4 [-3 to 10]	0.36 [-0.24 to 0.9]
Pope et al.	18 to 84	Non-Hispanic	Asian	All-causes	38 [-26 to 96]	0.33 [-0.23 to 0.84]
Pope et al.	18 to 84	Non-Hispanic	Black	All-causes	30 [9 to 49]	0.42 [0.13 to 0.69]
Pope et al.	18 to 84	Non-Hispanic	NHOPI	All-causes	3 [-2 to 6]	0.22 [-0.15 to 0.56]
Pope et al.	18 to 84	Non-Hispanic	Two or more races	All-causes	7 [-5 to 18]	0.22 [-0.15 to 0.56]
Pope et al.	18 to 84	Non-Hispanic	White	All-causes	236 [153 to 314]	0.43 [0.28 to 0.58]
Pope et al.	18 to 84	All	All	All-causes	398 [173 to 607]	0.40 [0.17 to 0.61]

Table 10 summarizes the annual $PM_{2.5}$-related all-cause mortality by race and ethnicity groups among older adults based on the Di et al. study.[54] We estimated 122 total deaths per year for this age group in census tracts fully or partially identified as overburdened and highly impacted by air pollution. The highest mortality rates were among non-Hispanic Black people, Hispanic people, and non-Hispanic Native Hawaiian and other Pacific Islander people in areas overburdened by air pollution.

Table 10. Annual number and rate of all-cause deaths among older adults by race and ethnicity associated with $PM_{2.5}$ air pollution in census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity	Race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Di et al.	65 to 99	Hispanic	All	All-causes	19 [16 to 21]	1.41 [1.22 to 1.60]
Di et al.	65 to 99	Non-Hispanic	AIAN	All-causes	2 [1 to 2]	0.93 [0.57 to 1.26]
Di et al.	65 to 99	Non-Hispanic	Asian	All-causes	18 [14 to 22]	0.88 [0.69 to 1.05]
Di et al.	65 to 99	Non-Hispanic	Black	All-causes	14 [13 to 14]	1.74 [1.68 to 1.81]
Di et al.	65 to 99	Non-Hispanic	NHOPI	All-causes	1 [1 to 1]	1.06 [0.65 to 1.45]
Di et al.	65 to 99	Non-Hispanic	Two or more races	All-causes	2 [1 to 3]	0.86 [0.53 to 1.18]
Di et al.	65 to 99	Non-Hispanic	White	All-causes	66 [63 to 68]	0.51 [0.49 to 0.53]
Di et al.	65 to 99	All	All	All-causes	122 [110 to 133]	0.69 [0.63 to 0.75]

Mortality and disease prevalence and incidence are just some of the health outcomes that are affected by exposure to $PM_{2.5}$ and other outdoor air pollutants. People also experience many short-term health impacts like hospitalizations and emergency room visits. Beyond these quantifiable health outcomes, people's health and well-being are impacted by exposure to air pollution in overburdened communities across the state. Here are some ways in which people have reported their health being impacted by air pollution during previous engagement events related to this work:

- Coughing and wheezing;
- Scratchy or sore throat;
- Headaches and cognitive impairment;
- Nausea;
- Ability to go about daily life (e.g., going on walks, commuting by bike, gardening, etc.);
- Ability to grow food and medicine;
- Worsened asthma symptoms;
- Worsened symptoms of other respiratory illnesses, like COVID-19; and

- Emergency room visits during acute pollution events.

As we continue to work with and learn from communities, we will aim to include more specific information about how health in each community is impacted.

Greenhouse gas emissions

A goal of the CCA, established by RCW 70A.65.020, is to ensure that the Cap-and-Invest Program achieves reductions of GHGs in overburdened communities highly impacted by air pollution. While it is too early to tell what the impacts of the Cap-and-Invest program are, we included the emissions information of stationary sources that are required to report to the GHG reporting program, including CCA-covered entities,[55] within and nearby overburdened communities highly impacted by air pollution. This will help Ecology and communities monitor changes in facility emissions over time that stem from the CCA and other climate policies.

With some exceptions, an entity is covered by the CCA if it emits more than 25,000 MT CO_2e (i.e., usually from burning fossil fuels) in a year, excluding biogenic CO_2.[56,57] The cap-and-invest program baseline for GHG emissions from CCA-covered entities is from the years 2015-2019.

The transportation sector was the leading contributor of GHGs in Washington State as of 2019. Transportation refers to on-road and non-road mobile sources. GHG emissions from transportation are projected to be reduced through laws and policy efforts such as the Zero-Emission Vehicle Law and Clean Fuel Standards. Reporting requirements from these laws and policies could be another way to help track reductions from mobile sources.

As more localized and granular data become available, we expect to provide more GHG totals in future reports for each community. To provide a baseline for GHG emissions in overburdened communities highly impacted by air pollution, we used mobile source emissions estimates and facility emissions from industrial processes, natural gas transmission systems, and electricity generation.

Facilities

As of 2021, 161 facilities reported their GHG emissions to Ecology. Of those facilities, 49 are in or nearby (within 3 miles) overburdened communities highly impacted by air pollution and account for 30% of Washington's facilities that report their GHG emissions. While proximity to sources of GHGs isn't any more harmful to people nearby as it is to people farther away, GHG emitters can also emit significant amounts of co-pollutants.

The results presented in Table 11 summarize the total facilities and GHG emissions in and nearby each overburdened community highly impacted by air pollution from 2021. The results

[55] Program coverage https://app.leg.wa.gov/RCW/default.aspx?cite=70A.65.080

[56] Washington State Cap-and-Invest Program https://ecology.wa.gov/Air-Climate/Climate-Commitment-Act/Cap-and-invest

[57] More information on compliance obligations for CCA-covered entities, Washington's greenhouse gas reporting program, and facility reporting requirements can be found in the "Introduction" section of this report.

in each of the following individual community summaries include details such as 2020 and 2021 facility GHG emissions, whether a stationary source is nearby to an overburdened community highly impacted by air pollution, and whether it is a major source of criteria air pollutants as designated in the Air Operating Permit program[58] or a CCA-covered entity.

Electric bulk power transmission and distribution plants, and natural gas suppliers and distribution companies were excluded as their emissions are only reported on a statewide aggregate basis, rather than a local, stationary basis. If a natural gas distribution company or bulk power distribution plant was located within the community, it is mentioned in the individual summaries for awareness.

Exclusions and exemptions

GHG emission inventory sectors and GHG reporting program facility sectors excluded from this analysis:

- Bulk power transmission and distribution systems – provides electricity statewide and emissions (fluorinated GHGs) are counted as a statewide total
- Natural gas suppliers – natural gas that is supplied statewide for wholesale and retail
- Natural gas distribution – leaks from pipelines that locally distribute natural gas, GHG emissions are counted as a statewide total
- Imported liquid fuels – fossil fuels imported from out of state
- Agricultural activities, consumption-based residential and commercial heating, and consumption-based electricity – we have not yet found a way to fully capture and provide GHG emissions from these categories in the specific geographical areas

Facility sectors included in this report but exempt from CCA:

- Landfills – Washington State has separate requirements to reduce landfill methane emissions[59]
- Coal plants – exempted in statute RCW 70A.65.080(7)(c)
- National security – based on the North American Industry Classification System (NAICS) code that references military bases
- Cattle feedlots – exemptions for covered GHG emissions regarding agriculture

[58] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant, including criteria air pollutants. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

[59] Landfills – methane emissions https://app.leg.wa.gov/RCW/default.aspx?cite=70A.540

Table 11. Total number of facilities and GHG emissions reported in 2021 in or nearby each overburdened community highly impacted by air pollution

Community	Total Facilities	Total MT CO_2e [biogenic CO_2]
Spokane and Spokane Valley	5	434,028 [159,308]
Tri-Cities to Wallula	8	1,418,691 [578,944]
East Yakima	2	25,554 [0]
Lower Yakima Valley	4	72,205 [0]
Moxee Valley	2	169,687 [0]
Mattawa	0	N/A
George and West Grant County	0	N/A
Ellensburg	1	12,824 [0]
Wenatchee and East Wenatchee	2	27,413 [0]
Everett	1	67,481 [0]
North Seattle and Shoreline	0	N/A
South Seattle	9	774,207 [0]
South King County	3	63,505 [0]
Northeast Puyallup	2	39,423 [0]
South and East Tacoma	6	1,285,290 [928,981]
Vancouver	4	782,861 [0]
Total	**49**	**5,173,169 [1,667,232]**

CO_2 = carbon dioxide, MT CO_2e = metric tons of carbon dioxide equivalent

In 2021, there were 29 facilities located in an overburdened communities highly impacted by air pollution and 20 were considered nearby to one or more communities. Of the 49 total, 22 are currently CCA-covered entities.

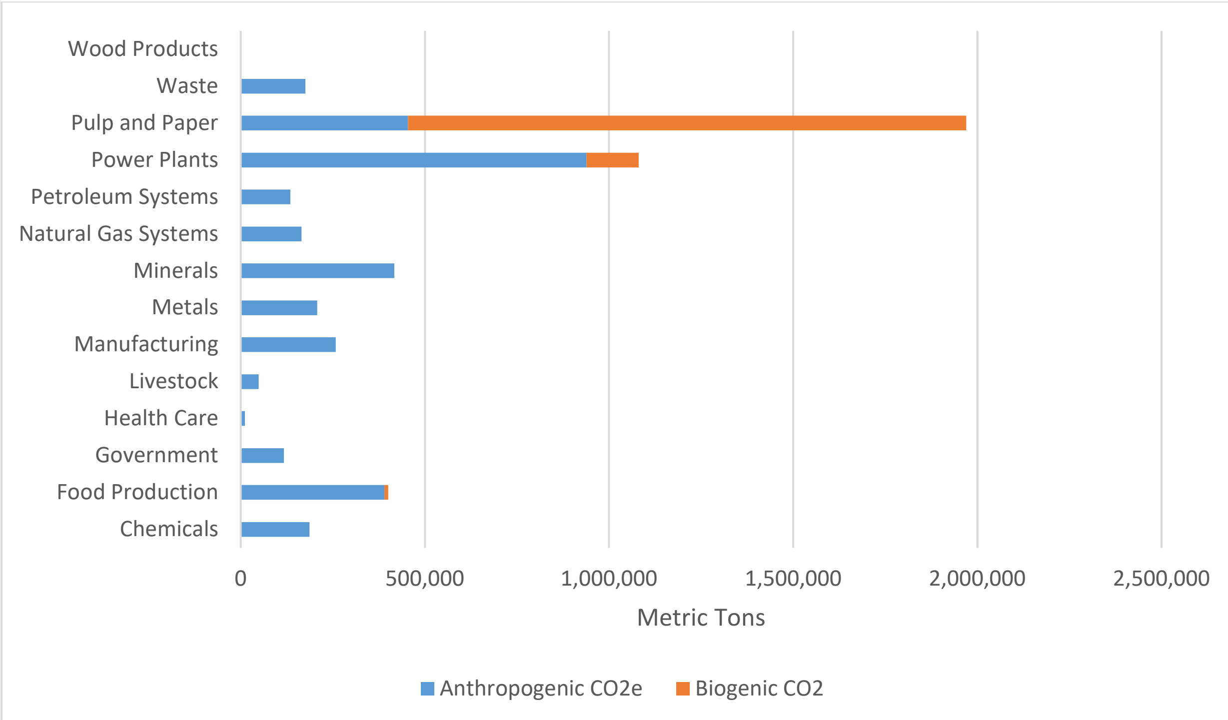

Figure 7. 2021 greenhouse gas emissions by facility sector within and nearby overburdened communities highly impacted by air pollution

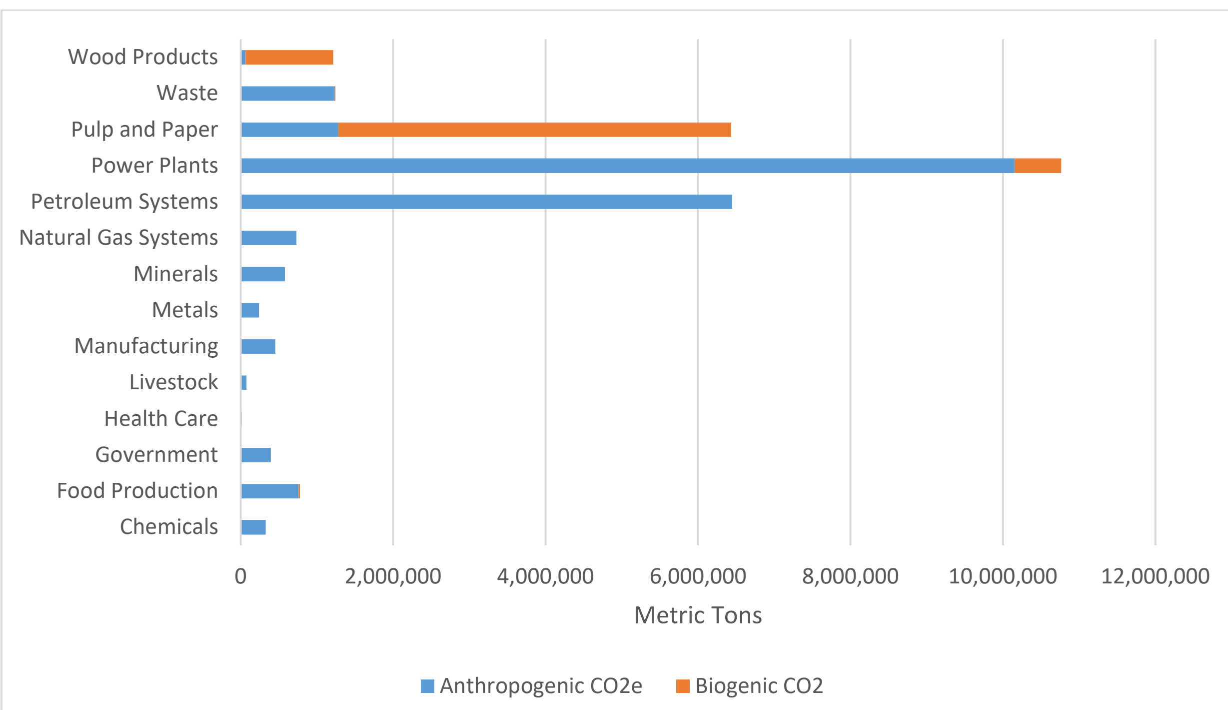

Figure 8. 2021 statewide greenhouse gas emissions by facility sector

Mobile Sources

GHG emission estimates from mobile sources in overburdened communities highly impacted by air pollution totaled 6,093,191 MT CO_2e, with the average per capita roughly being 6.3 MT CO_2e.

GHG emissions are produced by mobile sources as petroleum fuels are burned. Mobile sources include a variety of vehicles, engines, and equipment, that can be categorized as either on-road (e.g., passenger cars, trucks, buses, and motorcycles) or non-road (e.g., marine vessels, aircraft, locomotives, equipment used for lawn and agriculture, construction, recreation, etc.).

Figure 9 shows statewide emission totals from mobile sources over time, in millions of metric tons of CO_2e (MMT CO_2e), with the most current statewide total being 40.3 MMT CO_2e. Gasoline highway and diesel highway refer to on-road mobile sources and non-highway refers to non-road mobile sources of GHG emissions.

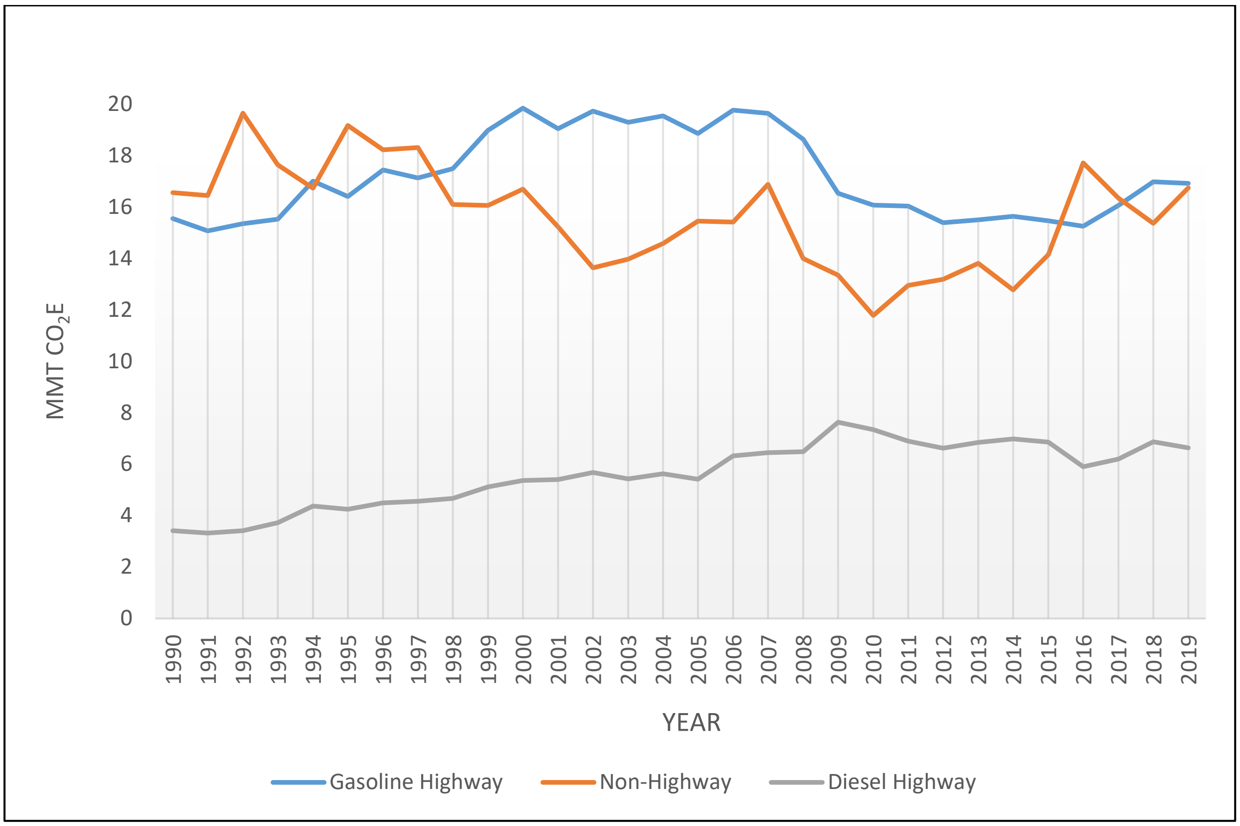

Figure 9. Statewide GHG Inventory for the transportation sector from 1990-2019

Spokane and Spokane Valley

Geographic description

This community is in the greater Spokane area and encompasses parts of both the city of Spokane and neighboring Spokane Valley. Air quality is managed by Spokane Regional Clean Air Agency. The community is approximately 42 square miles with a population of about 147,407 people. It is primarily urban and suburban and contains some prominent industrial areas, railways, and freeways.

Levels of criteria air pollutants

The main pollutants of concern that we identified for this community are long-term (annual) and short-term (24-hour) $PM_{2.5}$, as well as cumulative criteria air pollution, which is primarily driven by levels of $PM_{2.5}$, O_3, and NO_2. Previous modeling or air emissions inventory results have shown that concentrations of other criteria air pollutants (CO, lead, SO_2) are likely to be low in this area.[60,61] Some of the sources of pollution include wildfire, residential wood burning, mobile sources like cars, trucks, trains, and dust from construction and agriculture. Spokane is also surrounded by forest land and is likely to experience longer fire and smoke seasons in the decades ahead as the region becomes drier and warmer.[62] We will be examining the sources of pollution in Spokane and Spokane Valley in greater detail in future analyses.

Air quality monitoring

There are currently two monitoring sites for both $PM_{2.5}$ and PM_{10} within the community boundaries, one in Spokane and one in Spokane Valley (Figure 10; Table 12). As of March 2021, the Spokane-Augusta monitoring site was discontinued from Ecology's network. However, Spokane Regional Clean Air Agency continues to operate the site unsupported to provide air quality information for the area. This site is particularly important to understand potential air quality impacts from the North Spokane Corridor project less than a hundred meters to the east. There are also a few additional $PM_{2.5}$ monitoring sites nearby in Spokane's North Hill neighborhood, Colbert, and Airway Heights. Additional monitoring sites will be added across the community following community engagement.

[60] https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe
[61] https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory
[62] https://www.spokaneclimateproject.org/wildfires

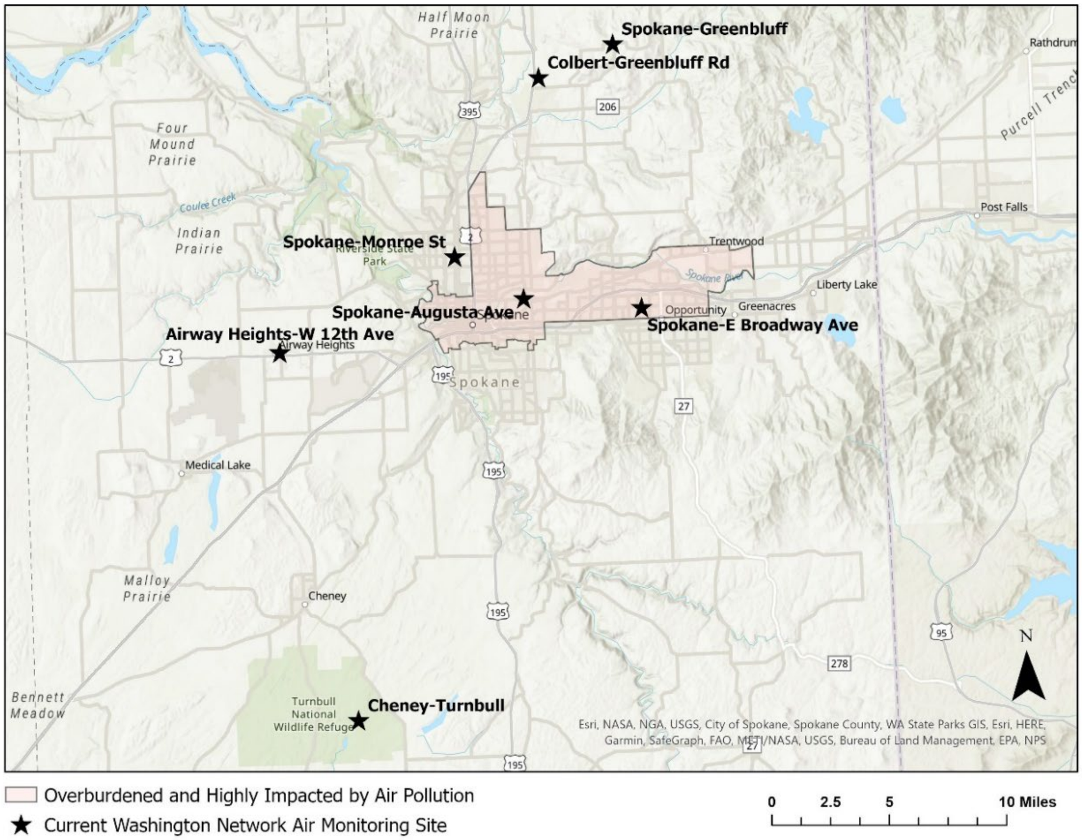

Figure 10. Spokane and Spokane Valley community boundaries and air monitoring sites

Table 12. Spokane and Spokane Valley monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?[63]
Spokane-E Broadway Ave	Spokane Regional Clean Air Agency	$PM_{2.5}$, PM_{10}	Neighborhood (0.5-4 km)	Yes
Spokane-Augusta Ave	Spokane Regional Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	No*
		PM_{10}	Urban (4-50 km)	No
Spokane-Greenbluff	Ecology	O_3	Urban (4-50 km)	Yes
Spokane-Cheney Turnbull	Ecology	O_3, PM_{10}	Urban (4-50 km)	Yes

PM = particulate matter, O_3 = ozone

*As of 2021, the Spokane-Augusta was discontinued from Ecology's network and is no longer used to determine compliance with National Ambient Air Quality Standards.

The Spokane area is currently in attainment with the national ambient air quality standards. However, there are routinely exceedances of $PM_{2.5}$ and PM_{10} during wildfire smoke events. With and without wildfire excluded, in 2021 and 2022, annual 98th percentile concentrations for $PM_{2.5}$ were 25-33 $\mu g/m^3$. While below the national air quality standard of 35 $\mu g/m^3$, these are higher than Ecology's healthy air goal of 20 $\mu g/m^3$.

For O_3, which is a regional pollutant that is typically highest downwind of urban areas, there are two monitors in Greenbluff and Cheney. These monitoring sites are co-representative of O_3 in the region. The fourth-highest daily O_3 values in the Spokane area have gotten close to the national standard of 0.070 ppm (as in 2021) with a three-year design value of 0.061 ppm. The mean level of O_3 during ozone season (May-September) is 0.039-0.047 ppm. O_3 in the Spokane area is usually in the "good" AQI range, although it sometimes goes into the "moderate" or "unhealthy for sensitive groups" range a few days per year when conditions are favorable to O_3 formation in the atmosphere.

[63] Monitors that have been designated by EPA as Federal Equivalent Method (FEM) or Federal Reference Method (FRM) monitors and can be used to demonstrate compliance with National Ambient Air Quality Standards.

Table 13. Criteria air pollutant summary statistics for Spokane and Spokane Valley monitoring sites, 2020-2022. A red box indicates a value above the NAAQS. Numbers in brackets [] indicates wildfire days >35.4 µg/m³ have been removed.

Pollutant & averaging time	Form	NAAQS Level	Site Name	2020	2021	2022	3-year Design Value
$PM_{2.5}$ 24-hour (µg/m³)	98th percentile	35	Spokane-E Broadway Ave	26.7 [18.6]	32.8 [26.7]	29.7 [25.4]	30 [24]
			Spokane-Augusta Ave	31.0 [17.6]	32.6 [30.7]	33.3 [28.1]	32 [25]
PM_{10} 24-hour (µg/m³)	# of annual exceedances >150 µg/m³	1	Spokane-E Broadway Ave	DNC	*0*	0	*0*
			Spokane-Augusta Ave	6	0	0	2
O_3 8-hour (ppm)	Annual fourth-highest daily maximum	0.070	Spokane-Greenbluff	0.055	0.069	0.061	0.061
			Spokane-Cheney Turnbull	0.054	0.068	0.056	0.059

Values in italics indicate incomplete data, DNC = data not collected, NAAQS = national ambient air quality standards, PM = particulate matter, µg/m³ = micrograms per cubic meter

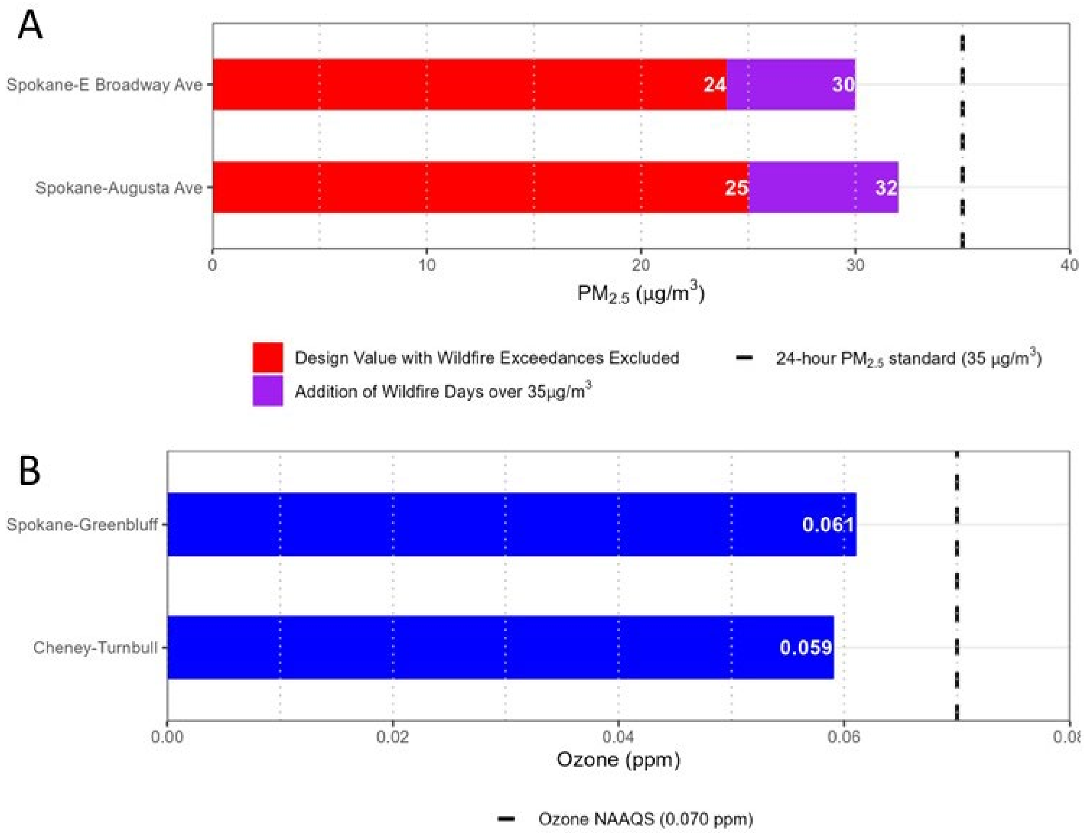

Figure 11. 2022 design values for A) 24-hour $PM_{2.5}$ and B) Ozone at Spokane and Spokane Valley monitoring sites

Particle pollution in Washington varies seasonally. In years with less wildfire activity, like in 2022, the average concentration of $PM_{2.5}$ was higher in the cold season. The primary source of particle pollution in the cold season is usually smoke from home heating. Whether it is worse in warmer months or cooler months mainly depends on the severity of wildfire smoke for that year. Figure 12 shows that the worst air quality days each year 2020-2022 occurred in the summer, between July and September. This overlaps with the time of year when O_3 levels peak. Because O_3 requires sunlight to form, it is highest from May to September in Washington. In the Spokane region, O_3 is only measured during this period.

Table 14. Seasonal and annual means for $PM_{2.5}$ and seasonal means for O_3 for Spokane and Spokane Valley monitoring sites, 2020-2022

Pollutant	Site	Season/annual mean	2020	2021	2022*	3-year mean
$PM_{2.5}$ (µg/m^3)	Spokane-E Broadway Ave	Warm Season (April-September)	13.21	10.63	7.64	10.5
		Cold Season (October-March)	7.41	7.45	8.07	7.6
		Annual	10.38	8.99	7.73	9.0
$PM_{2.5}$ (µg/m^3)	Spokane-Augusta Ave	Warm Season (April-September)	14.04	10.91	8.63	11.2
		Cold Season (October-March)	6.79	7.03	9.26	7.7
		Annual	10.28	8.81	8.89	9.3
O_3 (ppm)	Spokane-Greenbluff	Ozone Season (May-September)	0.039	0.046	0.042	0.043
O_3 (ppm)	Spokane-Cheney Turnbull	Ozone Season (May-September)	0.039	0.045	0.040	0.042

PM = particulate matter, O_3 = ozone, ppm = parts per million, µg/m^3 = micrograms per cubic meter

*In 2022, seasonal means are adjusted April-October 21 and October 22-March due to wildfires in October.

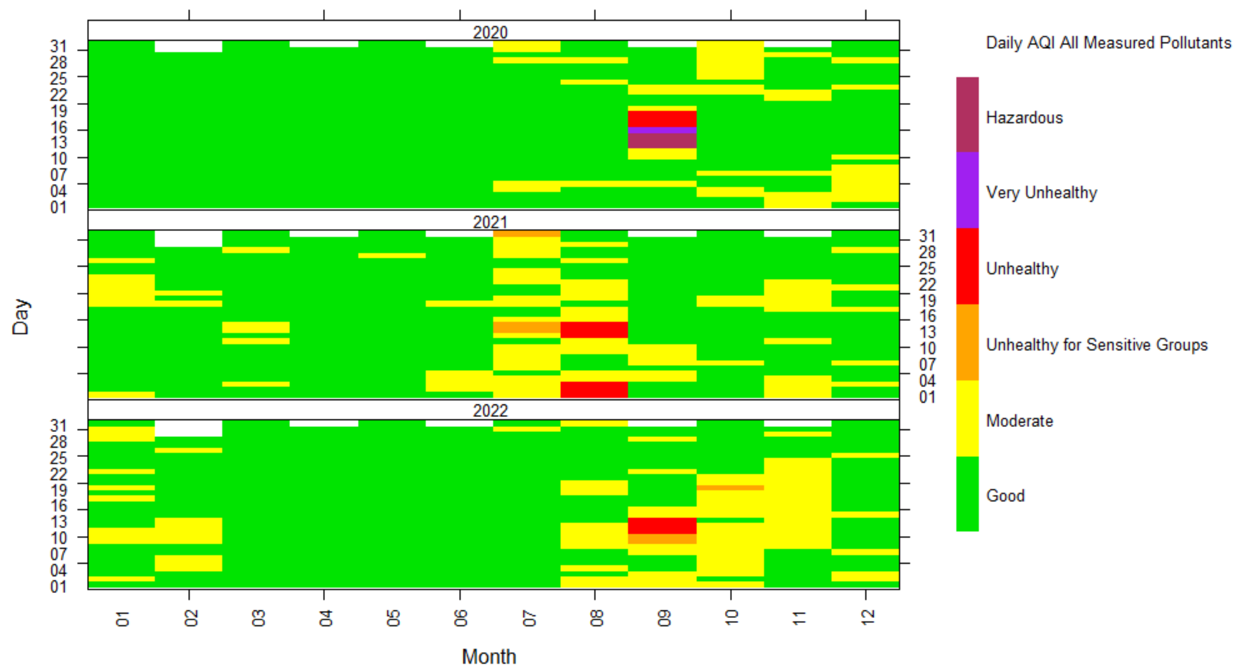

Figure 12. Calendar plot of daily maximum recorded air quality index from 2020-2022 for the Spokane and Spokane Valley community

$PM_{2.5}$ is most often the pollutant with the highest daily AQI measured in the Spokane area. Most days with an AQI "unhealthy for sensitive groups" or higher were from $PM_{2.5}$ (Figure 13). Otherwise, O_3 is usually the dominant pollutant with the highest AQI on days when particle pollution is low. Between 2020-2022, three days reached "unhealthy for sensitive groups" due to O_3 in July 2021.

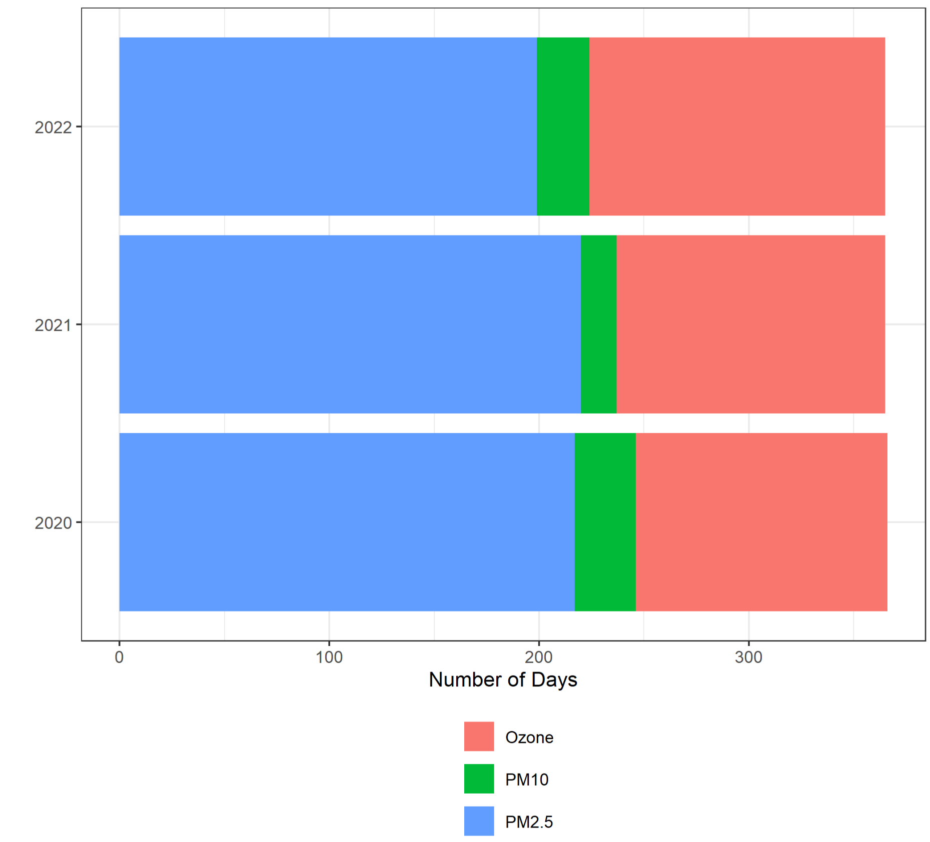

Figure 13. Dominant pollutant by AQI measured each day at monitoring sites for Spokane and Spokane Valley

Air quality modeling

Roadway NO_2

We modeled ambient 1-hour NO_2 concentrations from on-road mobile sources, which are the primary sources of NO_2 in Washington communities. Model parameters were selected to represent the conditions under which NO_2 concentrations would be highest (e.g., peak traffic volume, stable atmospheric conditions). The average modeled 1-hour NO_2 concentration across the area is 23.2 ppb. The modeled concentration representing peak near-road conditions, is 40.4 ppb. Figure 14 shows the relative distribution of roadway NO_2 across Spokane and Spokane Valley.

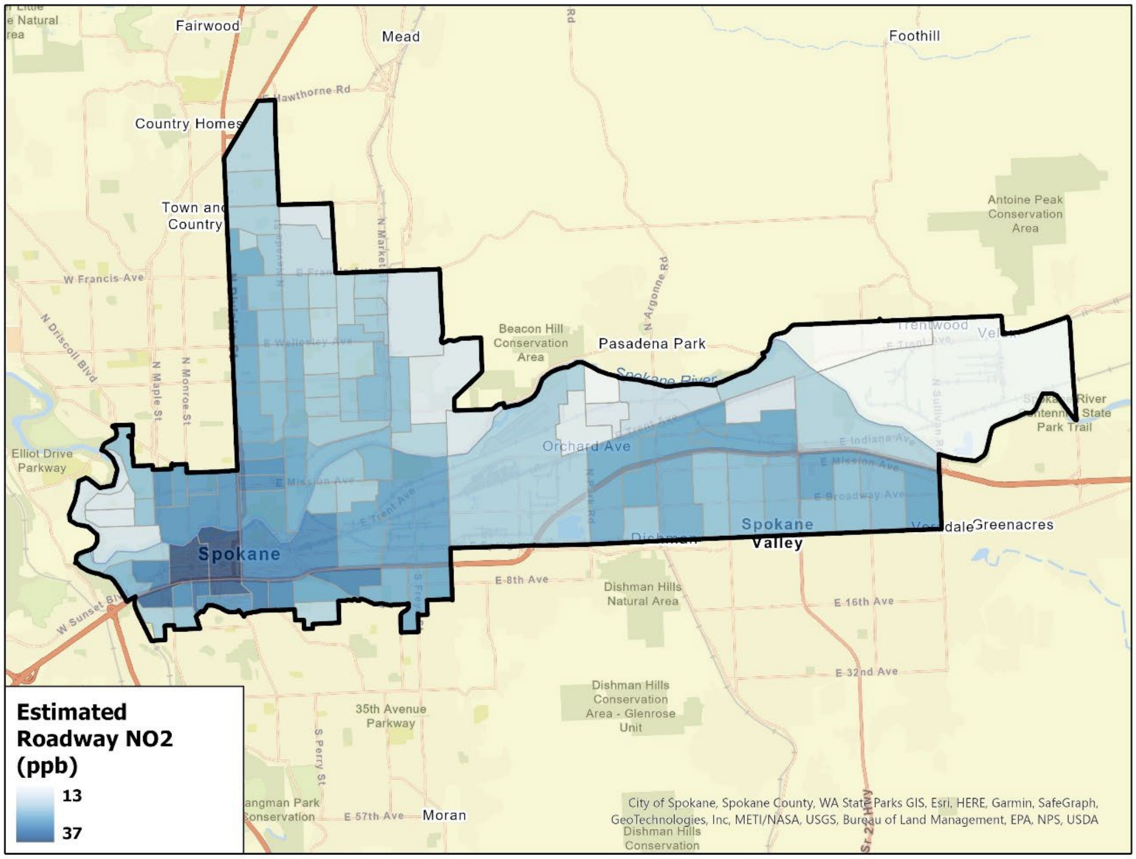

Figure 14. Average estimated 1-hour NO_2 concentration from on-road mobile sources by 2010 census block group in Spokane and Spokane Valley during weekday afternoon peak traffic under wintertime stable atmospheric conditions

Potential health impacts

Several economic factors indicate that populations within the Spokane and Spokane Valley community may be at greater risk of health impacts from air pollution, including high rates of poverty, unaffordable housing, and unemployment. The community on average experiences higher rates of asthma and lower life expectancy, compared to the rest of Washington State. The community has many schools, childcare facilities, multiple hospitals, and prisons. These are locations where occupants may be more vulnerable to the adverse health effects of pollution exposure.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 15). We estimated 65 all-cause deaths among all adults (0.52 deaths per 1,000 18-84-year-olds) associated with $PM_{2.5}$ in this community per year. By age, we found the largest impact on older adults, with an estimated 14 total deaths (0.62 deaths per 1,000 65–99-year-olds) each year associated with $PM_{2.5}$. The estimated death rates associated with $PM_{2.5}$ are higher than those for all overburdened communities highly impacted by air pollution, except for the all-cause death rate among older adults, which is lower.

Table 15. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in Spokane and Spokane Valley census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	64.2 [35.3 to 91.3]	0.52 [0.29 to 0.74]
Di et al.[54]	65 to 99	All	All-causes	14.0 [13 to 15]	0.62 [0.57 to 0.66]
Krewski et al. [52]	30 to 99	All	All-causes	37.0 [25 to 49]	0.44 [0.3 to 0.58]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	8.8 [7.2 to 10]	0.1 [0.08 to 0.12]
Krewski et al. [52]	30 to 99	All	Lung cancer	4.1 [1.8 to 6.3]	0.05 [0.02 to 0.07]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in Spokane and Spokane Valley. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

Five facilities in or nearby Spokane and Spokane Valley emitted a total of 411,237 MT CO_2e in 2020 and 434,028 MT CO_2e in 2021 (see Table 16).

Emissions are in units of metric tons of carbon dioxide equivalents (MT CO_2e) using AR4 global warming potentials as specified in WAC 173-441.

Table 16. Facilities and greenhouse gas emissions (MT CO_2e) in or nearby[64] Spokane and Spokane Valley

Facility Name and City	Facility Sector	Inside Community Boundary?	CCA-Covered Entity?	Major Source of CAPs? [65]	2020 Emissions [biogenic] (MT CO_2e)	2021 Emissions [biogenic] (MT CO_2e)
Boulder Park Generating Station – Spokane Valley	Power Plant	Nearby	Yes	No	23,578 [0]	34,396 [0]
Inland Empire Paper Company – Spokane	Pulp and Paper	Yes	No	Yes	34,724 [17,930]	34,507 [17,700]
Kaiser Aluminum (Trentwood Works) – Spokane Valley	Metals	Yes	Yes	Yes	106,233 [0]	110,563 [0]
Providence Sacred Heart Medical Center – Spokane	Healthcare	Yes	No	No	12,271 [0]	11,775 [0]
Spokane Waste to Energy Facility – Spokane	Power Plant	Nearby	Beginning in 2027	Yes	234,431 [140,581]	242,787 [141,607]

CAPs = criteria air pollutants, CCA = Climate Commitment Act, MT CO_2e = metric tons of carbon dioxide equivalent

Avista Corporation is a stationary source for a natural gas pipeline distribution system and bulk electricity transmission that runs through the community. However, they are excluded from the table and facility GHG totals because they report GHG emissions on a statewide basis for pipeline leaks and electrical transmission and distribution equipment. These Avista stationary

[64] For the purposes of this analysis, nearby is within 3 miles of the overburdened community boundary.
[65] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

sources are not CCA-covered entities, nor a major source of CAP emissions. Statewide emissions were 16,756 [0] MT CO_2e in 2020 and 21,787 [0] MT CO_2e in 2021.

Table 17. GHG estimates from mobile sources in Spokane and Spokane Valley

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
147,407	712,131	4.8

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future .

Additional resources

- Health resources:
  - Spokane Regional Health District
  - Better Health Together
- Reports and studies:
  - Odds Against Tomorrow: Health Inequities in Spokane County (2012), Spokane Regional Health District
  - Health-related Socioeconomic Inequalities in School Neighborhoods in Spokane, Washington, USA (2018), Washington State University
  - Fire and Smoke Impact Study for Spokane, Washington (2020), The Spokane Climate Project
- Greenhouse gas resources:
  - Spokane Greenhouse Gas Inventory (2019), City of Spokane

Tri-Cities to Wallula

Geographic description

The Tri-Cities to Wallula community has approximately 112,708 residents and spans approximately 173 square miles. It includes parts of Franklin, Walla Walla, and Benton Counties. In Benton County, air quality is managed by the Benton Clean Air Agency, and in Franklin and Walla Walla Counties, it is managed by Ecology's Eastern Regional Office. The community encompasses all or part of the Tri-Cities (Richland, Pasco, and Kennewick), Finley, Burbank, and Wallula. The Tri-Cities is the third largest metropolitan area in Washington and is surrounded by rural, primarily agricultural land. The part that is identified as overburdened and highly impacted by air pollution is located along the Columbia River in the Tri-Cities, as well as a sizeable portion of rural land to the East, including Wallula.

Levels of criteria air pollutants

The pollutants of concern in the Tri-Cities to Wallula community are primarily regional in scale. Ozone forms in the atmosphere on hot summer days when two forms of air pollution – nitrogen oxides (NO_x) and volatile organic compounds (VOCs) – react with sunlight. NO_x and VOCs come from many sources, but cars and trucks are the largest contributors. Conditions in the Tri-Cities area, including prevailing winds, push ground-level ozone up against the Horse Heaven Hills, where it can become concentrated in the basin over more populated areas. PM_{10} and $PM_{2.5}$ also collect in the basin, and come from sources like windblown dust from construction, agriculture, or open lands, outdoor and agricultural burning, residential wood burning, wildfires, mobile sources like cars and trucks, and industrial sources.

While the community is in attainment with the national ambient air quality standards for criteria air pollution, it does experience high levels of ozone and particulate matter when compared to the rest of Washington state. This area is subject to windblown dust storms and wildfire smoke, which can lead to temporary spikes in unhealthy air quality. Previous modeling or air emissions inventory results have shown that concentrations of other criteria air pollutants (CO, lead, SO_2) are likely to be low in this area.[66,67]

Air quality monitoring

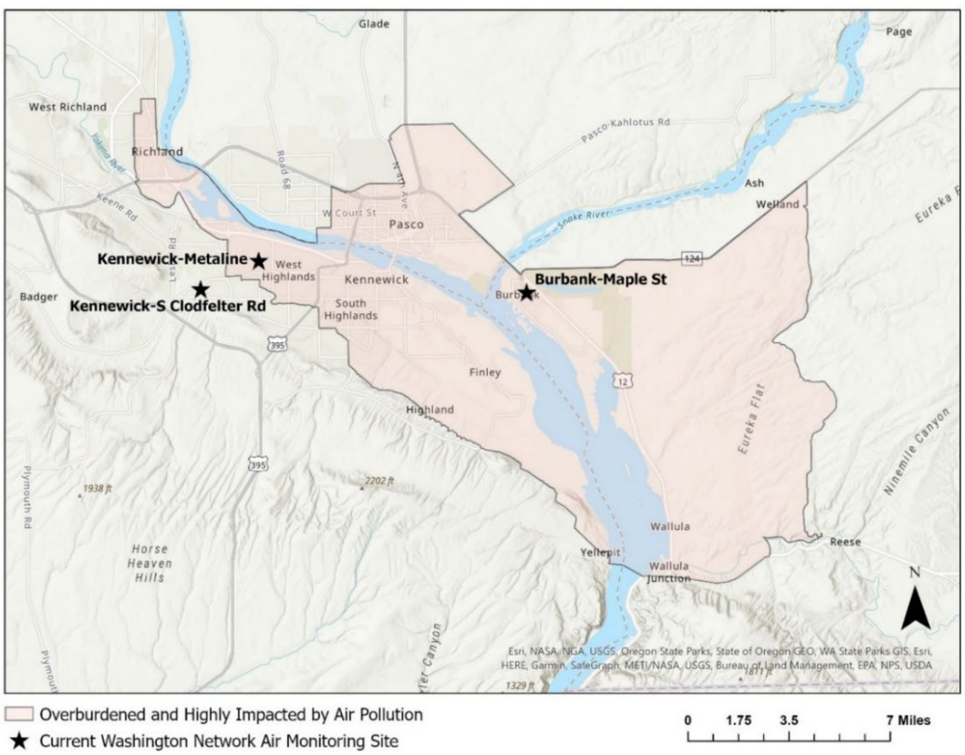

Figure 15. Tri-Cities to Wallula community boundaries and air monitoring sites

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66 https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe

67 https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory

Table 18. Tri-Cities to Wallula monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
Kennewick-Metaline	Benton Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	No
		PM_{10}	Neighborhood (0.5-4 km)	Yes
Kennewick-S Clodfelter	Benton Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	No
		O_3	Urban (4-50 km)	Yes
Burbank-Maple St	Ecology	$PM_{2.5}$	Neighborhood (0.5-4 km)	No
		PM_{10}	Neighborhood (0.5-4 km)	Yes

PM = particulate matter, O_3 = ozone

There are currently three monitoring sites within or near the community boundaries (Figure 15; Table 18), with more to be added in 2024 following community engagement. Monitoring shows the area routinely experiences high short-term levels of both $PM_{2.5}$ and PM_{10}. These pollution spikes are primarily attributable to wildfire smoke and high wind dust events. When wildfire days are excluded, measured levels of $PM_{2.5}$ are significantly lower, with annual 98th percentile concentrations around 14-21 µg/m^3. Also, the annual fourth highest O_3 values in the Tri-Cities area have gotten close to the national standard of 0.070 ppm, as in 2021.

Table 19. Criteria air pollutant annual and 3-year summary statistics for Tri-Cities to Wallula monitoring sites for 2020-2022. A red box indicates a value above the NAAQS. Numbers in brackets [] indicates wildfire days >35.4 µg/m³ $PM_{2.5}$ have been removed.

Pollutant	Form	NAAQS Level	Site Name	2020	2021	2022	3-year Design Value*
$PM_{2.5}$ 24-hour (µg/m³)	98th percentile	35	Kennewick-Metaline	76.5 [14.3]	28.6 [16.1]	17.1 [15.9]	41 [15]
			Kennewick-S Clodfelter	DNC	DNC	25.7 [18.5]	N/A
			Burbank-Maple St	DNC	DNC	56.1 [21.3]	N/A
PM_{10} 24-hour (µg/m³)	# of annual exceedances >150 µg/m³	1	Kennewick-Metaline	12.5	2.1	0	4.9
			Burbank-Maple St	9.5	1.1	0	3.5
O_3 8-hour (ppm)	Annual fourth-highest daily maximum	0.070	Kennewick-S Clodfelter	0.061	0.068	0.064	0.064

DNC = data not collected, NAAQS = national ambient air quality standards, PM = particulate matter, µg/m³ = micrograms per cubic meter

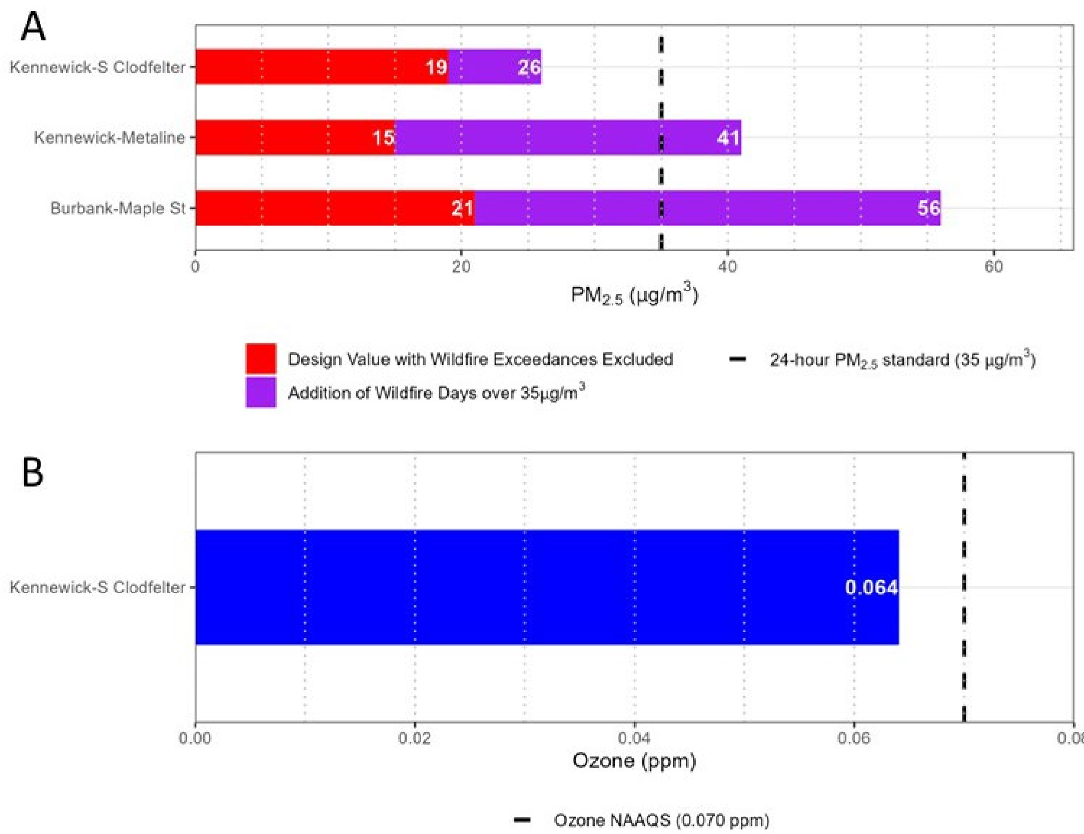

Figure 16. 2022 design values for A) 24-hour PM2.5 and B) Ozone at Tri-Cities to Wallula monitoring sites. Note that $PM_{2.5}$ design values at Kennewick-S Clodfelter and Burbank-Maple St are biased because of missing data (see Table 19).

For both $PM_{2.5}$ and O_3, it is helpful to look at average ambient concentrations at different times of the year. During the summer, the dominant source of $PM_{2.5}$ is usually wildfire smoke, whereas in colder months (October-March), the primary source is wood burning for home heating. Between 2020 and 2022 the average level of $PM_{2.5}$ has been higher in the warm season. This also overlaps with when O_3 is highest. Because O_3 requires sunlight to form, it is highest from May to September in Washington. In the Tri-Cities, O_3 is only measured during this period.

Table 20. Seasonal and annual means for $PM_{2.5}$ and seasonal means for O_3 for Tri-Cities to Wallula monitoring sites, 2020-2022

Pollutant	Site	Season/annual mean	2020	2021	2022*	3-year mean
$PM_{2.5}$ (µg/m^3)	Kennewick-Metaline	Warm Season (April-September)	11.50	7.99	5.77	8.4
		Cold Season (October-March)	5.69	4.20	5.33	5.1
		Annual	8.55	5.77	5.55	6.6
$PM_{2.5}$ (µg/m^3)	Kennewick-S Clodfelter	Warm Season (April-September)	DNC	DNC	5.26	N/A
		Cold Season (October-March)	DNC	DNC	6.67	N/A
		Annual	DNC	DNC	4.95	N/A
$PM_{2.5}$ (µg/m^3)	Burbank-Maple St	Warm Season (April-September)	DNC	DNC	10.25	N/A
		Cold Season (October-March)	DNC	DNC	7.61	N/A
		Annual	DNC	DNC	9.10	N/A
O_3 (ppm)	Kennewick-S Clodfelter	Ozone Season (May-September)	0.041	0.047	0.043	0.044

DNC = data not collected, PM = particulate matter, O_3 = ozone, ppm = parts per million, µg/m^3 = micrograms per cubic meter

*In 2022, seasonal means are adjusted April-October 21 and October 22-March due to wildfires in October.

Large spikes in $PM_{2.5}$ and PM_{10} occur during wildfire smoke and dust storm events. Figure 17 shows unhealthy AQI levels were measured all three years in August and September, when wildfire activity is highest. Levels of O_3 are more consistently elevated in the summer months.

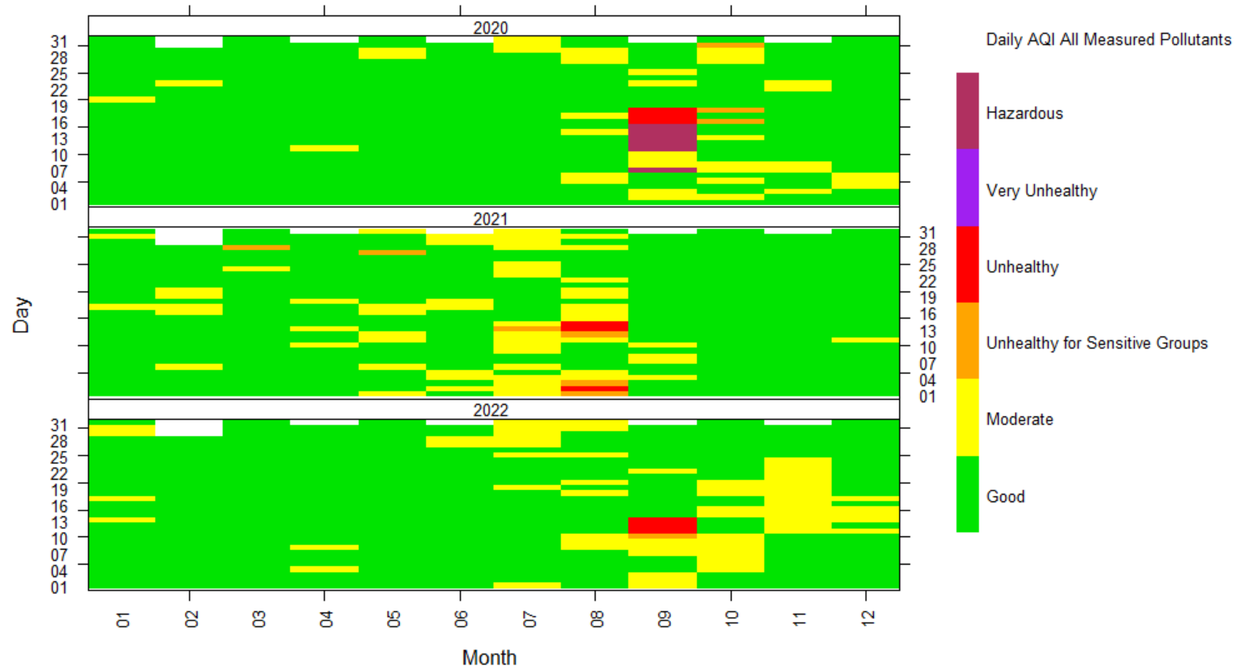

Figure 17. Calendar plot of daily maximum recorded air quality index from 2020-2022 for the Tri-Cities to Wallula community

In this area, the dominant pollutant, or the pollutant with the daily highest recorded air quality index, is spread out between $PM_{2.5}$, PM_{10}, and O_3 (Figure 18). All three of these pollutants contribute to health impacts and the cumulative environmental and health burden from air pollution exposure.

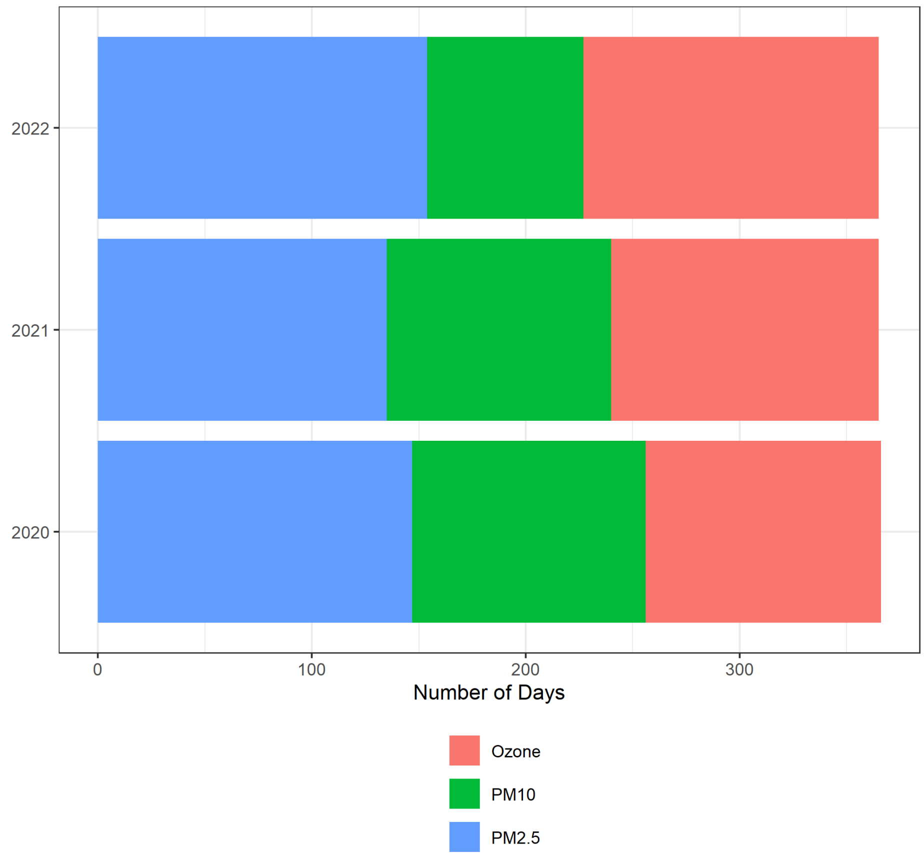

Figure 18. Dominant pollutant by AQI measured each day at monitoring sites for the Tri-Cities to Wallula community

Air quality modeling

Roadway NO_2

We modeled ambient 1-hour NO_2 concentrations from on-road mobile sources, which are the primary sources of NO_2 in Washington communities. Model parameters were selected to represent the conditions under which NO_2 concentrations would be highest (e.g., peak traffic volume, stable atmospheric conditions). The average modeled 1-hour NO_2 concentration across the area is 9.3 ppb. The modeled concentration representing peak near-road conditions, is 30.0 ppb. Figure 19 shows the relative distribution of roadway NO_2 across Tri-Cities. Some areas of the identified community were left out due to model restrictions and low expected mobile NO_2 emissions in less densely populated block groups.

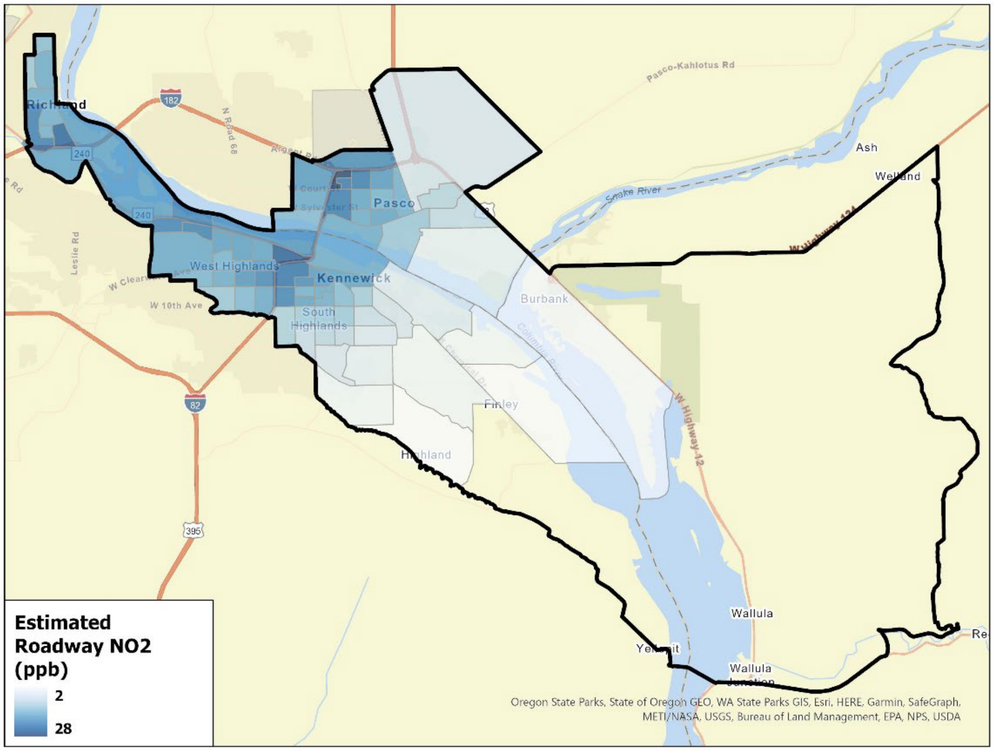

Figure 19. Average estimated 1-hour NO_2 concentration from on-road mobile sources by 2010 census block group in Tri-Cities to Wallula during weekday afternoon peak traffic under wintertime stable atmospheric conditions (some census block groups missing due to spatial limitations of model)

Potential health impacts

Several socioeconomic and health factors indicate that parts of the Tri-Cities to Wallula community may be more vulnerable to air pollution impacts, including high rates of poverty. Some parts of the community also have higher rates of asthma and relatively lower life expectancy compared to the rest of the state. The community has many locations where occupants may be more vulnerable to the adverse effects of pollution exposure, such as childcare facilities, schools, healthcare facilities, and nursing homes.

We estimated the number and rates of death by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 21). We estimated 37 all-cause deaths among all adults (0.40 deaths per 1,000 18-84-year-olds) each year associated with $PM_{2.5}$ in this community. By age group, we found the largest impact on older adults, with an estimated 9 total deaths (0.50 deaths per 1,000 65–99-year-olds) each year associated with $PM_{2.5}$. The estimated death rates associated with $PM_{2.5}$ in this community are similar to those reported for all overburdened communities highly impacted by air pollution, except for the all-cause death rate for older adults, which is lower.

Table 21. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in Tri-Cities to Wallula census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al.[53]	18 to 84	All	All-causes	37.0 [20.7 to 52.1]	0.40 [0.22 to 0.56]
Di et al.[54]	65 to 99	All	All-causes	9.1 [8.3 to 9.8]	0.50 [0.45 to 0.54]
Krewski et al.[52]	30 to 99	All	All-causes	17.0 [12 to 23]	0.25 [0.17 to 0.33]
Krewski et al.[52]	30 to 99	All	Ischemic heart disease	5.4 [4.4 to 6.3]	0.08 [0.06 to 0.09]
Krewski et al.[52]	30 to 99	All	Lung cancer	2.4 [1.0 to 3.6]	0.03 [0.01 to 0.05]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in this community. There are also other pollutants of concern in the Tri-Cities area, including O_3 and PM_{10}, that are associated with additional health impacts. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

Eight facilities in or nearby Tri-Cities to Wallula emitted a total of 1,437,956 MT CO_2e in 2020 and 1,418,691 MT CO_2e in 2021 (see Table 22).

Emissions are in units of metric tons of carbon dioxide equivalents (MT CO_2e) using AR4 global warming potentials as specified in WAC 173-441.

Table 22. Facilities and greenhouse gas emissions (MT CO_2e) in or nearby[68] Tri-Cities to Wallula

Facility Name and City	Facility Sector	Inside Community Boundary?	CCA-Covered Entity?	Major source of CAPs? [69]	2020 emissions [biogenic] (MT CO_2e)	2021 emissions [biogenic] (MT CO_2e)
Gas Transmission Northwest Compressor Station 8 - Wallula	Natural Gas Systems	Nearby	Yes	Yes	135,772 [0]	136,751 [0]
Lamb Weston - Pasco	Food Production	Nearby	Yes	No	38,996 [0]	40,297 [0]
Lamb Weston - Richland	Food Production	Nearby	Yes	No	86,387 [11,549]	84,268 [10,027]
Nutrien US LLC - Kennewick	Chemicals	Yes	Yes	Yes	144,928 [0]	186,638 [0]
Packaging Corporation of America -Wallula	Pulp and Paper	Yes	Yes	Yes	853,083 [630,030]	801,746 [568,917]
Pasco Processing LLC - Pasco	Food Production	Yes	No	No	16,449 [0]	23,073 [0]
Simplot Feeders LTD - Burbank	Livestock	Yes	Exempt	No	32,477 [0]	39,056 [0]
Tyson Fresh Meats Inc. - Wallula	Food Production	Yes	Yes	No	129,863 [0]	106,862 [0]

CAPs = criteria air pollutants, CCA = Climate Commitment Act, MT CO_2e = metric tons of carbon dioxide equivalent

Cascade Natural Gas Corporation is a stationary source for a natural gas pipeline distribution system that runs through the community. However, they are excluded from the table and facility GHG totals because they report GHG emissions on a statewide basis for pipeline leaks,

[68] For the purposes of this analysis, nearby is within 3 miles of the overburdened community boundary.
[69] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

such as methane. This facility is not a CCA-covered entity, nor a source of CAP emissions. Statewide emissions were 23,564 [0] MT CO_2e in 2020 and 24,418 [0] MT CO_2e in 2021.

Table 23. GHG estimates from mobile sources in Tri-Cities to Wallula

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
112,708	684,906	6.1

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future .

Additional resources

- Air pollution resources:
  - Benton Clean Air Agency
  - Ozone Forecast Tool, Washington State University
  - Studies and reports:
    - The Tri-Cities Ozone Precursor Study (T-COPS) (2017), Washington State University & Ecology – investigated causes of high ozone in the Tri-Cities
- Health resources:
  - Benton-Franklin Health District
  - Walla Walla County Department of Community Health
  - Greater Health Now
- Benton-Franklin Trends

East Yakima

Geographic description

East Yakima is a community in Yakima County, located in the upper Yakima Valley. Air quality is managed by the Yakima Regional Clean Air Agency. The East Yakima community is approximately 15.8 square miles, with a population of about 59,803 people. The community also contains Union Gap on the south end. This area is in a valley and is surrounded by agricultural land outside of the city.

Levels of criteria air pollutants

The main pollutants of concern that we identified for this community are long-term and short-term $PM_{2.5}$, as well as cumulative criteria air pollution, which is again primarily driven by levels of $PM_{2.5}$, with some contribution from O_3 and NO_2. Ozone and NO_2 are not monitored in the East Yakima community but were interpolated statewide using model output and monitoring data elsewhere in Washington. Previous modeling or air emissions inventory results have also shown that concentrations of other criteria air pollutants (CO, lead, SO_2) are likely to be low in this area.[70,71] East Yakima often experiences elevated levels of $PM_{2.5}$ year-round, when compared to the rest of the state. Yakima is situated in a valley, which can act as a funnel for air pollution. Temperature inversions, which keep pollution trapped close to the ground, are a common reason for elevated levels of $PM_{2.5}$ in the wintertime.

Air quality monitoring

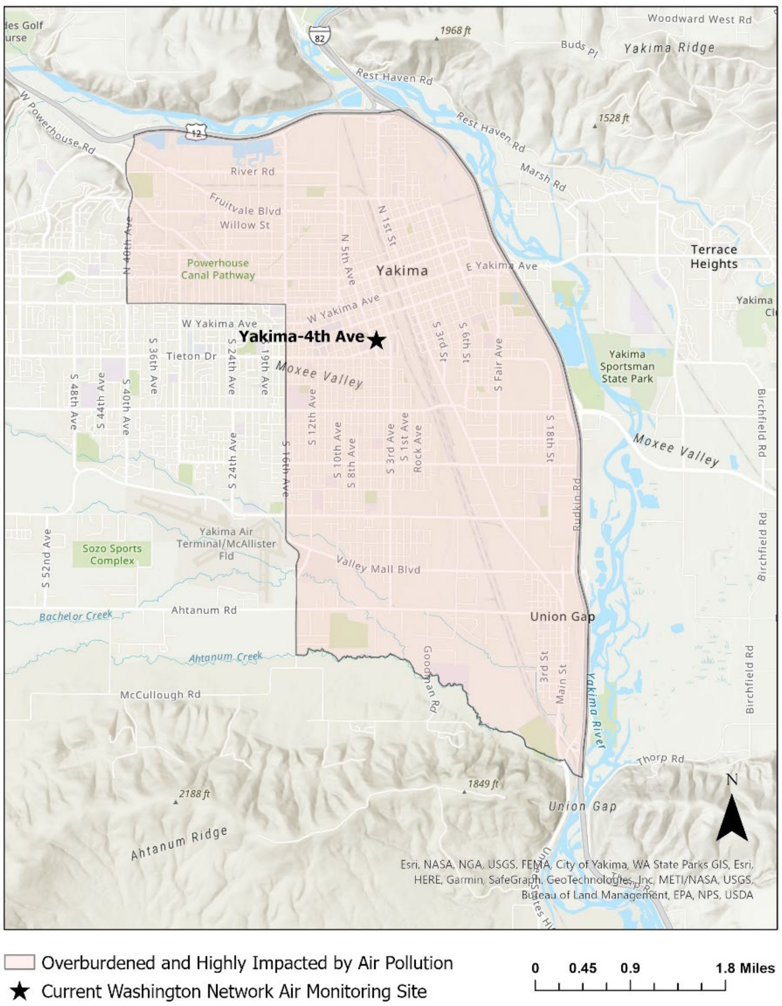

Figure 20. East Yakima community boundaries and air monitoring sites

70 https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe

71 https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory

Table 24. East Yakima monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
Yakima-4th Ave	Yakima Regional Clean Air Agency	$PM_{2.5}$, PM_{10}	Neighborhood (0.5-4 km)	Yes

PM = particulate matter

There is currently one monitoring station for $PM_{2.5}$ and PM_{10} in Ecology's network in this community, which is centrally located in East Yakima on 4th Ave (Figure 20; Table 24). More monitoring stations will be added in 2024, with community input. Yakima routinely experiences spikes in both $PM_{2.5}$ and PM_{10} pollution. In 2020 and 2021, annual 98th percentile concentrations exceeded the 24-hour NAAQS for $PM_{2.5}$ and PM_{10}. These elevated concentrations, and the variability year-to-year, are primarily attributable to wildfire smoke events. With wildfire excluded, the annual 98th percentile concentrations for $PM_{2.5}$ are more consistent, around 28 $\mu g/m^3$. While below the national air quality standard of 35 $\mu g/m^3$, they are higher than Ecology's healthy air goal of 20 $\mu g/m^3$.

Table 25. Criteria air pollutant annual and 3-year summary statistics for East Yakima monitoring sites for 2020-2022. A red box indicates a value above the NAAQS. Numbers in brackets [] indicates wildfire days >35.4 $\mu g/m^3$ $PM_{2.5}$ have been removed.

Pollutant	Form	NAAQS Level	Site Name	2020	2021	2022	3-year Design Value
$PM_{2.5}$ 24-hour ($\mu g/m^3$)	98th Percentile	35	Yakima-4th Ave*	*104.6 [26.7]*	69.4 [27.1]	29.4 [29.0]	*68 [28]*
PM_{10} 24-hour ($\mu g/m^3$)	# of annual exceedances >150 $\mu g/m^3$	1	Yakima-4th Ave*	*8.2*	1	0	*3.1*

*The Yakima-4th Ave monitor was not operating 9/19/2020-11/1/2020. As a result, summary statistics may be biased from missing data for this year (incomplete data denoted in italics).

NAAQS = national ambient air quality standards, PM = particulate matter, $\mu g/m^3$ = micrograms per cubic meter

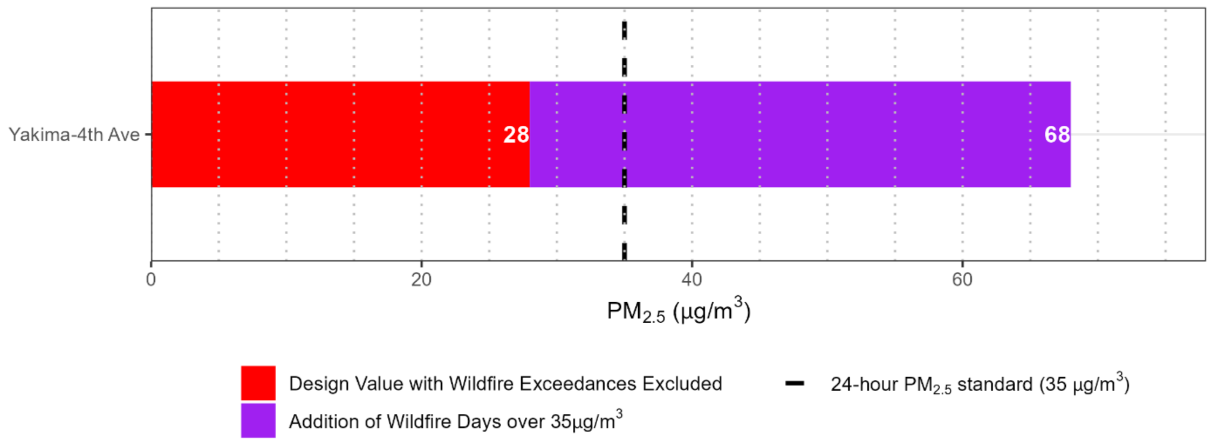

Figure 21. 24-hour $PM_{2.5}$ 2022 design value at East Yakima monitoring site

When there is less wildfire smoke, wintertime $PM_{2.5}$ in this area is usually higher than summertime, as it was in 2022 (Table 26). This pattern is visible in the calendar plot (Figure 22). Pollution levels are more likely to sharply spike in August and September when wildfire smoke is highest. Levels remain more consistently elevated, usually in the moderate AQI range, throughout the winter months. Altogether, Yakima experiences elevated long-term levels of $PM_{2.5}$. In 2020, the annual $PM_{2.5}$ mean exceeded the NAAQS level of 12 µg/m^3.

Particulate matter comes predominantly from woodburning related to home heating in the wintertime. A significant portion of wintertime $PM_{2.5}$ also forms from other pollutants in the atmosphere, including ammonia and oxides of nitrogen. Ecology and our partners conducted a study on this type of particle pollution in Yakima in 2013.[72]

[72] https://apps.ecology.wa.gov/publications/documents/1402002.pdf

Table 26. Seasonal and annual means for $PM_{2.5}$ for East Yakima monitoring sites, 2020-2022

Pollutant	Site	Season/annual mean	2020	2021	2022*	3-year mean
$PM_{2.5}$ (µg/m^3)	Yakima-4th Ave**	Warm Season (April-September)	13.00	13.95	7.07	11.3
		Cold Season (October-March)	*10.09*	8.31	11.84	*10.1*
		Annual	*12.30*	10.99	9.14	*10.8*

PM = particulate matter, µg/m^3 = micrograms per cubic meter

*In 2022, seasonal means are adjusted April-October 21 and October 22-March due to wildfires in October.

**The Yakima-4th Ave monitor was not operating 9/19/2020-11/1/2020 (incomplete data denoted in italics).

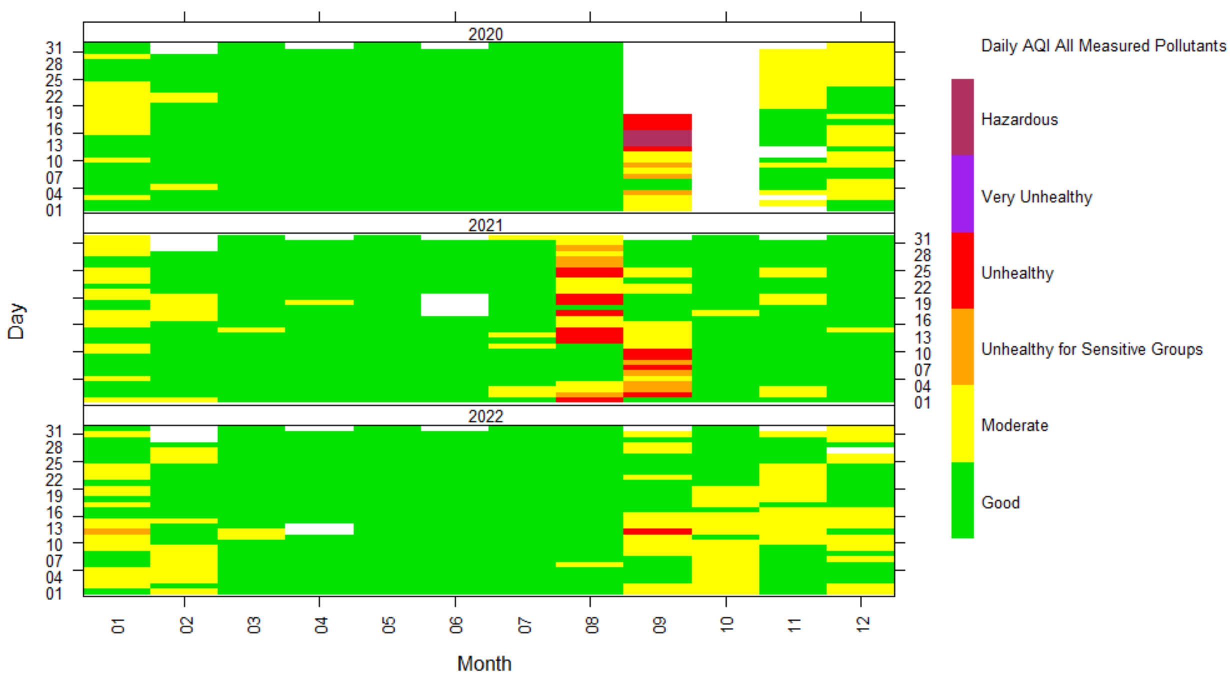

Figure 22. Calendar plot of daily maximum recorded air quality index from 2020-2022 for the East Yakima community

In East Yakima, $PM_{2.5}$ usually had a higher AQI than PM_{10} (Figure 23), and thus is of greater concern for health. Although, all pollutants together, including those not measured, can contribute to the overall health burden from air pollution exposure.

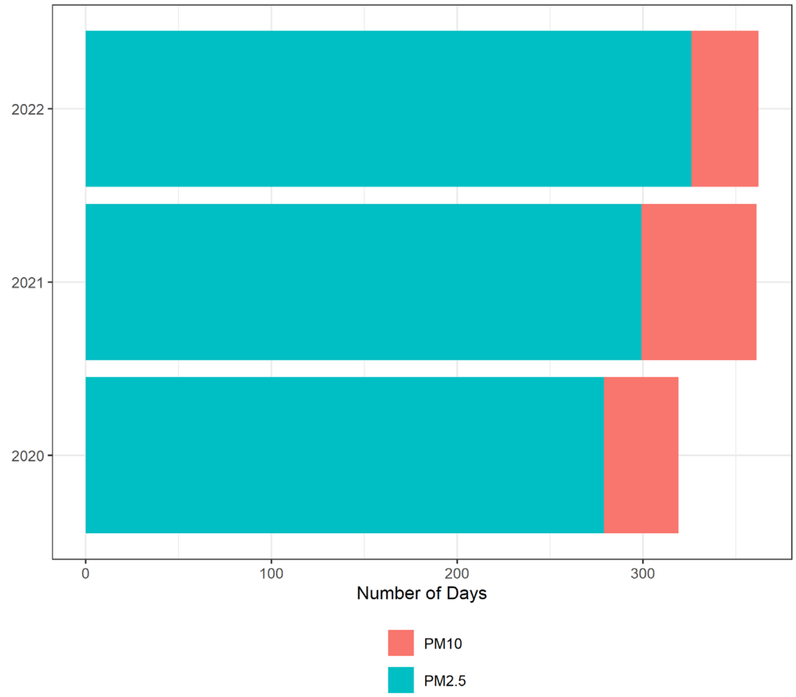

Figure 23. Dominant pollutant by AQI measured each day at monitoring sites for East Yakima

Air quality modeling

Roadway NO_2

We modeled ambient 1-hour NO_2 concentrations from on-road mobile sources, which are the primary sources of NO_2 in Washington communities. Model parameters were selected to represent the conditions under which NO_2 concentrations would be highest (e.g., peak traffic volume, stable atmospheric conditions). The average modeled 1-hour NO_2 concentration across the area is 13.0 ppb. The modeled concentration representing peak near-road conditions, is 29.4 ppb. Figure 24 shows the relative distribution of roadway NO_2 across Easy Yakima.

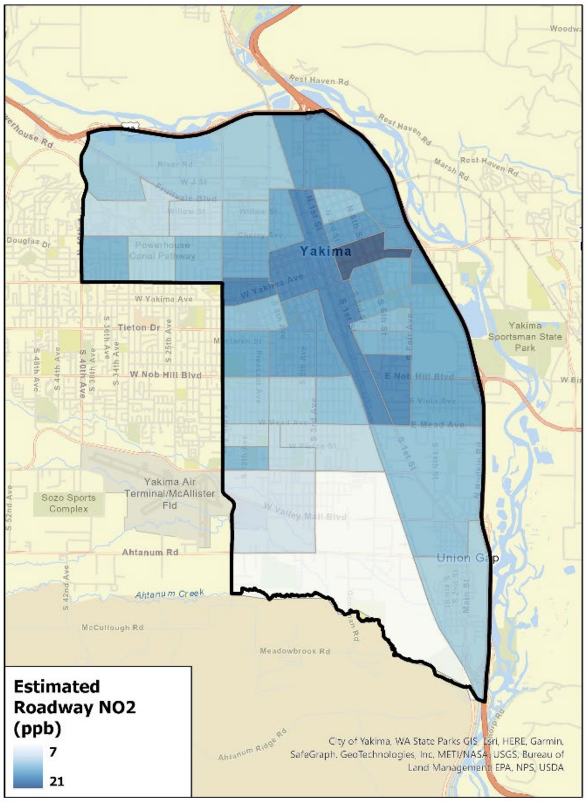

Figure 24. Average estimated 1-hour NO_2 concentration from on-road mobile sources by 2010 census block group in East Yakima during weekday afternoon peak traffic under wintertime stable atmospheric conditions

Ozone

For East Yakima, the average estimated 8-hour O_3 design value during July 2014 through June 2017 was 0.057 ppm. Long-term O_3 monitoring across the state has shown that O_3 levels in Washington have stayed relatively consistent over time, although spikes may occur during severe heat, drought, or wildfire events.

Potential health impacts

Several factors indicate that some groups in East Yakima may be more vulnerable to air pollution, including people of color and low-income residents. The community experiences relatively high rates of asthma, chronic obstructive pulmonary disease, and cardiovascular disease compared to the statewide average. The community has many schools, childcare facilities, health clinics, long term care facilities, and migrant farmworker housing. These are locations where occupants may be more vulnerable to the adverse effects of pollution exposure.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 27). We estimated 34 all-cause deaths among all adults (0.84 deaths per 1,000 18-84-year-olds) each year associated with $PM_{2.5}$ in this community. By age group, we found the largest impact on older adults, with an estimated 11 all-cause deaths (1.17 deaths per 1,000 65–99-year-olds) each year associated with $PM_{2.5}$. Estimated death rates associated with $PM_{2.5}$ in this area are the highest of all 16 identified overburdened communities in this report. Within the East Yakima community, older adults had the highest estimated all-cause death rate (1.17 deaths per 1,000 65–99-year-olds). Moreover, the estimated death rate for ischemic heart disease associated with $PM_{2.5}$ is twice as high as the rate among all overburdened communities highly impacted by air pollution.

Table 27. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in East Yakima census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	33.8 [18.7 to 47.9]	0.84 [0.46 to 1.18]
Di et al.[54]	65 to 99	All	All-causes	10.1 [9.1 to 11]	1.17 [1.06 to 1.27]
Krewski et al. [52]	30 to 99	All	All-causes	15.0 [10.0 to 20.0]	0.52 [0.35 to 0.68]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	5.8 [4.7 to 6.8]	0.2 [0.16 to 0.23]
Krewski et al. [52]	30 to 99	All	Lung cancer	1.4 [0.6 to 2.1]	0.05 [0.02 to 0.07]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in East Yakima. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

Two facilities in or nearby East Yakima emitted a total of 30,871 MT CO_2e in 2020 and 25,554 MT CO_2e in 2021 (see Table 28).

Emissions are in units of metric tons of carbon dioxide equivalents (MT CO_2e) using AR4 global warming potentials as specified in WAC 173-441.

Table 28. Facilities and greenhouse gas emissions (MT CO_2e) in or nearby[73] East Yakima

Facility Name and City	Facility Sector	Inside Community Boundary?	CCA-Covered Entity?	Major source of CAPs?[74]	2020 emissions [biogenic] (MT CO_2e)	2021 emissions [biogenic] (MT CO_2e)
Michelsen Packaging - Yakima	Pulp and Paper	Yes	No	No	10,532 [0]	10,481 [0]
Tree Top - Selah	Food Production	Nearby	No	No	20,339 [0]	15,073 [0]

CAPs = criteria air pollutants, CCA = Climate Commitment Act, MT CO_2e = metric tons of carbon dioxide equivalent

Table 29. GHG estimates from mobile sources in East Yakima

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
59,803	328,369	5.5

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future .

Additional resources

- Air pollution resources:
  - Yakima Regional Clean Air Agency
  - Studies and reports:
    - Yakima Air Wintertime Nitrate Study (YAWNS) Report (2014), Washington State University – studied the conditions that led to high nitrate in wintertime $PM_{2.5}$
- Health resources:

[73] For the purposes of this analysis, nearby is within 3 miles of the overburdened community boundary.
[74] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

- Yakima Health District
- Greater Health Now
- Yakima Valley Farm Workers Clinic

Lower Yakima Valley

Geographic description

The Lower Yakima Valley intersects both Yakima County and Benton County. Air quality is managed by either the Yakima Regional Clean Air Agency or the Benton Clean Air Agency in the corresponding counties. This area has approximately 54,838 residents and spans 157 square miles. It includes the cities of Granger, Outlook, Sunnyside, Mabton, Grandview, Apricot, and Prosser. The Lower Yakima Valley is primarily an agricultural community with a high density of dairy farms.

Levels of criteria air pollutants

The main pollutants of concern that we identified for this community are long-term (annual) and short-term (24-hour) $PM_{2.5}$, as well as cumulative criteria air pollution, which is again primarily driven by levels of $PM_{2.5}$, with some contribution from O_3 and NO_2. The Lower Yakima Valley often experiences elevated levels of $PM_{2.5}$ year-round, when compared to the rest of the state. Particulate matter comes from sources like wildfire smoke, silvicultural and prescribed burning, residential and agricultural burning, and agricultural dust. The community is situated in a valley, which can act as a funnel for air pollution. Temperature inversions, which keep pollution trapped close to the ground, are a common reason for elevated levels of $PM_{2.5}$ in the wintertime. Previous modeling or air emissions inventory results have shown that concentrations of other criteria air pollutants (CO, lead, SO_2) are likely to be low in this area.[75,76]

Air quality monitoring

There are currently two monitoring stations in Ecology's network in the Lower Yakima Valley located in Sunnyside and Prosser (Figure 25; Table 30). Additional air quality monitoring sites will be added in 2024, with community engagement.

[75] https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe
[76] https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory

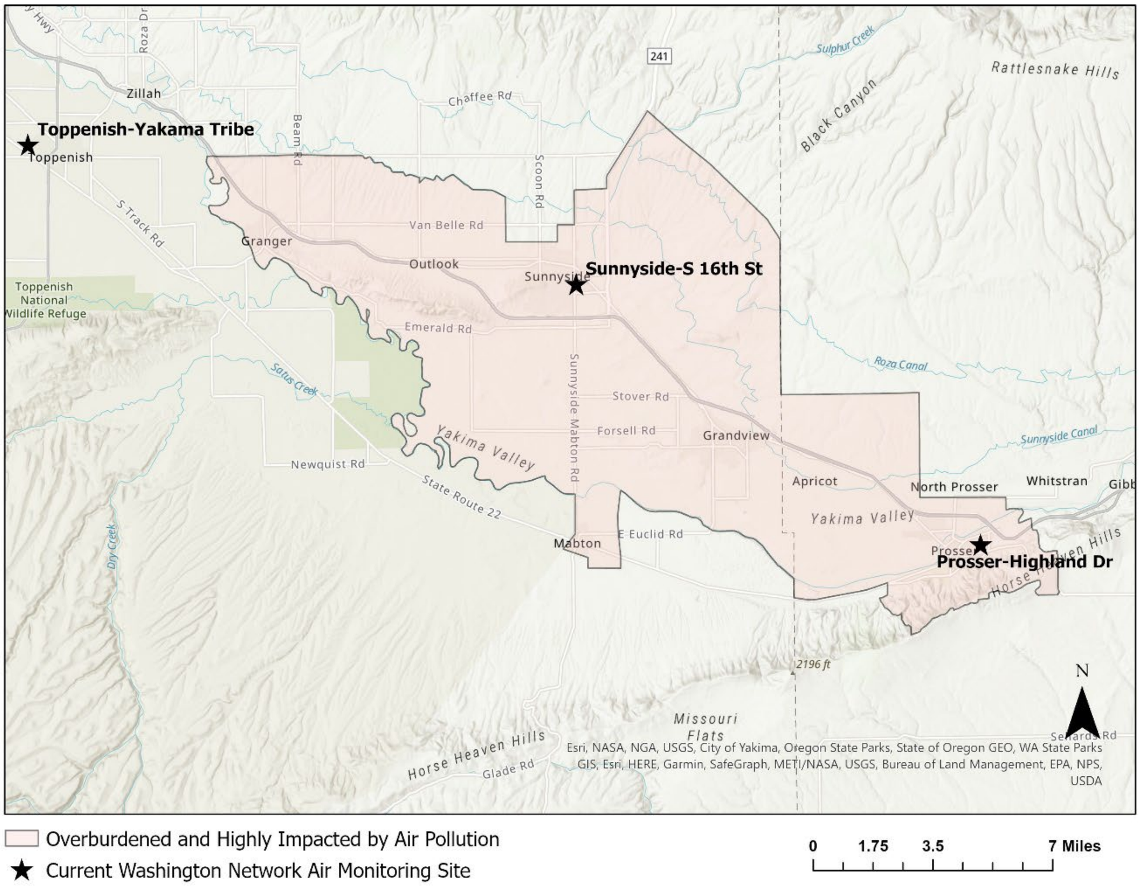

Figure 25. Lower Yakima Valley community boundaries and air monitoring sites

Table 30. Lower Yakima Valley monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
Sunnyside-S 16th St	Yakima Regional Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	No
Prosser-Highland Dr	Benton Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	No

The Lower Yakima Valley routinely experience spikes in $PM_{2.5}$. In 2020 and 2021, annual 98th percentile concentrations exceeded the 24-hour NAAQS for $PM_{2.5}$. The elevated concentrations, and the variability year to year, are attributable primarily to wildfire smoke events. With wildfire excluded, the annual 98th percentile concentrations for $PM_{2.5}$ were more consistent, around 31 µg/m^3 in Sunnyside. While lower than the national air quality standard of 35 µg/m^3, they are higher than Ecology's healthy air goal of 20 µg/m^3.

Table 31. Criteria air pollutant annual and 3-year summary statistics for Lower Yakima Valley monitoring sites for 2020-2022. A red box indicates a value above the NAAQS. Numbers in brackets [] indicates wildfire days >35.4 µg/m³ $PM_{2.5}$ have been removed.

Pollutant	Form	NAAQS Level	Site Name	2020	2021	2022	3-year Design Value*
$PM_{2.5}$ 24-hour (µg/m³)	98th percentile	35	Sunnyside-S 16th St	118.1 [29.0]	42.3 [32.0]	34.4 [32.8]	65 [31]
			Prosser-Highland Dr*	DNC	DNC	*21.7 [21.7]*	N/A

DNC = data not collected, NAAQS = national ambient air quality standards, PM = particulate matter, µg/m³ = micrograms per cubic meter

*The Prosser monitor was installed in November 2022, so this data only represents the last two months of that year (incomplete data denoted in italics).

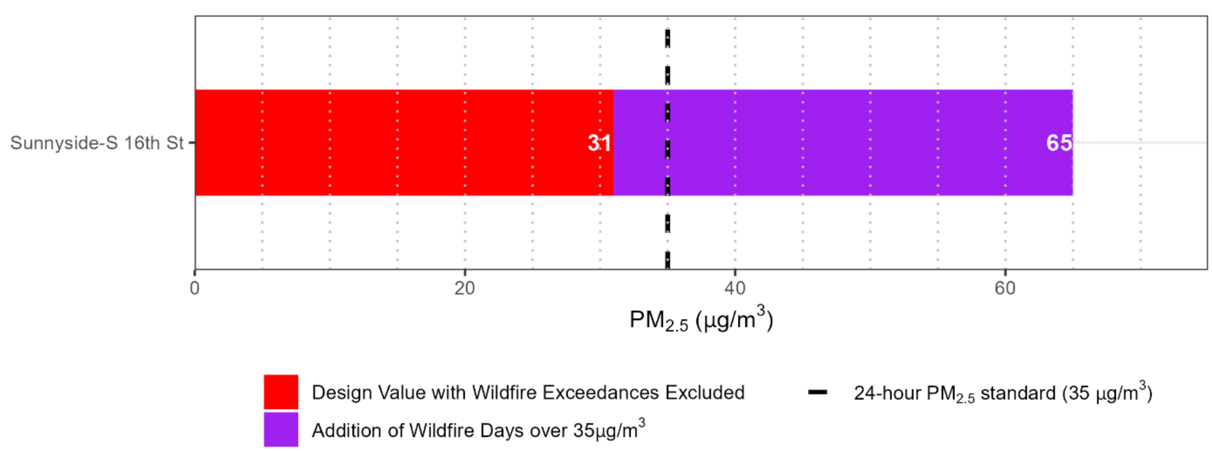

Figure 26. 24-hour $PM_{2.5}$ 2022 design value for Sunnyside-S 16th St monitoring site

Particle pollution in Washington varies seasonally. When there is less wildfire smoke, wintertime $PM_{2.5}$ in this area is usually higher than summertime, as it was in 2022 (Table 32). This pattern is visible in the calendar plot for Lower Yakima Valley (Figure 27). Pollution levels tend to sharply spike in August and September when wildfire smoke is highest. Levels remain more consistently elevated, usually in the moderate AQI range, throughout the winter months. Altogether, Lower Yakima Valley experiences elevated long-term levels of $PM_{2.5}$. In 2020, and on average 2020-2022, the annual $PM_{2.5}$ mean exceeded the NAAQS level of 12 µg/m³.

Particulate matter comes predominantly from woodburning related to home heating in the wintertime. A significant portion of wintertime $PM_{2.5}$ also forms from other pollutants in the atmosphere, like nitrates. Ecology and our partners conducted a study on this type of particle pollution in Yakima in 2013.[77] Prescribed and agricultural burning also tends to occur in Fall and Spring, and depend on local conditions.

Table 32. Seasonal and annual means for $PM_{2.5}$ for Lower Yakima Valley monitoring sites, 2020-2022

Pollutant	Site	Season/annual mean	2020	2021	2022*	3-year mean
$PM_{2.5}$ (µg/m³)	Sunnyside-S 16th St	Warm Season (April-September)	19.37	11.07	9.09	13.2
		Cold Season (October-March)	11.15	10.78	13.85	11.9
		Annual	15.21	10.93	11.18	12.4
$PM_{2.5}$ (µg/m³)	Prosser-Highland Dr**	Warm Season (April-September)	DNC	DNC	DNC	DNC
		Cold Season (October-March)	DNC	DNC	*9.2*	DNC
		Annual	DNC	DNC	*9.2*	DNC

DNC = data not collected, PM = particulate matter, µg/m³ = micrograms per cubic meter

*In 2022, seasonal means are adjusted April-October 21 and October 22-March due to wildfires in October.

**The Prosser monitor was installed in November 2022, so this data only represents the last two months of that year (incomplete data denoted it italics).

[77] https://apps.ecology.wa.gov/publications/documents/1402002.pdf

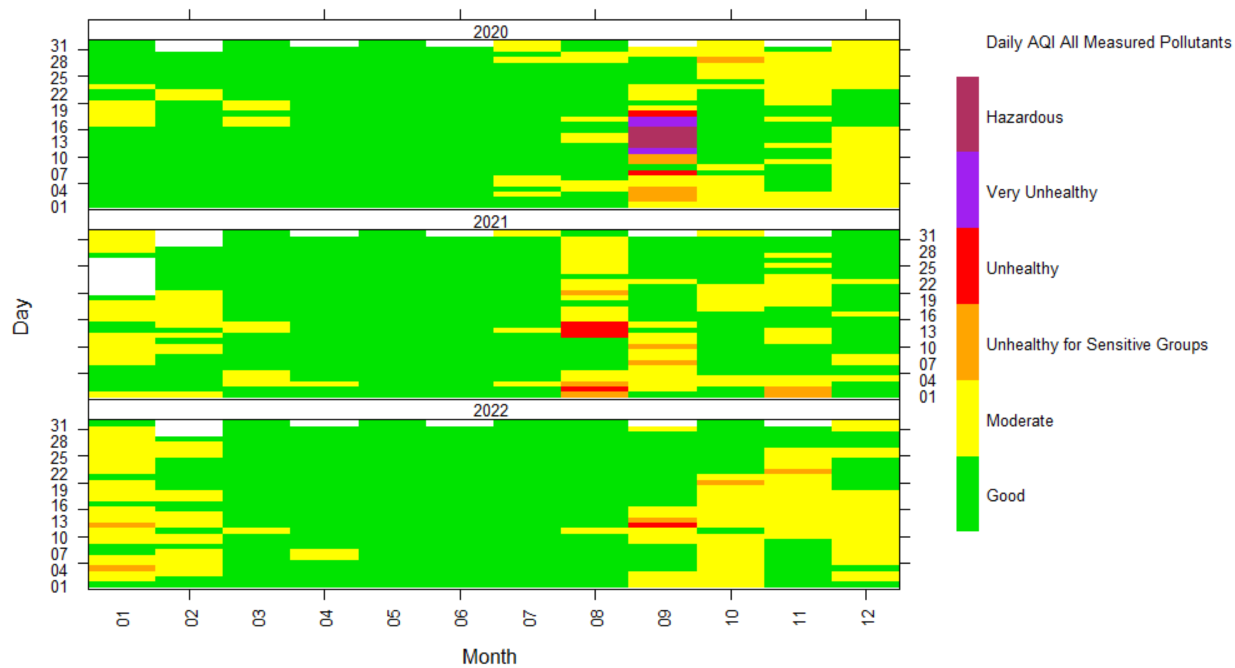

Figure 27. Calendar plot of daily maximum recorded air quality index from 2020-2022 for the Lower Yakima Valley community

Air quality modeling

Roadway NO_2

We modeled ambient 1-hour NO_2 concentrations from on-road mobile sources, which are the primary sources of NO_2 in Washington communities. Model parameters were selected to represent the conditions under which NO_2 concentrations would be highest (e.g., peak traffic volume, stable atmospheric conditions). The average modeled 1-hour NO_2 concentration across the area is 2.3 ppb. The modeled concentration representing peak near-road conditions, is 12.8 ppb. Figure 28 shows the relative distribution of roadway NO_2 across Lower Yakima Valley.

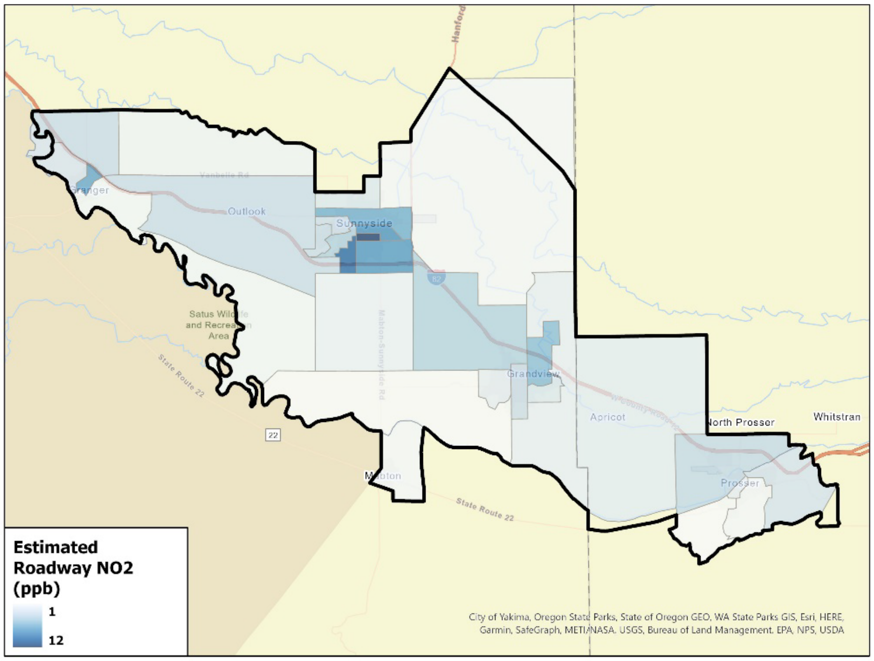

Figure 28. Average estimated 1-hour NO_2 concentration from on-road mobile sources by 2010 census block group in Lower Yakima Valley during weekday afternoon peak traffic under wintertime stable atmospheric conditions

Ozone

For Lower Yakima Valley, the average estimated 8-hour O_3 design value during July 2014 through June 2017 was 0.057 ppm. Long-term O_3 monitoring across the state has shown that O_3 levels in Washington have stayed relatively consistent over time, although spikes may occur during severe heat, drought, or wildfire events.

Potential health impacts

The Lower Yakima Valley community has a high percentage of children under age 18, who are particularly sensitive to air pollution. Additional factors such as poverty, linguistic isolation, and limited access to health care can increase the vulnerability of community members to air pollution. The community has many schools, childcare facilities, health clinics, long term care facilities, and migrant farmworker housing. These are locations where occupants may be more vulnerable to the adverse effects of pollution exposure.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 33). We estimated 19 all-cause deaths among all adults (0.46 deaths per 1,000 18-84-year-olds) each year associated with $PM_{2.5}$ in this community. By age group, we found the largest impact on older adults, with an estimated 6 all-cause deaths (0.56 deaths per 1,000 65–99-year-olds) each year associated with $PM_{2.5}$. The estimated death rate for ischemic heart disease associated with

$PM_{2.5}$ is much higher than the rate for all overburdened communities highly impacted by air pollution, and twice as high as the statewide rate.

Table 33. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in Lower Yakima Valley census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	18.5 [10.6 to 25.9]	0.46 [0.26 to 0.64]
Di et al.[54]	65 to 99	All	All-causes	5.6 [4.9 to 6.2]	0.56 [0.5 to 0.63]
Krewski et al. [52]	30 to 99	All	All-causes	8.0 [5.4 to 11]	0.27 [0.18 to 0.35]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	4.5 [3.7 to 5.3]	0.15 [0.12 to 0.18]
Krewski et al. [52]	30 to 99	All	Lung cancer	1.3 [0.5 to 1.9]	0.04 [0.02 to 0.06]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in the Lower Yakima Valley. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

Four facilities in or nearby Lower Yakima Valley emitted a total of 78,625 MT CO_2e in 2020 and 72,205 MT CO_2e in 2021 (see Table 34).

Emissions are in units of metric tons of carbon dioxide equivalents (MT CO_2e) using AR4 global warming potentials as specified in WAC 173-441.

Table 34. Facilities and greenhouse gas emissions (MT CO_2e) in or nearby[78] Lower Yakima Valley

Facility Name and City	Facility Sector	Inside Community Boundary?	CCA-Covered Entity?	Major source of CAPs? [79]	2020 emissions [biogenic] (MT CO_2e)	2021 emissions [biogenic] (MT CO_2e)
Darigold - Sunnyside	Food Production	Yes	Yes	No	40,732 [0]	38,759 [0]
Milne Fruit Products - Prosser	Food Production	Yes	No	No	10,402 [0]	8,939 [0]
Horse Heaven Cattle Feeders Inc. - Sunnyside	Livestock	Yes	Exempt	No	9,508 [0]	9,395 [0]
Tree Top - Prosser	Food Production	Yes	No	No	17,983 [0]	15,112 [0]

CAPs = criteria air pollutants, CCA = Climate Commitment Act, MT CO_2e = metric tons of carbon dioxide equivalent

Table 35. GHG estimates from mobile sources in Lower Yakima Valley

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
54,838	305,677	5.7

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future .

Additional resources

- Air pollution resources:
    - Yakima Regional Clean Air Agency
    - Benton Clean Air Agency

[78] For the purposes of this analysis, nearby is within 3 miles of the overburdened community boundary.

[79] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

- Reports and studies:
    - Aggravating Factors of Asthma in a Rural Environment (AFARE), University of Washington
    - Yakama Reservation Air Exposure Investigation Summary (2019), Agency for Toxic Substances and Disease Registry
- Health resources:
  - Yakima Health District
  - Benton-Franklin Health District
  - Greater Health Now
  - Yakima Valley Farm Workers Clinic

Moxee Valley

Geographic description

Moxee Valley is in Yakima County, approximately 5 miles to the east of the city of Yakima. Air quality is managed by the Yakima Regional Clean Air Agency. The portion of Moxee Valley included in this initiative is approximately 38 square miles, with a population of about 5,793 residents. It is primarily an agricultural area.

Levels of criteria air pollutants

Although there are currently no monitors in the Ecology network in this community, previous air modeling results have indicated that there are possibly elevated levels of short-term $PM_{2.5}$, as well as cumulative criteria air pollution (primarily driven by $PM_{2.5}$ and O_3). Previous modeling or air emissions inventory results have shown that concentrations of other criteria air pollutants (CO, lead, NO_2, SO_2) are likely to be low in this area.[80,81] Like much of the surrounding area, this community has experienced increasing exposure to wildfire smoke, particularly in the last several years. Also, like nearby Yakima Valley, Moxee Valley likely experiences temperature inversions, which keeps pollution close to the ground during the winter months. However, emissions of particle pollution from sources like home heating and outdoor burning are likely less in this area due to the smaller population.

Air quality monitoring

Currently, the nearest monitor is approximately 6 miles away in Yakima (Figure 29; See "East Yakima" section for monitoring results at that site). Monitoring will be expanded in this area to provide more localized air quality information.

[80] https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe
[81] https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory

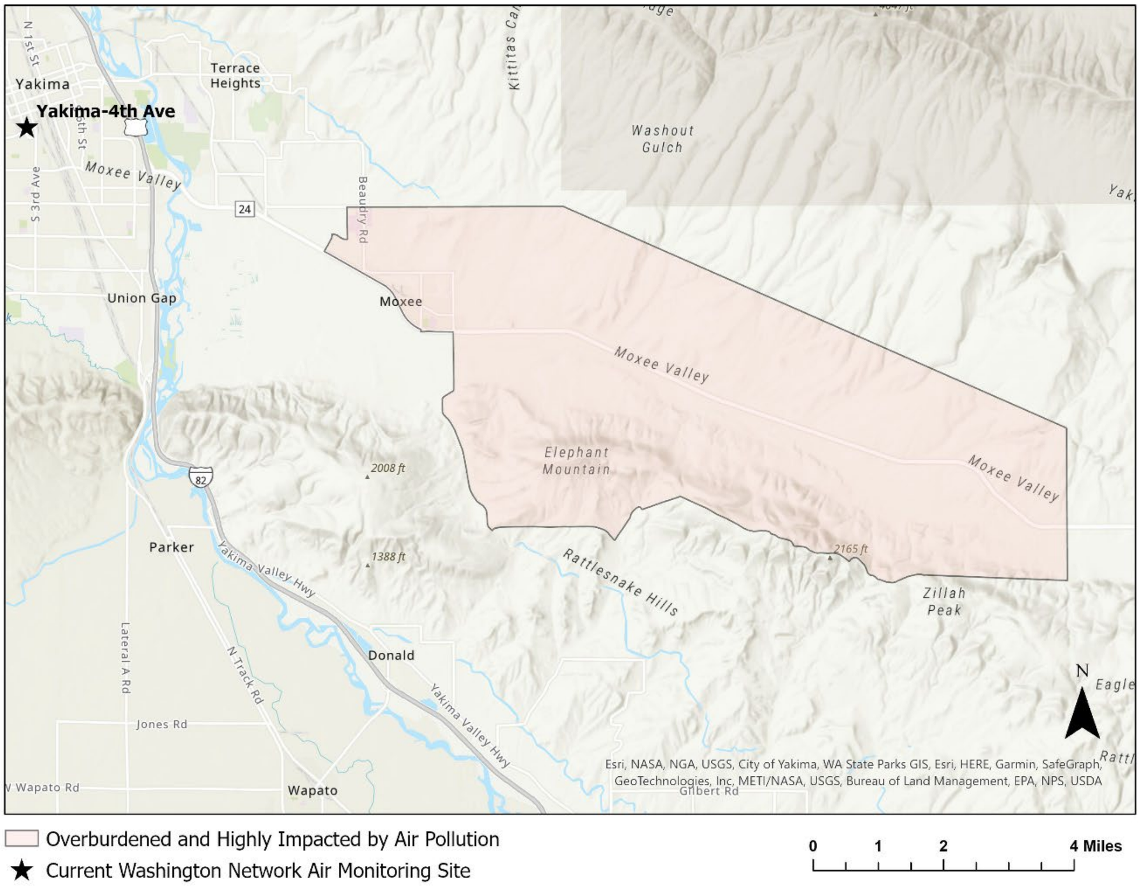

Figure 29. Moxee Valley community boundaries and air monitoring sites

Air quality modeling

$PM_{2.5}$

For Moxee Valley, the average estimated 24-hour $PM_{2.5}$ design value during July 2014 through June 2017 was 26 µg/m^3. This estimate excludes wildfire pollution. Like nearby East Yakima, Moxee Valley periodically experiences unhealthy air quality during wildfire smoke events. Otherwise, while levels of 24-hour $PM_{2.5}$ in Moxee Valley are likely lower than the national air quality standard of 35 µg/m^3, modeling results indicated that they may be higher than Ecology's healthy air goal of 20 µg/m^3 when wildfire is excluded.

Ozone

For Moxee Valley, the average estimated 8-hour O_3 design value during July 2014 through June 2017 was 0.060 ppm. Long-term O_3 monitoring across the state has shown that O_3 levels in Washington have stayed relatively consistent over time, although spikes may occur during severe heat, drought, or wildfire events.

Potential health impacts

Data show that the Moxee Valley community experiences relatively high rates of poverty and chronic obstructive pulmonary disease, which may increase vulnerability to air pollution impacts. The community also has several schools, childcare facilities, long term care facilities, and migrant farmworker housing. These are locations where occupants may be more vulnerable to the adverse effects of pollution exposure.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 36). We estimated 2 all-cause deaths among all adults (0.30 deaths per 1,000 18-84-year-olds) each year associated with $PM_{2.5}$ in this community. By age, we found the largest impact on older adults, with an estimated 1 death (0.53 deaths per 1,000 65–99-year-olds) each year associated with $PM_{2.5}$. The estimated all-cause death rates associated with $PM_{2.5}$ in the Moxee Valley community are higher than the statewide rates and lower than the rates for all overburdened communities highly impacted by air pollution. The estimated death rate for ischemic heart disease associated with $PM_{2.5}$ is much higher than the rate for all overburdened communities highly impacted by air pollution, and over twice as high as the statewide rate.

Table 36. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in Moxee Valley census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	2.1 [1.2 to 3]	0.30 [0.17 to 0.42]
Di et al.[54]	65 to 99	All	All-causes	0.8 [0.8 to 0.9]	0.53 [0.48 to 0.57]
Krewski et al. [52]	30 to 99	All	All-causes	1.3 [0.9 to 1.7]	0.23 [0.15 to 0.30]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	0.9 [0.7 to 1.1]	0.16 [0.13 to 0.19]
Krewski et al. [52]	30 to 99	All	Lung cancer	0.2 [0.1 to 0.3]	0.04 [0.02 to 0.06]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in Moxee Valley. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

Two facilities in or nearby Moxee Valley emitted a total of 165,048 MT CO_2e in 2020 and 169,687 MT CO_2e in 2021 (see 37).

Emissions are in units of metric tons of carbon dioxide equivalents (MT CO_2e) using AR4 global warming potentials as specified in WAC 173-441.

Table 37. Facilities and greenhouse gas emissions (MT CO_2e) in or nearby[82] Moxee Valley

Facility Name and City	Facility Sector	Inside Community Boundary?	CCA-Covered Entity?	Major Source of CAPs?[83]	2020 Emissions [biogenic] (MT CO_2e)	2021 Emissions [biogenic] (MT CO_2e)
Cheyne Landfill - Zillah	Waste	Nearby	Exempt	No	42,145 [0]	43,966 [0]
Terrace Heights Landfill - Yakima	Waste	Nearby	Exempt	No	122,903 [0]	125,721 [0]

CAPs = criteria air pollutants, CCA = Climate Commitment Act, MT CO_2e = metric tons of carbon dioxide equivalent

Table 38. GHG estimates from mobile sources in Moxee Valley

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
5,793	31,808	5.5

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future.

Additional resources

- Air pollution resources:
    - Yakima Regional Clean Air Agency

[82] For the purposes of this analysis, nearby is within 3 miles of the overburdened community boundary.
[83] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

- Health resources:
  - Yakima Health District
  - Greater Health Now

Mattawa

Geographic description

Mattawa is in Grant County along the Columbia River. Air quality is managed by Ecology's Eastern Regional Office. The area included in this initiative is approximately 10 square miles, with a population of about 4,398 residents. It is a rural, predominantly agricultural community.

Levels of criteria air pollutants

The main pollutant of concern that we identified for this community is short-term $PM_{2.5}$. The Washington State emissions inventory shows that particulate matter pollution in Grant County comes mainly from sources like outdoor burning, agricultural tilling, and dust from roads and livestock. Like much of central Washington, this community has also experienced increasing exposure to wildfire smoke, particularly in the last several years. Previous modeling or air emissions inventory results have shown that concentrations of other criteria air pollutants (CO, lead, NO_2, SO_2) are likely to be low in this area.[84,85] O_3, which is naturally higher in the western US, is not expected to be significantly elevated over background levels in the absence of anthropogenic sources.

Air quality monitoring

84 https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe
85 https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory

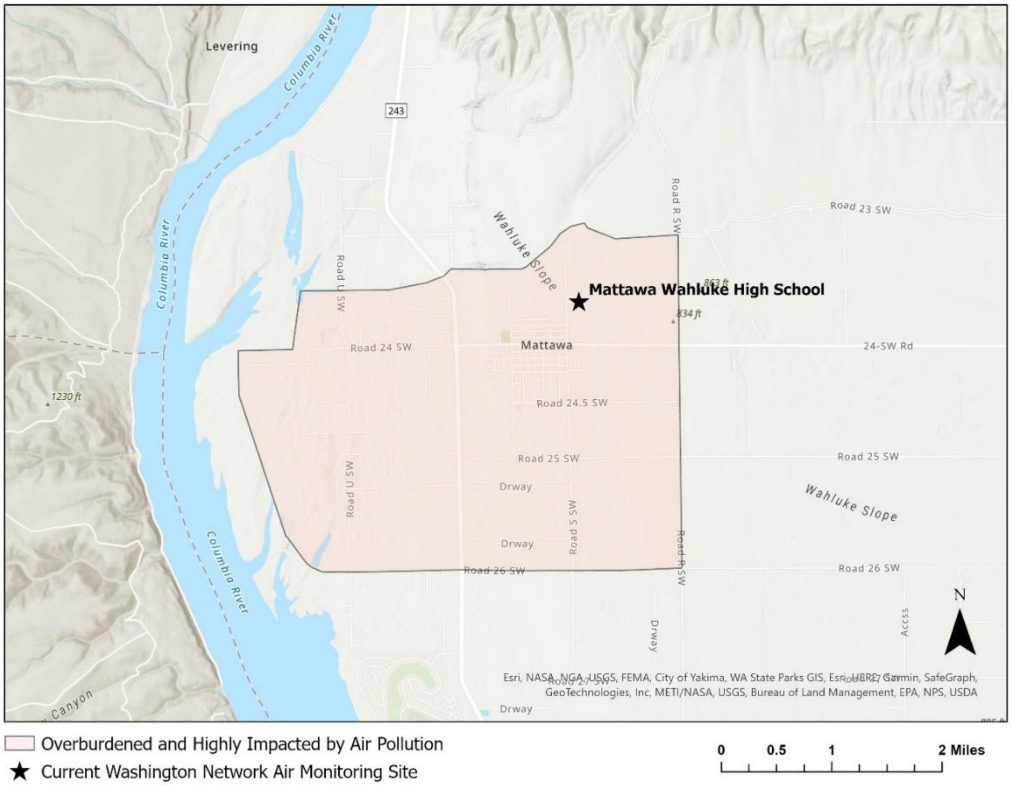

Figure 30. Mattawa community boundaries and air monitoring sites

Table 39. Mattawa monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
Mattawa Wahluke High School	Ecology	$PM_{2.5}$	Neighborhood (0.5-4 km)	No

PM = particulate matter

Ecology installed a $PM_{2.5}$ monitor in the community in January 2023 due to air pollution concerns expressed by the community and air quality modeling that indicates a possible elevated level of $PM_{2.5}$ in the community (Figure 30; Table 39). The calendar plot in Figure 31 shows the daily AQI at the Wahluke High School reached as high as the "very unhealthy" range during the August 2023 wildfire smoke event. Otherwise, the air quality index has mostly been in the "good" range, occasionally reaching "moderate" during the period that has been monitored so far this year. However, a full winter season has not yet been monitored, which will tell us more about seasonal sources like residential wood smoke.

Table 40. Criteria air pollutant summary statistics for Mattawa monitoring sites in 2023. A red box indicates a value above the NAAQS. Numbers in brackets [] indicate wildfire days >35.4 µg/m^3 have been removed.

Pollutant	Form	NAAQS Level	Site Name	2023
$PM_{2.5}$ 24-hour (µg/m^3)	98th percentile	35	Mattawa Wahluke High School*	*15.0 [12.3]*

NAAQS = national ambient air quality standards, PM = particulate matter, µg/m^3 = micrograms per cubic meter

*Monitor installed mid-year (incomplete data denoted in italics)

Table 41. Seasonal and annual means for $PM_{2.5}$ for Mattawa monitoring sites in 2023

Pollutant	Site	Season/annual mean	2023
$PM_{2.5}$ (µg/m^3)	Mattawa Wahluke High School*	Warm Season (April-September)	5.6
		Cold Season (October-March)	*2.5*
		Annual	*4.1*

PM = particulate matter, µg/m^3 = micrograms per cubic meter

*Monitor installed mid-year (incomplete data denoted in italics)

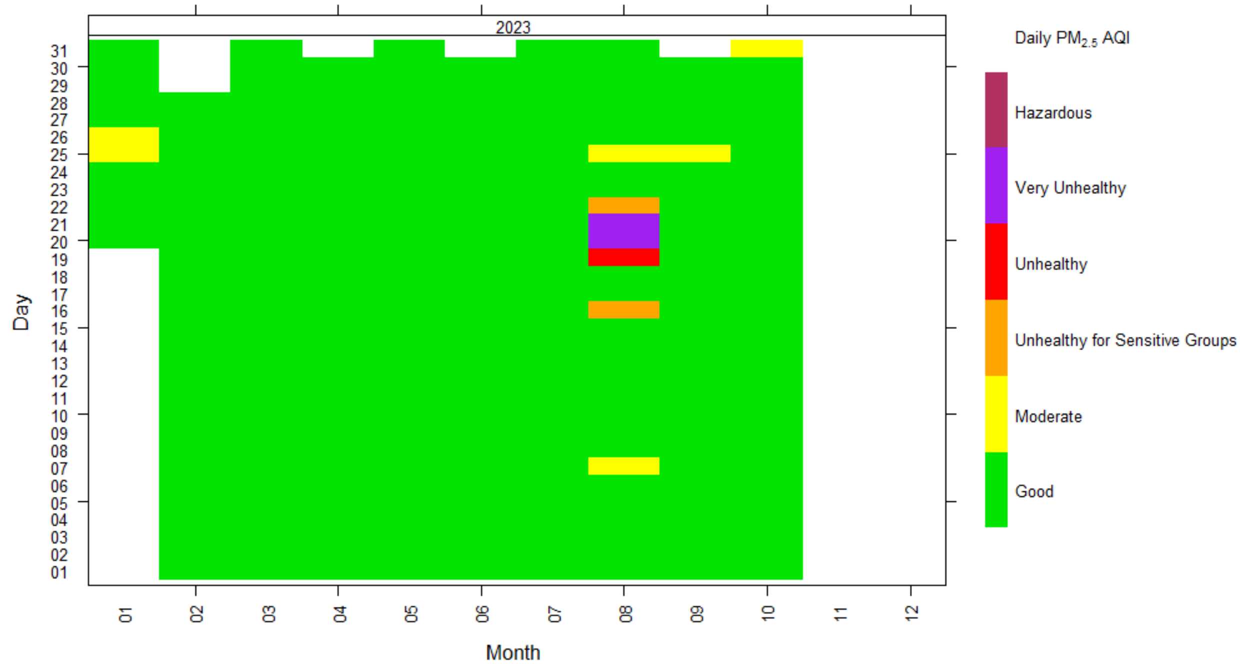

Figure 31. Calendar plot of daily air quality index from 2023 for the Mattawa community

Potential health impacts

Several socioeconomic and health factors indicate that groups in the Mattawa community may be more vulnerable to air pollution impacts, including high rates of poverty, asthma, and limited access to health care. The community has several schools, childcare facilities, health clinics, long term care facilities, and migrant farmworker housing. These are locations where occupants may be more vulnerable to the adverse effects of pollution exposure.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 42). Results for Mattawa were combined with George and West Grant County due to overlapping census tracts. We estimated 3 all-cause deaths among all adults (0.30 deaths per 1,000 18-84-year-olds) each year associated with $PM_{2.5}$ in the census tracts containing Mattawa, George, and West Grant County. By age, we found the largest impact on older adults, with an estimated 1 all-cause death (0.53 deaths per 1,000 65–99-year-olds) each year associated with $PM_{2.5}$. In the Mattawa, George, and West Grant County communities, all reported rates of death are lower than the rates among all overburdened communities highly impacted by air pollution, and the same or lower than the statewide rates.

Table 42. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in the combined Mattawa, George and West Grant County census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	2.2 [1.3 to 3.1]	0.19 [0.11 to 0.26]
Di et al.[54]	65 to 99	All	All-causes	0.4 [0.37 to 0.5]	0.22 [0.2 to 0.24]
Krewski et al. [52]	30 to 99	All	All-causes	1.0 [0.7 to 1.3]	0.12 [0.08 to 0.16]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	0.6 [0.5 to 0.7]	0.07 [0.06 to 0.08]
Krewski et al. [52]	30 to 99	All	Lung cancer	0.2 [0.1 to 0.3]	0.02 [0.01 to 0.03]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

There are no major stationary sources of greenhouse gas emissions in or near Mattawa. Emissions from energy use are also likely to be relatively low due to the low population density.

Table 43. GHG estimates from mobile sources in Mattawa

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
4,398	38,845	8.8

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future.

Additional resources

- Air pollution resources:
    - Wildfire & Smoke Resources, Grant County Health District
- Health resources:
    - Grant County Health District
    - Thriving Together North Central Washington

George and West Grant County

Geographic description

This community is in Grant County near the Columbia River. Air quality is managed by Ecology's Eastern Regional Office. This area spans about 118 square miles with a population of about 2,206 residents. It is mainly a rural farming community.

Levels of criteria air pollutants

The main pollutant of concern that we identified for this community is short-term $PM_{2.5}$. The Washington State emissions inventory shows that particulate matter pollution in Grant County comes mainly from sources like outdoor burning, agricultural tilling, and dust from roads and livestock. Like much of central Washington, this community has also experienced increasing exposure to wildfire smoke, particularly in the last several years. Previous modeling or air emissions inventory results have shown that concentrations of other criteria air pollutants (CO, lead, NO_2, SO_2) are likely to be low in this area.[86,87] O_3, which is naturally higher in the western US, is not expected to be elevated over background levels in the absence of anthropogenic sources.

Air quality monitoring

In early August 2023, a $PM_{2.5}$ sensor was installed at George Elementary School, as part of this initiative. In late August 2023, another $PM_{2.5}$ sensor was added in Royal City (Figure 32; Table 44). While this is outside of the community boundaries, it can still provide air quality information to the surrounding area with similar geographic and meteorological conditions, particularly south of Frenchman Hills.

[86] https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe
[87] https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory

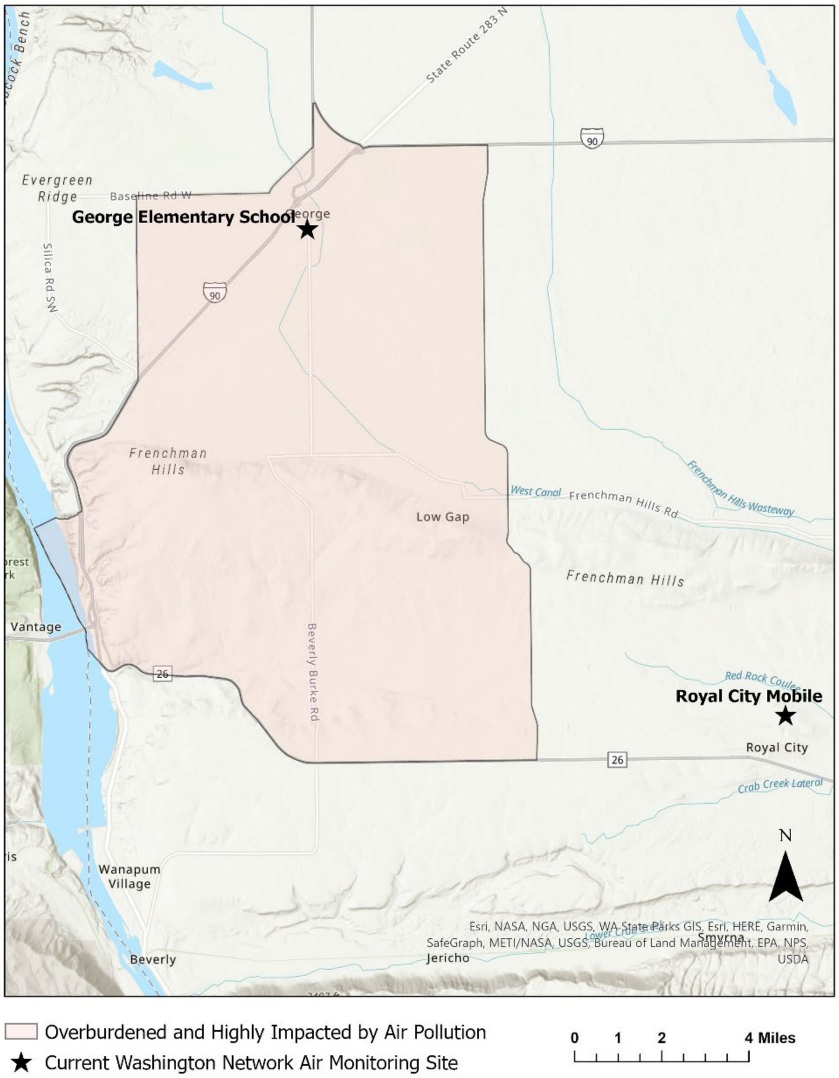

Figure 32. George and West Grant County community boundaries and air monitoring sites

Table 44. George and West Grant County monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
George Elementary School	Ecology	$PM_{2.5}$	Neighborhood (0.5-4 km)	No
Royal City	Ecology	$PM_{2.5}$	Neighborhood (0.5-4 km)	No

Due to the recency of these installations, sufficient data are not available for representative summary statistics. The calendar plot in Figure 33 shows the daily AQI at the George monitoring site, which reached as high as the "very unhealthy" range during the August 2023 wildfire smoke event.

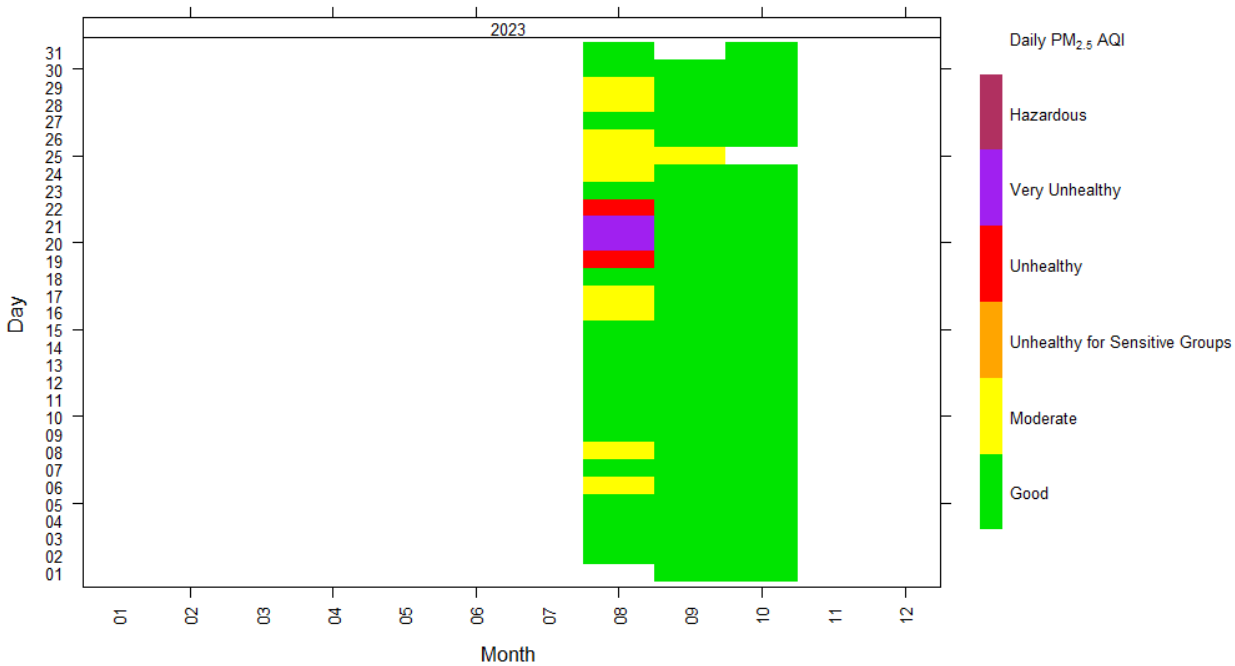

Figure 33. Calendar plot of daily air quality index from 2023 for the George monitoring site

Potential health impacts

Data show that the George and West Grant County community experiences high rates of poverty and limited access to healthcare, which may increase vulnerability to air pollution impacts.

Due to overlapping census tracts, we reported the estimated death and death rates in the Mattawa, George and West Grant County communities combined in Table 42 (See description in Mattawa: Potential health impacts).

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

There are no major stationary sources of greenhouse gas emissions in or near George and West Grant County. Emissions from energy use are also likely to be relatively low due to the low population density.

Table 45. GHG estimates from mobile sources in George and West Grant County

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
2,206	19,484	8.8

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future.

Additional resources

- Air pollution resources:
  - Wildfire & Smoke Resources, Grant County Health District
- Health resources:
  - Grant County Health District
  - Thriving Together North Central Washington

Ellensburg

Geographic description

Ellensburg is in Kittitas County. Air quality is managed by Ecology's Central Regional Office. The community is about 5.5 square miles and has a population of approximately 16,273 residents. The city of Ellensburg is home to Central Washington University, which means that it has an additional student population for most of the year, many of which are not counted as residents in the census. The area identified as overburdened and highly impacted includes most of the city of Ellensburg and borders Interstate 90.

Levels of criteria air pollutants

The main pollutant of concern that we identified for this community is short-term $PM_{2.5}$, as well as cumulative criteria air pollution, which is again primarily driven by levels of $PM_{2.5}$, with some contribution from O_3 and NO_2. The 2020 statewide emissions inventory shows that wildfire is the predominant source of $PM_{2.5}$ in Kittitas County, by a wide margin. Prescribed burning and woodstove smoke related to home heating are also prominent sources. Ozone and NO_2 are not monitored through the Washington Air Monitoring Network but were interpolated statewide using model output and monitoring data elsewhere in Washington. Previous modeling or air emissions inventory results have shown that concentrations of other criteria air pollutants (CO, lead, SO_2) are likely to be low in this area.[88,89]

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88 https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe
89 https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory

Air quality monitoring

There is an existing $PM_{2.5}$ monitor located centrally within the identified community boundaries (Figure 34; Table 46). The city is relatively small in area and past Ecology mobile monitoring has shown pollution levels to be relatively consistent across the community.

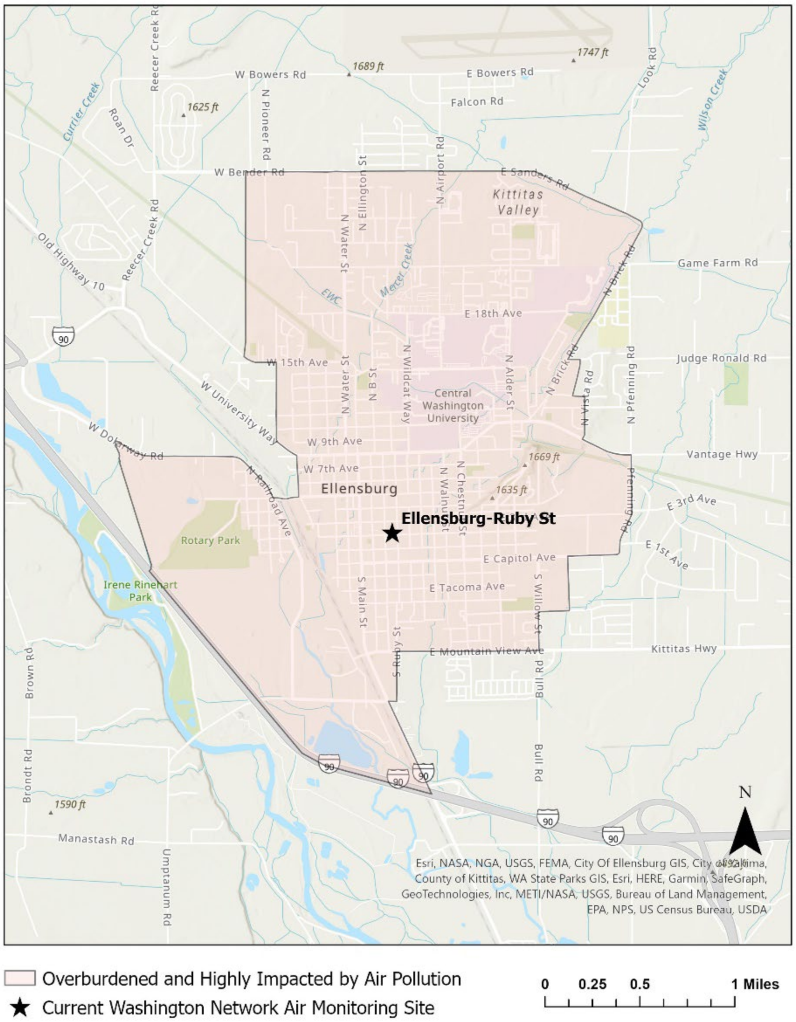

Figure 34. Ellensburg community boundaries and air monitoring sites

Table 46. Ellensburg monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
Ellensburg-Ruby St	Ecology	$PM_{2.5}$	Neighborhood (0.5-4 km)	Yes

PM = particulate matter

Ellensburg routinely experiences large spikes in $PM_{2.5}$. In 2020, the annual 98^{th} percentile daily concentration exceeded the 24-hour NAAQS for $PM_{2.5}$. These elevated concentrations and the variability in $PM_{2.5}$ levels year to year are primarily attributable to wildfire smoke events. With wildfire excluded, the 98th percentile concentrations for $PM_{2.5}$ were more consistent, around 18-25 µg/m³. While lower than the national air quality standard of 35 µg/m³, they are sometimes higher than Ecology's healthy air goal of 20 µg/m³.

Table 47. Criteria air pollutant annual and 3-year summary statistics for Ellensburg monitoring sites for 2020-2022. A red box indicates a value above the NAAQS. Numbers in brackets [] indicate wildfire days >35.4 µg/m³ $PM_{2.5}$ have been removed.

Pollutant	Form	NAAQS Level	Site Name	2020	2021	2022	3-year Design Value
$PM_{2.5}$ 24-hour (µg/m³)	98th Percentile	35	Ellensburg-Ruby St	50.3 [18.1]	22.8 [14.5]	25.1 [25.1]	33 [19]

NAAQS = national ambient air quality standards, PM = particulate matter, µg/m³ = micrograms per cubic meter

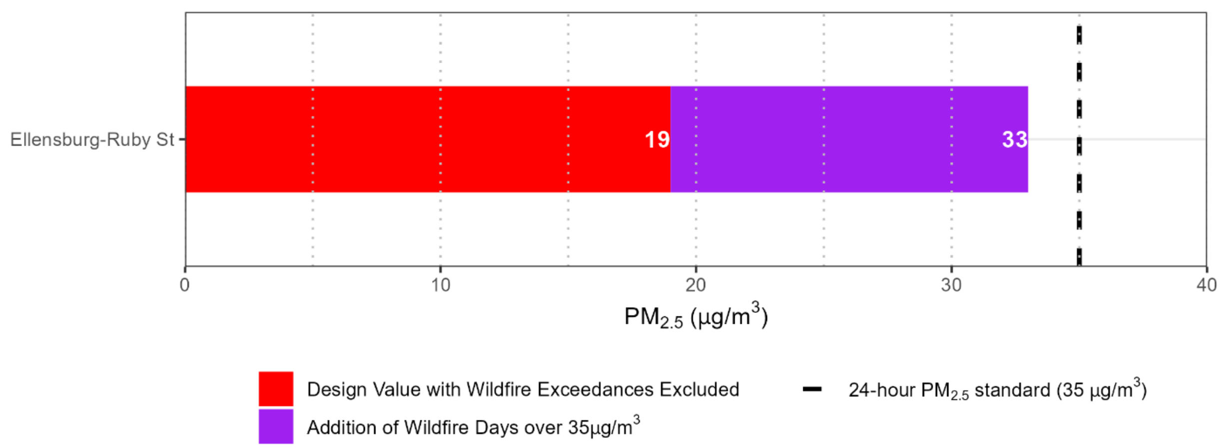

Figure 35. 24-hour $PM_{2.5}$ 2022 design value at Ellensburg monitoring site

Most unhealthy air quality in Ellensburg over the last three years occurred in August and September, during wildfire season. In years when there is less wildfire activity, as in 2022, $PM_{2.5}$ is higher in the cold season when there is more woodsmoke from home heating, as well as some smoke from prescribed burning and agricultural burning (Table 48). Figure 36 shows that AQI in the winter is more consistently elevated, often in the moderate AQI range and occasionally unhealthy for sensitive groups.

Table 48. Seasonal and annual means for $PM_{2.5}$ for Ellensburg monitoring sites, 2020-2022

Pollutant	Site	Season/annual mean	2020	2021	2022*	3-year mean
$PM_{2.5}$ (µg/m^3)	Ellensburg-Ruby St	Warm Season (April-September)	14.17	6.29	5.86	8.8
		Cold Season (October-March)	6.64	6.18	8.90	7.2
		Annual	9.29	6.28	7.07	7.5

PM = particulate matter, µg/m^3 = micrograms per cubic meter

*In 2022, seasonal means are adjusted April-October 21 and October 22-March due to wildfires in October.

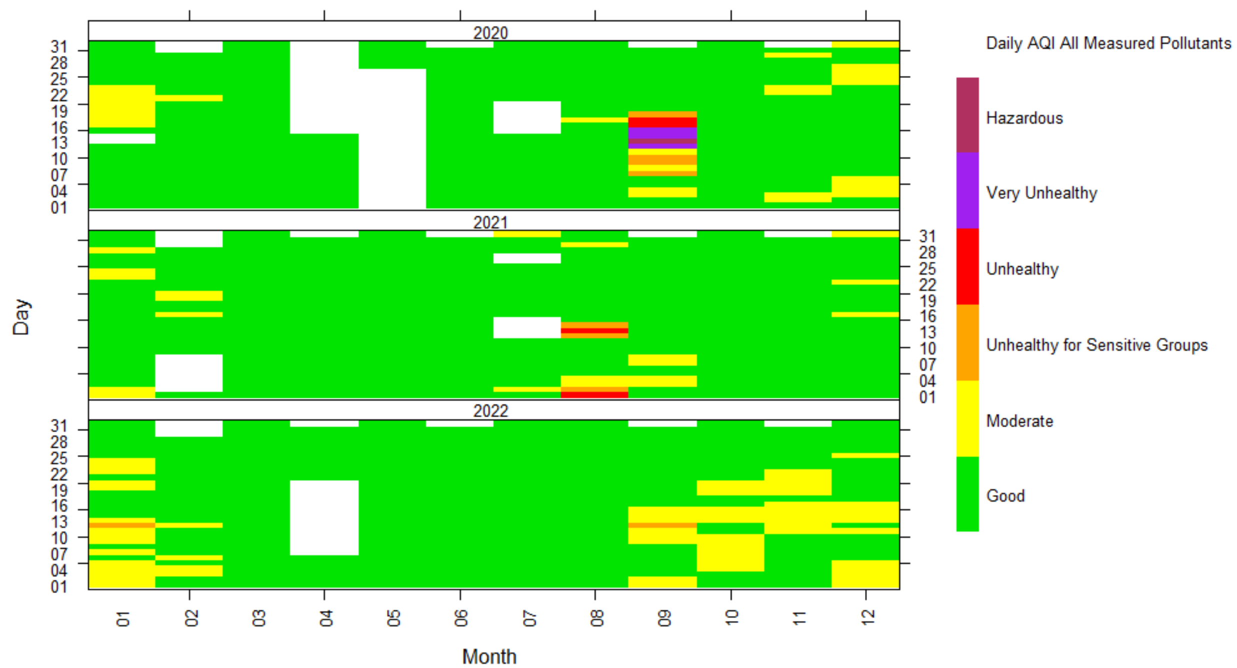

Figure 36. Calendar plot of daily maximum recorded air quality index from 2020-2022 for the Ellensburg community

Air quality modeling

Roadway NO_2

We modeled ambient 1-hour NO_2 concentrations from on-road mobile sources, which are the primary sources of NO_2 in Washington communities. Model parameters were selected to represent the conditions under which NO_2 concentrations would be highest (e.g., peak traffic volume, stable atmospheric conditions). The average modeled 1-hour NO_2 concentration across the area is 8.9 ppb. The modeled concentration representing peak near-road conditions, is 24.5 ppb. Figure 37 shows the relative distribution of roadway NO_2 across Ellensburg.

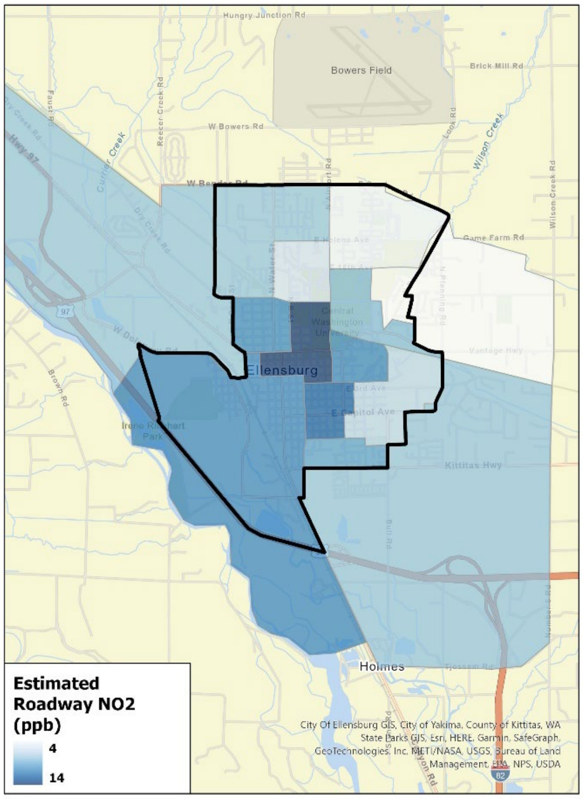

Figure 37. Average estimated 1-hour NO_2 concentration from on-road mobile sources by 2010 census block group in Ellensburg during weekday afternoon peak traffic under wintertime stable atmospheric conditions

Ozone

For Ellensburg, the average estimated 8-hour O_3 design value during July 2014 through June 2017 was 0.056 ppm. Long-term O_3 monitoring across the state has shown that O_3 levels in Washington have stayed relatively consistent over time, although spikes may occur during severe heat, drought, or wildfire events.

Potential health impacts

Several socioeconomic and health factors indicate that some population groups in Ellensburg may be more vulnerable to health effects from air pollution, including high rates of poverty and asthma prevalence. The community also has numerous schools, childcare facilities, healthcare clinics, and a hospital. These are locations where occupants may be more vulnerable to the adverse effects of pollution exposure.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 49). We estimated 3 all-cause deaths among all adults (0.12 deaths per 1,000 18-84-year-olds) each year associated with $PM_{2.5}$ in Ellensburg, which is a much lower all-cause death rate than the statewide rate for this age group. By age, we found the largest impact on older adults, with an estimated 1 all-cause death (0.39 deaths per 1,000 65–99-year-olds) each year associated with $PM_{2.5}$, similar to the statewide death rate for this age group. The estimated death rate for ischemic heart disease associated with $PM_{2.5}$ is higher than the rate for all overburdened communities highly impacted by air pollution.

Table 49. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in Ellensburg census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	2.1 [1.3 to 3.0]	0.12 [0.07 to 0.17]
Di et al.[54]	65 to 99	All	All-causes	1.0 [0.97 to 1.1]	0.39 [0.36 to 0.41]
Krewski et al. [52]	30 to 99	All	All-causes	1.9 [1.3 to 2.5]	0.22 [0.15 to 0.29]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	1.1 [0.9 to 1.3]	0.13 [0.1 to 0.15]
Krewski et al. [52]	30 to 99	All	Lung cancer	0.4 [0.2 to 0.6]	0.04 [0.02 to 0.07]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in Ellensburg. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

One facility in Ellensburg emitted a total of 11,930 MT CO_2e in 2020 and 12,824 MT CO_2e in 2021 (see Table 50).

Emissions are in units of metric tons of carbon dioxide equivalents (MT CO_2e) using AR4 global warming potentials as specified in WAC 173-441.

Table 50. Facilities and greenhouse gas emissions (MT CO_2e) in or nearby[90] Ellensburg

Facility Name and City	Facility Sector	Inside Community Boundary?	CCA-Covered Entity?	Major Source of CAPs? [91]	2020 Emissions [biogenic] (MT CO_2e)	2021 Emissions [biogenic] (MT CO_2e)
Central Washington University - Ellensburg	Government	Yes	No	No	11,930 [0]	12,824 [0]

CAPs = criteria air pollutants, CCA = Climate Commitment Act, MT CO_2e = metric tons of carbon dioxide equivalent

Table 51. GHG estimates from mobile sources in Ellensburg

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
16,273	288,329	17.7

MT CO_2e = metric tons of carbon dioxide equivalent

The rate of MT CO_2e per capita is relatively high to the population of the overburdened community highly impacted by air pollution due to Ellensburg being a major transportation hub. The area identified as overburdened and highly impacted includes most of the city of Ellensburg and borders Interstate 90. Central Washington University is located within this community and many of the additional student population for most of the year are not counted as residents in the census.

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future.

Additional resources

- Air pollution resources:
  - Air Quality Monitoring, Central Washington University
  - Public Health – Air Quality Resources, Kittitas County
- Health resources:
  - Kittitas County Public Health

[90] For the purposes of this analysis, nearby is within 3 miles of the overburdened community boundary.
[91] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

- Greater Health Now

Wenatchee and East Wenatchee

Geographic description

The Wenatchee and East Wenatchee community is located along the boundary between Chelan County and Douglas County. Air quality is managed by Ecology's Central Regional Office. The community is about 10 square miles and has approximately 32,183 residents. The part identified as highly impacted by air pollution includes the higher density housing around the business districts in Wenatchee, as well as the business district and surrounding residential area in East Wenatchee.

Levels of criteria air pollutants

We identified the Wenatchee and East Wenatchee communities as highly impacted by air pollution, specifically from short-term exposure to $PM_{2.5}$. Previous modeling or air emissions inventory results have shown that concentrations of other criteria air pollutants (CO, lead, NO_2, SO_2) are likely to be low in this area.[92,93] O_3, which is naturally higher in the western US, is not expected to be elevated over background levels in the absence of anthropogenic sources.

Air quality monitoring

While there are currently no monitors within the community boundaries, there is an Ecology $PM_{2.5}$ monitor nearby at Wenatchee Valley College, which provides air quality information for the area (Figure 38; Table 52). There was also a temporary $PM_{2.5}$ monitoring site in East Wenatchee in 2016. During the temporary monitoring period, there were zero days in which $PM_{2.5}$ concentrations in East Wenatchee were 5 or more $\mu g/m^3$ greater than observed in Wenatchee. Monitoring results from 2020-2022 are described below. Additional monitoring will be added soon following engagement with community members.

[92] https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe
[93] https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory

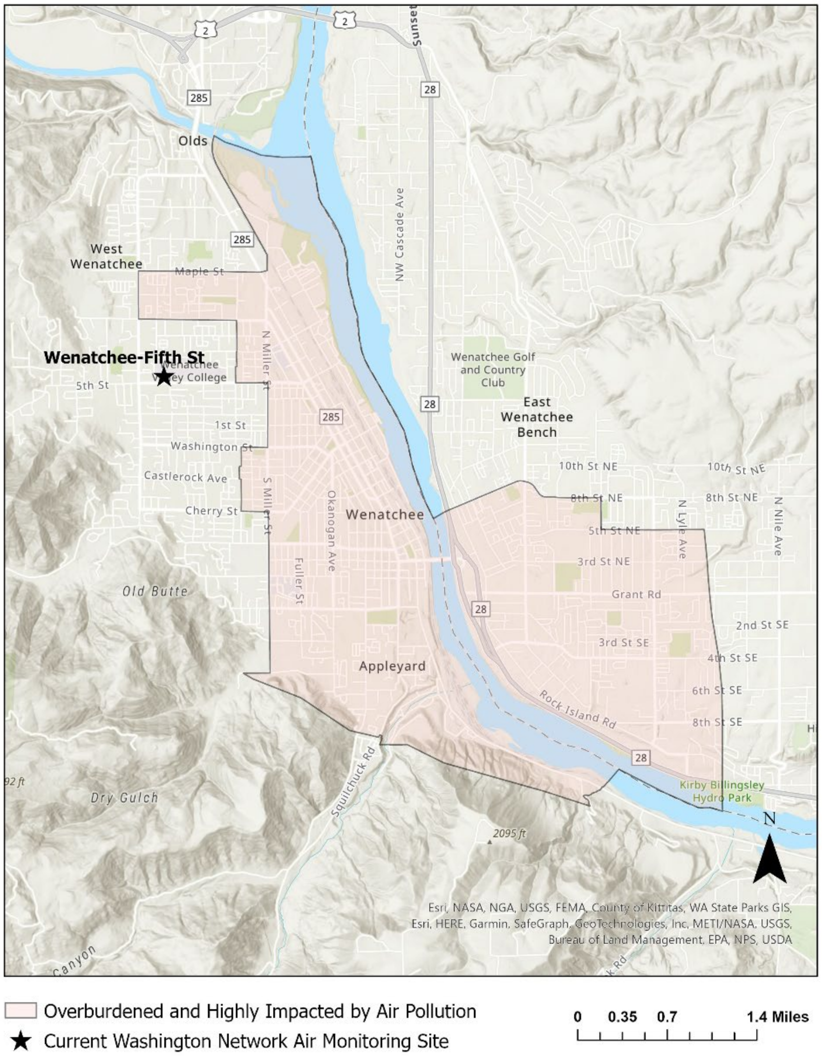

Figure 38. Wenatchee and East Wenatchee community boundaries and air monitoring sites

Table 52. Wenatchee and East Wenatchee monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
Wenatchee-Fifth St	Ecology	$PM_{2.5}$	Neighborhood (0.5-4 km)	No

PM = particulate matter

The Wenatchee area routinely experiences large spikes in $PM_{2.5}$. In 2020 and 2022, annual 98th percentile concentrations exceeded the 24-hour NAAQS for $PM_{2.5}$. These elevated concentrations, and the variability year to year, are attributable primarily to wildfire smoke events. With wildfire excluded, the annual 98th percentile concentrations for $PM_{2.5}$ were more consistent year to year, around 14-23 µg/m^3. While lower than the national air quality standard of 35 µg/m^3, they are sometimes higher than Ecology's healthy air goal of 20 µg/m^3.

Table 53. Criteria air pollutant annual and 3-year summary statistics for Wenatchee and East Wenatchee monitoring sites for 2020-2022. A red box indicates a value above the NAAQS. Numbers in brackets [] indicates wildfire days >35.4 µg/m³ $PM_{2.5}$ have been removed.

Pollutant	Form	NAAQS Level	Site Name	2020	2021	2022	3-year Design Value
$PM_{2.5}$ 24-hour (µg/m³)	98th Percentile	35	Wenatchee-Fifth St	92.7 [14.4]	17.7 [14.1]	70.9 [23.0]	60 [17]

NAAQS = national ambient air quality standards, PM = particulate matter, µg/m³ = micrograms per cubic meter

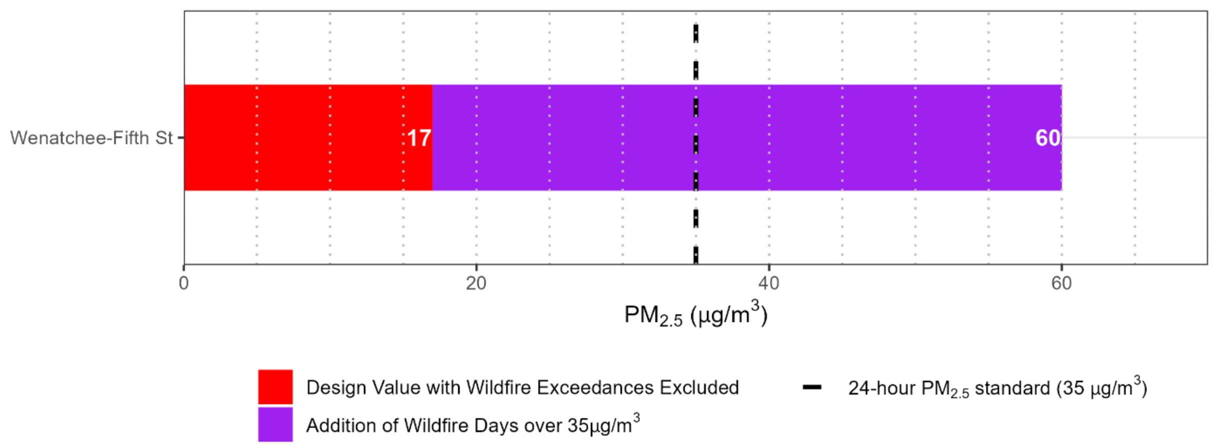

Figure 39. 24-hour $PM_{2.5}$ 2022 design value at Wenatchee monitoring site

All daily $PM_{2.5}$ concentrations that were “unhealthy for sensitive groups” or worse occurred from August through October, during wildfire season (Figure 40). The Wenatchee and East Wenatchee communities have increasingly experienced more frequent wildfire smoke events. Other sources of particulate matter include silvicultural and prescribed burning, agricultural burning, and wood smoke associated with home heating. Temperature inversions, which keep pollution trapped close to the ground, are a common reason for occasional elevated levels of $PM_{2.5}$ in the wintertime. We will be examining the sources of pollution in Wenatchee and East Wenatchee in greater detail in future analyses.

Table 54. Seasonal and annual means for $PM_{2.5}$ for Wenatchee and East Wenatchee monitoring sites, 2020-2022

Pollutant	Site	Season/annual mean	2020	2021	2022*	3-year mean
$PM_{2.5}$ ($\mu g/m^3$)	Wenatchee-Fifth St	Warm Season (April-September)	16.02	6.42	12.57	11.7
		Cold Season (October-March)	6.99	5.94	7.30	6.7
		Annual	10.62	6.07	10.21	9.0

PM = particulate matter, $\mu g/m^3$ = micrograms per cubic meter

*In 2022, seasonal means are adjusted to April-October 21 and October 22-March due to wildfires in October.

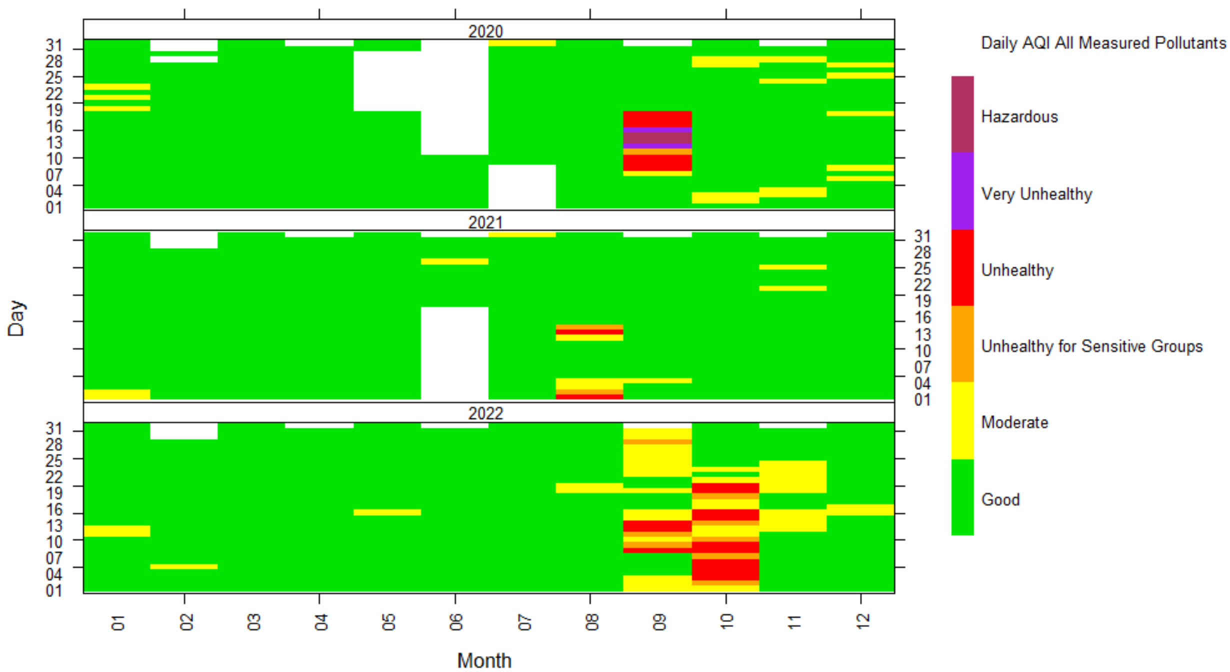

Figure 40. Calendar plot of daily maximum recorded air quality index from 2020-2022 for the Wenatchee and East Wenatchee community

Potential health impacts

Parts of the Wenatchee and East Wenatchee communities have high rates of poverty, asthma, uninsured populations, as well as a high proportion of children under age 18. These population groups are at greater risk of health impacts from air pollution. This community also includes several schools, hospitals and healthcare clinics, long term care facilities, and migrant farmworker housing. These are locations where occupants may be more vulnerable to the adverse effects of pollution exposure.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 55). Differing from all other overburdened communities highly impacted by air pollution, the largest impact associated with $PM_{2.5}$ was all-cause deaths among all adults (0.27 deaths per 1,000 18-84-year-olds) each year in this community, followed by older adults with an estimated 2 all-cause deaths (0.22 deaths per 1,000 65–99-year-olds) each year. This may be due to differences in age distributions across communities. Moreover, the reported all-cause death rates in the Wenatchee and East Wenatchee communities are similar to the statewide rates and much lower than the rates among all overburdened communities highly impacted by air pollution.

Table 55. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in Wenatchee and East Wenatchee census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	7.6 [4.4 to 10.7]	0.27 [0.16 to 0.38]
Di et al.[54]	65 to 99	All	All-causes	1.5 [1.4 to 1.6]	0.22 [0.20 to 0.24]
Krewski et al. [52]	30 to 99	All	All-causes	5.0 [3.3 to 6.5]	0.23 [0.16 to 0.31]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	2.1 [1.7 to 2.4]	0.1 [0.08 to 0.11]
Krewski et al. [52]	30 to 99	All	Lung cancer	0.7 [0.3 to 1.1]	0.03 [0.01 to 0.05]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in Wenatchee and East Wenatchee. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

Two facilities nearby Wenatchee and East Wenatchee emitted a total of 26,717 MT CO_2e in 2020 and 27,413 MT CO_2e in 2021 (see Table 56).

Emissions are in units of metric tons of carbon dioxide equivalents (MT CO_2e) using AR4 global warming potentials as specified in WAC 173-441.

Table 56. Facilities and greenhouse gas emissions (MT CO_2e) in or nearby[94] Wenatchee and East Wenatchee

Facility Name and City	Facility Sector	Inside Community Boundary?	CCA-Covered Entity?	Major Source of CAPs? [95]	2020 Emissions [biogenic] (MT CO_2e)	2021 Emissions [biogenic] (MT CO_2e)
Keyes Fibre Corporation - Wenatchee	Pulp and Paper	Nearby	No	No	17,588 [0]	16,806 [0]
Tree Top - Wenatchee	Food Production	Nearby	No	No	9,129 [0]	10,607 [0]

CAPs = criteria air pollutants, CCA = Climate Commitment Act, MT CO_2e = metric tons of carbon dioxide equivalent

Table 57. GHG estimates from mobile sources in Wenatchee and East Wenatchee

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
32,183	201,941	6.3

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future.

Additional resources

- Air pollution resources:
  - Air Quality Resources, Chelan-Douglas Health District
- Health resources:
  - Chelan-Douglas Health District
  - Thriving Together North Central Washington
- Studies and reports:

[94] For the purposes of this analysis, nearby is within 3 miles of the overburdened community boundary.

[95] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

- [Surveillance Investigation of the Cardiopulmonary Health Effects of the 2012 Wildfires in North Central Washington State](#) (2015), WA State Department of Health

Everett

Geographic description

Everett is in Snohomish County. Air quality is managed by Puget Sound Clean Air Agency. The part of Everett that is identified as overburdened and highly impacted by air pollution is about 16.5 square miles, with a population of approximately 83,973 people. The community runs parallel to Interstate 5 on the eastside and extends from the Snohomish River in the north to Paine Field Airport in the south.

Levels of criteria air pollutants

The main pollutant of concern that we identified for Everett is short-term $PM_{2.5}$. Previous modeling or air emissions inventory results have shown that concentrations of other criteria air pollutants (CO, lead, NO_2, SO_2) are likely to be low in this area.[96,97] O_3, which is naturally higher in the western US, is not expected to be elevated over background levels in the absence of anthropogenic sources. While there are currently no air monitors in Ecology's network in the community boundaries, nearby monitoring as well as air modeling results indicate a possible elevated level of $PM_{2.5}$, when compared to the rest of Washington State. The 2017 statewide emissions inventory indicates that the vast majority of $PM_{2.5}$ pollution in Snohomish County is from residential wood smoke associated with home heating. However, this community includes or is near several other sources of air pollution, including Interstate 5 to the east and Paine Field Airport and the industrial section of Everett to the southwest. We will be examining the sources of pollution in Everett in greater detail in future analyses.

Air quality monitoring

For this report, we will look at the data from the nearest monitor, which is less than 3 miles away in Marysville (Figure 41; Table 58). Additional air quality monitoring stations will be added in 2024, with community engagement.

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[96] https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe
[97] https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory

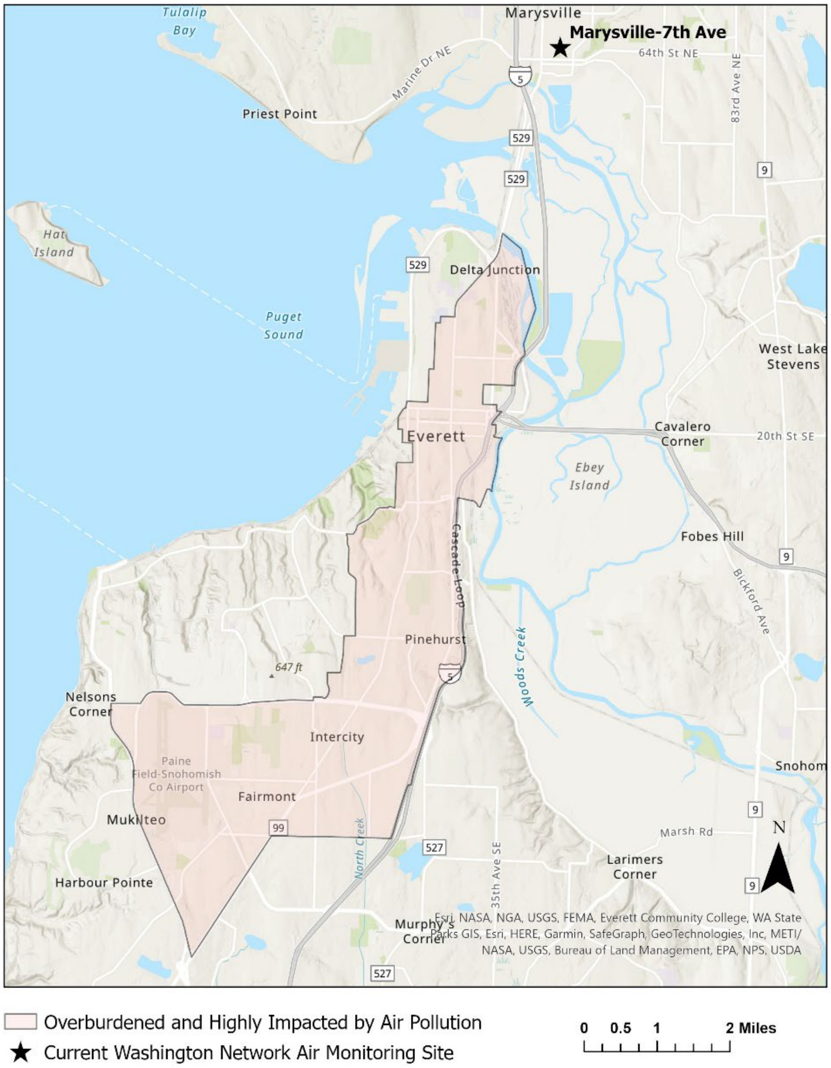

Figure 41. Everett community boundaries and air monitoring sites

Table 58. Everett area monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
Marysville-7th Ave	Puget Sound Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	Yes

PM = particulate matter

The Marysville monitor routinely experiences spikes in $PM_{2.5}$. In 2020 and 2022, annual 98th percentile concentrations exceeded the 24-hour NAAQS for $PM_{2.5}$. These elevated concentrations and the variability year to year are attributable primarily to wildfire smoke events. With wildfire excluded, the annual 98th percentile concentrations for $PM_{2.5}$ were more consistent year to year, around 26 µg/m^3. While lower than the national air quality standard of 35 µg/m^3, they are higher than Ecology's healthy air goal of 20 µg/m^3.

Table 59. Criteria air pollutant annual and 3-year summary statistics for Everett area monitoring sites for 2020-2022. A red box indicates a value above the NAAQS. Numbers in brackets [] indicates wildfire days >35.4 µg/m^3 $PM_{2.5}$ have been removed.

Pollutant	Form	NAAQS Level	Site Name	2020	2021	2022	3-year Design Value
$PM_{2.5}$ 24-hour (µg/m^3)	98th Percentile	35	Marysville-7th Ave	47.2 [25.0]	22.1 [22.1]	38.1 [29.7]	36 [26]

NAAQS = national ambient air quality standards, PM = particulate matter, µg/m^3 = micrograms per cubic meter

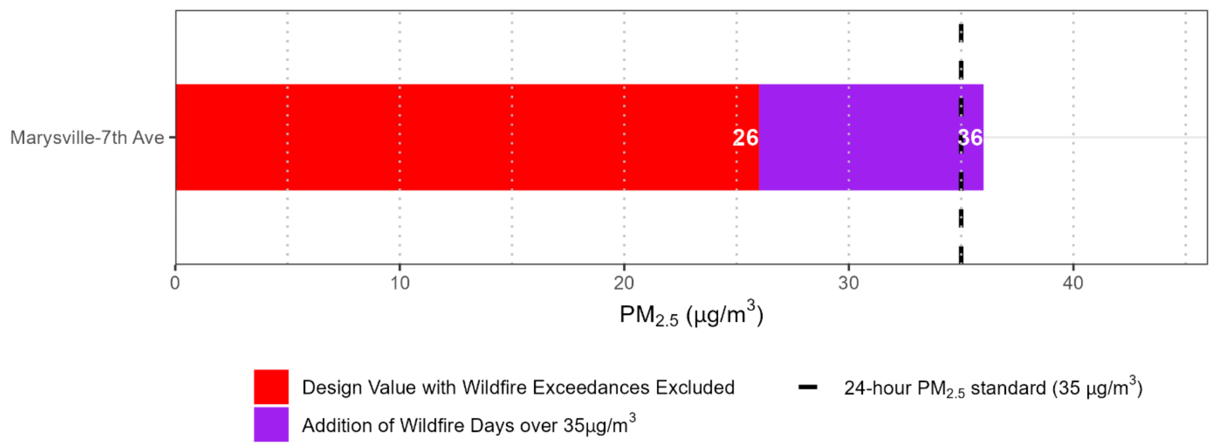

Figure 42. 24-hour $PM_{2.5}$ 2022 design value at the Everett area monitoring site

Over the past three years, the highest $PM_{2.5}$ concentrations in the area have been measured in August and September, when wildfire activity is highest. However, on average, $PM_{2.5}$ is usually higher in the cold season (Table 60). Figure 43 shows that, throughout the winter months, AQI is usually more consistently elevated in the moderate range, occasionally reaching unhealthy for sensitive groups. This is usually indicative of woodsmoke from home heating, which is consistent with the emission inventory for Snohomish County.

Table 60. Seasonal and annual means for $PM_{2.5}$ for Everett area monitoring sites, 2020-2022

Pollutant	Site	Season/annual mean	2020	2021	2022*	3-year mean
$PM_{2.5}$ (µg/m^3)	Marysville-7th Ave	Warm Season (April-September)	11.86	5.96	7.62	8.5
		Cold Season (October-March)	9.46	8.09	11.02	9.5
		Annual	10.57	7.01	9.12	8.9

PM = particulate matter, µg/m^3 = micrograms per cubic meter

*In 2022, seasonal means are adjusted April-October 21 and October 22-March due to wildfires in October.

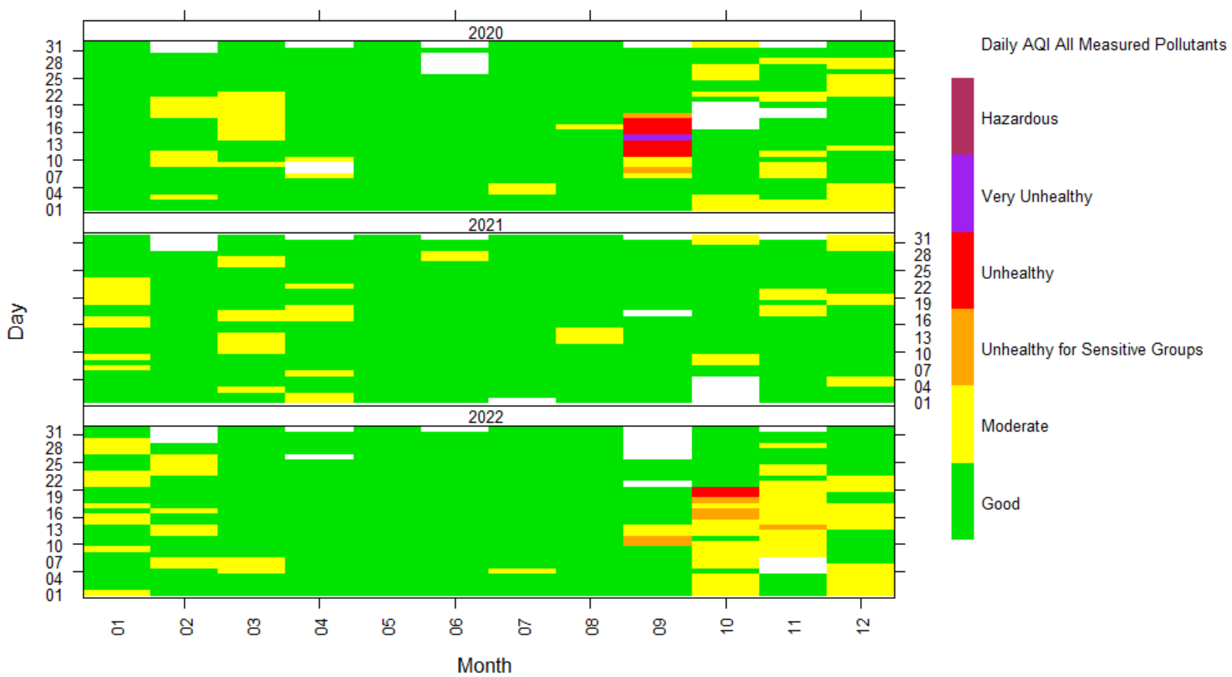

Figure 43. Calendar plot of daily maximum recorded air quality index from 2020-2022 for the Everett community

Potential health impacts

Several economic factors indicate that parts of Everett may be at greater risk of health impacts from air pollution, including lower income and unaffordable housing. Data showed that parts of the community also experience high rates of asthma and lower life expectancy relative to the rest of Washington State. Everett has many locations where occupants may be more vulnerable to the adverse effects of pollution exposure, such as childcare facilities, schools, healthcare facilities, and nursing homes.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 61). We estimated 20 all-cause deaths among all adults (0.30 deaths per 1,000 18-84-year-olds) each year associated with $PM_{2.5}$ in this community. Furthermore, we found the largest impact on older adults, with an estimated 6 deaths (0.48 deaths per 1,000 65–99-year-olds) each year associated with $PM_{2.5}$. Across all reported causes of death in Everett, the estimated rates are lower than those reported for all overburdened communities highly impacted by air pollution.

Table 61. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in Everett census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	20.0 [9.2 to 30]	0.30 [0.14 to 0.45]
Di et al.[54]	65 to 99	All	All-causes	5.3 [4.9 to 5.7]	0.48 [0.44 to 0.51]
Krewski et al. [52]	30 to 99	All	All-causes	12.0 [7.8 to 15]	0.23 [0.15 to 0.30]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	2.9 [2.3 to 3.4]	0.06 [0.05 to 0.07]
Krewski et al. [52]	30 to 99	All	Lung cancer	1.3 [0.5 to 2.0]	0.02 [0.01 to 0.04]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in Everett. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

One facility in Everett emitted a total of 67,553 MT CO_2e in 2020 and 67,481 MT CO_2e in 2021 (see Table 62).

Emissions are in units of metric tons of carbon dioxide equivalents (MT CO_2e) using AR4 global warming potentials as specified in WAC 173-441.

Table 62. Facilities and greenhouse gas emissions (MT CO_2e) in or nearby[98] Everett

Facility Name and City	Facility Sector	Inside Community Boundary?	CCA-Covered Entity?	Major Source of CAPs? [99]	2020 Emissions [biogenic] (MT CO_2e)	2021 Emissions [biogenic] (MT CO_2e)
Boeing Commercial Airplanes - Everett	Manufacturing	Yes	Yes	Yes	67,553 [0]	67,481 [0]

CAPs = criteria air pollutants, CCA = Climate Commitment Act, MT CO_2e = metric tons of carbon dioxide equivalent

Table 63. GHG estimates from mobile sources in Everett

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
83,973	377,279	4.5

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future.

Additional resources

- Air pollution resources:
  - Puget Sound Clean Air Agency
    - PSCAA Air Sensor Map
    - PSCAA studies, reports, plans, etc.
- Health resources:
  - Snohomish Health District
  - North Sound Accountable Community of Health (ACH)
- Greenhouse gas resources:
  - Emissions Reports, Snohomish County

[98] For the purposes of this analysis, nearby is within 3 miles of the overburdened community boundary.
[99] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

- Puget Sound Clean Air Agency GHG Emissions Inventory, 2018

North Seattle and Shoreline

Geographic description

This community is in north King County and includes parts of both Seattle and Shoreline. Air quality is managed by Puget Sound Clean Air Agency. This community covers approximately 4.5 square miles and has a population of approximately 39,997 people. It is primarily residential and includes all or part of the following neighborhoods in Shoreline: Ridgecrest and Briarcrest; and all or part of the following areas of Seattle: Northgate, Lake City, Bitter Lake, and Greenwood.

Levels of criteria air pollutants

The main pollutants of concern that we identified for the North Seattle and Shoreline community are short-term $PM_{2.5}$ and cumulative criteria air pollution, which is again primarily driven by levels of $PM_{2.5}$, with some contribution from O_3 and NO_2. Previous modeling or air emissions inventory results have shown that concentrations of other criteria air pollutants (CO, lead, SO_2) are likely to be low in this area.[100,101] According to various environmental justice tools, this area ranks high for proximity to heavy traffic roadways and diesel exhaust particulate matter emissions. We will be examining the sources of pollution in North Seattle and Shoreline in greater detail in future analyses.

Air quality monitoring

For this report, we will look at the data from the nearest monitor, which is less than 3 miles away, located in Lake Forest Park (Figure 44; Table 64). Additional air quality monitoring stations will be added in 2024, with community engagement.

[100] https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe
[101] https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory

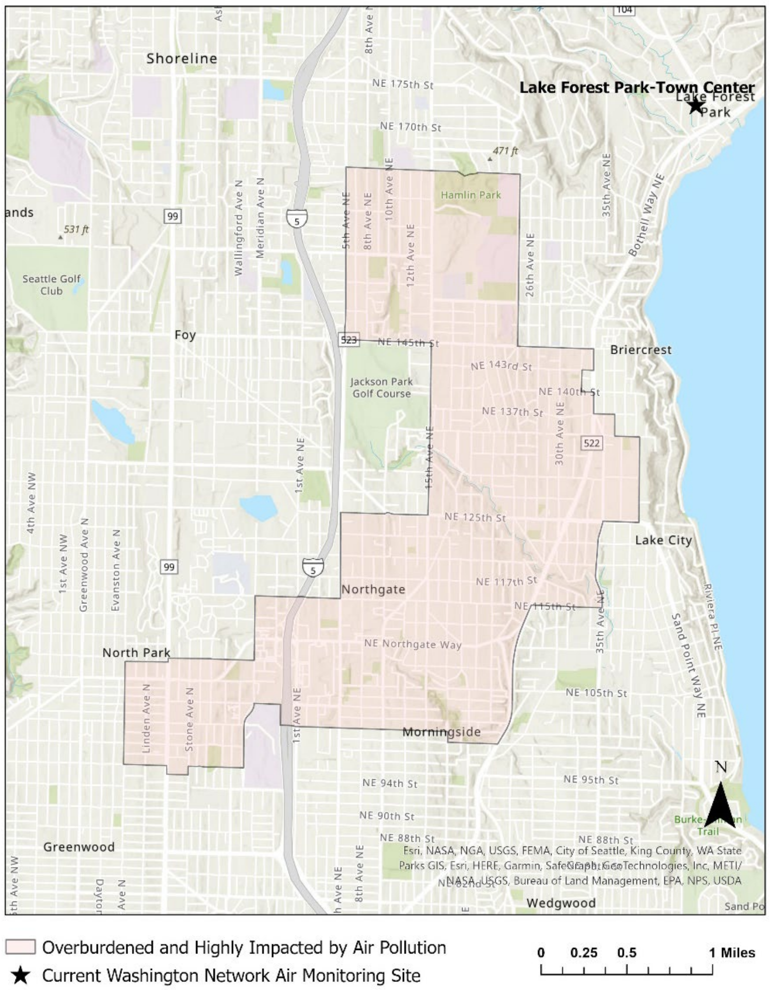

Figure 44. North Seattle and Shoreline community boundaries and air monitoring sites

Table 64. North Seattle and Shoreline area monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
Lake Forest Park-Town Center	Puget Sound Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	No

PM = particulate matter

This area routinely experiences spikes in $PM_{2.5}$. In 2020, the annual 98th percentile concentration exceeded the 24-hour NAAQS for $PM_{2.5}$. These elevated concentrations and the variability in $PM_{2.5}$ levels year to year, are primarily attributable to wildfire smoke events. With wildfire excluded, the annual 98th percentile concentrations for $PM_{2.5}$ were more consistent year to year, around 15-24 µg/m^3. While lower than the national air quality standard of 35 µg/m^3, they are sometimes higher than Ecology's healthy air goal of 20 µg/m^3.

Table 65. Criteria air pollutant annual and 3-year summary statistics for North Seattle and Shoreline area monitoring site for 2020-2022. A red box indicates a value above the NAAQS. Numbers in brackets [] indicate wildfire days >35.4 µg/m³ $PM_{2.5}$ have been removed.

Pollutant	Form	NAAQS Level	Site Name	2020	2021	2022	3-year Design Value
$PM_{2.5}$ 24-hour (µg/m³)	98th Percentile	35	Lake Forest Park-Town Center	52.7 [17.8]	15.8 [15.5]	33.3 [24.0]	34 [19]

NAAQS = national ambient air quality standards, PM = particulate matter, µg/m³ = micrograms per cubic meter

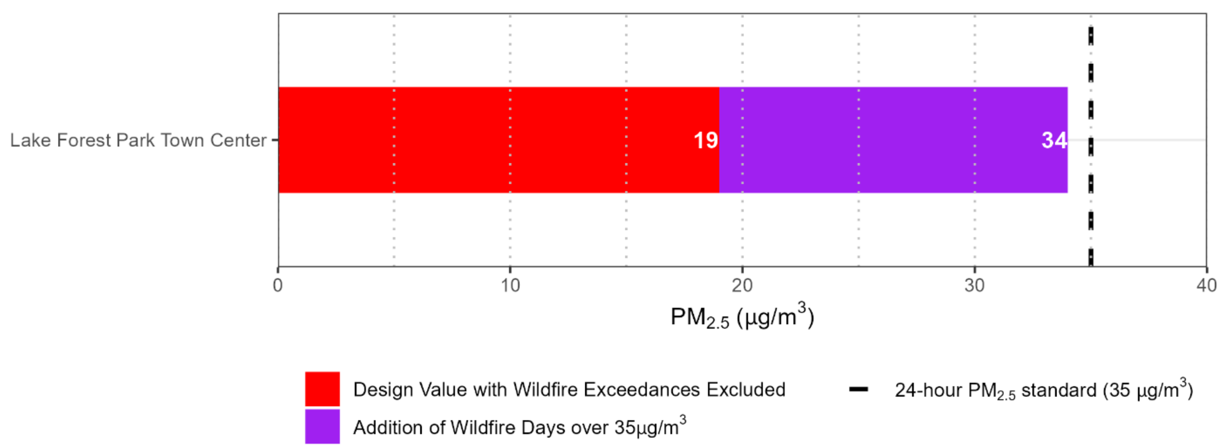

Figure 45. 24-hour $PM_{2.5}$ 2022 design value at the North Seattle and Shoreline area monitoring site

Depending on the year, the levels of $PM_{2.5}$ in this area can be higher in either the warmer months or the colder months (Table 66). Spikes in $PM_{2.5}$ that reach AQI levels in the "unhealthy for sensitive groups" or higher are more common in the warm season, particularly in August-October when wildfire activity is highest (Figure 46). On the other hand, wintertime levels of $PM_{2.5}$ are more consistent with more days in the moderate AQI range. This is usually due to wood-burning for home heating in the winter.

Table 66. Seasonal and annual means for $PM_{2.5}$ for North Seattle and Shoreline sites, 2020-2022

Pollutant	Site	Season/annual mean	2020	2021	2022*	3-year mean
$PM_{2.5}$ (µg/m^3)	Lake Forest Park-Town Center	Warm Season (April-September)	9.45	5.12	8.61	7.8
		Cold Season (October-March)	7.01	5.71	7.22	6.6
		Annual	8.13	5.46	7.89	7.2

PM = particulate matter, µg/m^3 = micrograms per cubic meter

*In 2022, seasonal means are adjusted April-October 21 and October 22-March due to wildfires in October.

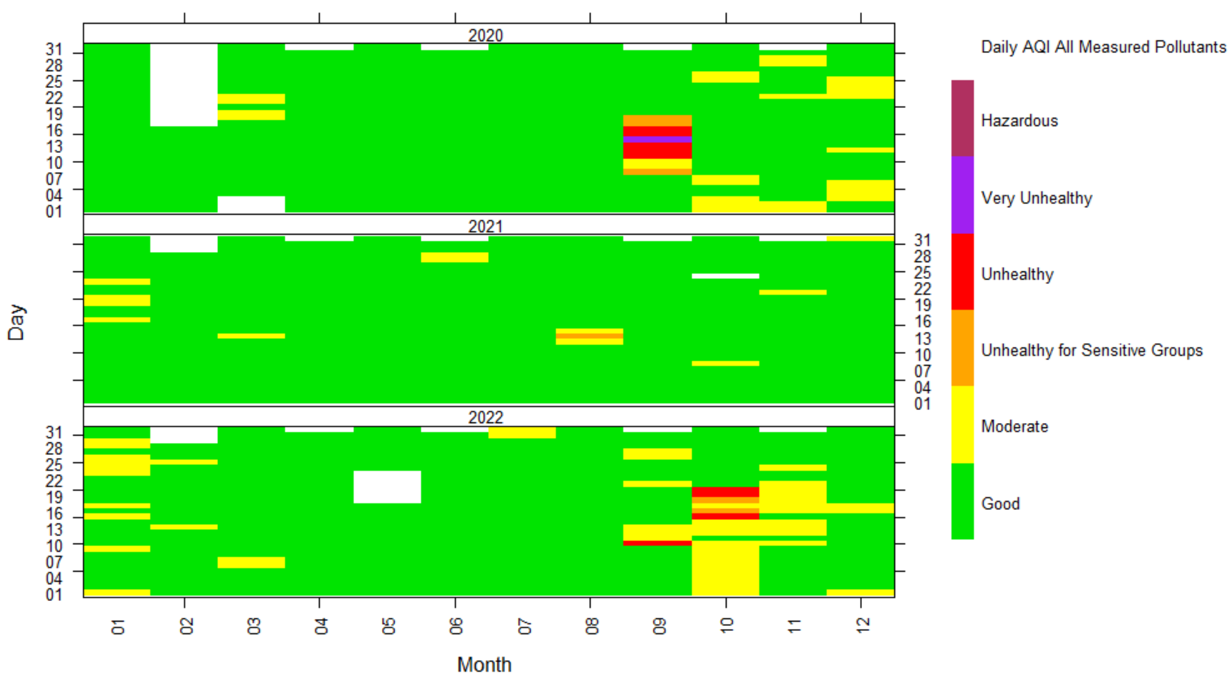

Figure 46. Calendar plot of daily maximum recorded air quality index from 2020-2022 for the North Seattle and Shoreline community

Air quality modeling

Roadway NO_2

We modeled ambient 1-hour NO_2 concentrations from on-road mobile sources, which are the primary sources of NO_2 in Washington communities. Model parameters were selected to represent the conditions under which NO_2 concentrations would be highest (e.g., peak traffic volume, stable atmospheric conditions). The average modeled 1-hour NO_2 concentration across the area is 19.7 ppb. The modeled concentration representing peak near-road conditions, is 40.1 ppb. Figure 47 shows the relative distribution of roadway NO_2 across the North Seattle and Shoreline communities.

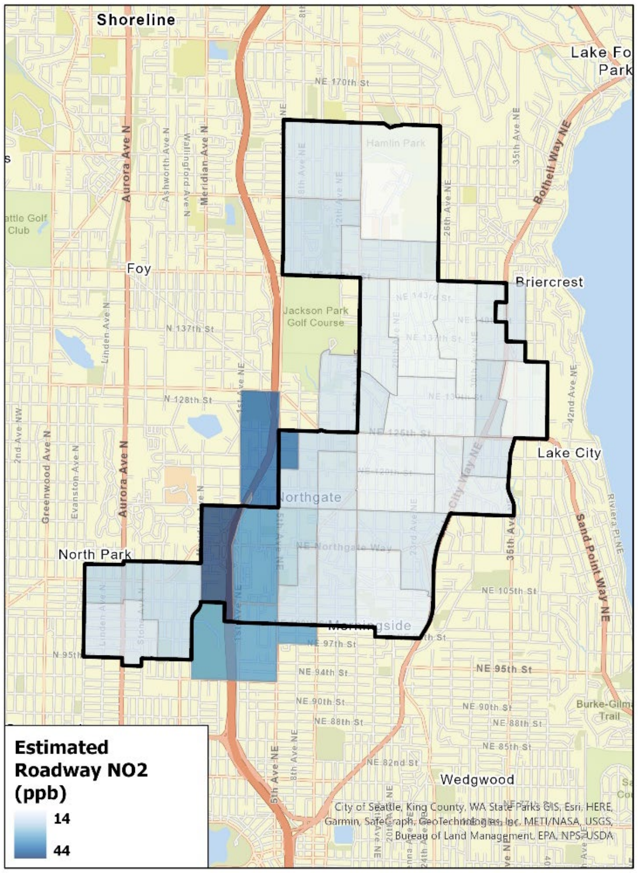

Figure 47. Average estimated 1-hour NO_2 concentration from on-road mobile sources by 2010 census block group in North Seattle and Shoreline during weekday afternoon peak traffic under wintertime stable atmospheric conditions

Ozone

For North Seattle and Shoreline, the average estimated 8-hour O_3 design value from July 2014 through June 2017 was 0.048 ppm. Long-term O_3 monitoring across the state has shown that O_3 levels in Washington have stayed relatively consistent over time, although spikes may occur during severe heat, drought, or wildfire events.

Potential health impacts

Several socioeconomic factors indicate that people in parts of North Seattle and Shoreline may be more vulnerable to health impacts from air pollution, including people of color, linguistically isolated, and low-income populations. This community also has several locations where occupants may be more vulnerable to the adverse effects of pollution exposure, such as childcare facilities, schools, healthcare facilities, and nursing homes.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 67). We estimated 8 all-cause deaths among all adults (0.17 deaths per 1,000 18-84-year-olds) each year associated with $PM_{2.5}$ in this community. By age, we found the largest impact on older adults, with an estimated 3 all-cause deaths (0.44 deaths per 1,000 65–99-year-olds) each year associated with $PM_{2.5}$. Across all reported causes of death in the North Seattle and Shoreline communities, the estimated rates are lower than those for all overburdened communities highly impacted by air pollution.

Table 67. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in North Seattle and Shoreline census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	7.2 [2.3 to 11.8]	0.17 [0.06 to 0.28]
Di et al.[54]	65 to 99	All	All-causes	2.6 [2.3 to 2.8]	0.44 [0.40 to 0.48]
Krewski et al. [52]	30 to 99	All	All-causes	4.8 [3.2 to 6.3]	0.16 [0.11 to 0.21]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	1.6 [1.3 to 1.9]	0.05 [0.04 to 0.06]
Krewski et al. [52]	30 to 99	All	Lung cancer	0.6 [0.3 to 0.96]	0.02 [0.01 to 0.03]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in North Seattle and Shoreline. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

There are no major stationary sources of greenhouse gas emissions in or near North Seattle and Shoreline. This is likely due to the community having a smaller geographic area and being close to other areas where more major industry exists.

Table 68. GHG estimates from mobile sources in North Seattle and Shoreline

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
39,997	187,552	4.7

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future.

Additional resources

- Exploring the Patterns of People in Seattle and the Region, City of Seattle
- Air pollution resources:
  - Puget Sound Clean Air Agency
    - PSCAA Air Sensor Map
    - PSCAA studies, reports, plans, etc.
- Health resources:
  - Seattle and King County Public Health
  - HealthierHere
- Greenhouse gas resources:
  - Greenhouse gas emissions, King County
  - One Seattle Climate Portal, City of Seattle
  - Understanding Our Emissions - Environment, City of Seattle
  - Measuring Greenhouse Gas Emissions at Port of Seattle
  - Puget Sound Clean Air Agency GHG Emissions Inventory, 2018

South Seattle

Geographic description

South Seattle is in King County. Air quality is managed by Puget Sound Clean Air Agency. The area identified as highly impacted by air pollution is approximately 44 square miles and includes about 192,634 residents. It stretches from the seaports of Seattle in the north to the SeaTac airport in the south, including a large portion of South Seattle, as well as parts of Tukwila, Burien, and SeaTac. This community is a hub of transportation and industry, intermingled alongside residential areas.

Levels of criteria air pollutants

The main pollutants of concern that we identified for this community were long-term and short-term $PM_{2.5}$, as well as cumulative criteria air pollution, which is primarily driven by levels of $PM_{2.5}$, O_3, and NO_2. Criteria air pollutants come from a variety of sources, and we will be examining the sources of pollution in South Seattle in greater detail in future analyses.

Air quality monitoring

This community has five monitors in Ecology's network (Figure 48; Table 69). One of them is the National Core (NCore) air monitoring location at Jefferson Park in Beacon Hill. It monitors for every criteria pollutant and other types of air pollutants like air toxics.

Figure 48. South Seattle community boundaries and air monitoring sites

Table 69. South Seattle monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
Seattle-10th & Weller	Ecology	CO, NO_2, $PM_{2.5}$	Microscale (≤ 100 m)	Yes
Seattle-Beacon Hill	Ecology	CO, Lead, NO_2, O_3, $PM_{2.5}$, PM_{10}, SO_2	Urban (4-50 km)	Yes
Seattle-Duwamish	Puget Sound Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	Yes
Seattle-South Park	Puget Sound Clean Air Agency	$PM_{2.5}$	Microscale (≤ 100 m)	No
Tukwila Allentown	Puget Sound Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	Yes

CO = carbon monoxide, NO_2 = nitrogen dioxide, O_3 = ozone, PM = particulate matter, SO_2 = sulfur dioxide

For $PM_{2.5}$, this area experienced a large spike in September 2020, with very unhealthy air quality conditions that lasted about a week. The annual 98th percentile concentration exceeded the 24-hour NAAQS for $PM_{2.5}$ as a result. These elevated concentrations, as well as more and more frequent spikes in $PM_{2.5}$ levels and the variability in $PM_{2.5}$ levels year-to-year, are primarily attributable to wildfire smoke events. With wildfire excluded, the annual 98th percentile concentrations for $PM_{2.5}$ ranged from 10-28 µg/m^3 depending on the site and the year. While lower than the national air quality standard of 35 µg/m^3, they are sometimes higher than Ecology's healthy air goal of 20 µg/m^3.

Levels of $PM_{2.5}$, which are monitored at all 5 sites in the community, are fairly consistent from site to site, particularly in years with less wildfire activity. In both 2021 and 2022, 24-hour $PM_{2.5}$ design values differed by about 5 µg/m^3 at most between sites. They were generally lowest at Beacon Hill, which is an urban-scale monitoring station, and highest at 10th & Weller, which is a microscale monitoring station representative of near-road conditions.

NO_2 is also measured at 10th & Weller, near the junction of Interstate 5 and Interstate 90. This is an area where we would expect near-peak emissions from on-road vehicles (the primary source of NO_2) in Seattle. The 1-hour design value for NO_2 at this site is 53 ppb, which is about half of the national standard of 100 ppb. NO_2 is also measured at the urban scale at Beacon Hill, where the design value is slightly lower, at 41 ppb.

Several air pollution monitoring studies have been conducted in this area recently (see "additional resources" for South Seattle below). A 2019-2020 study conducted by the University of Washington did extensive mobile monitoring across this area and found levels of $PM_{2.5}$ and

NO_2 were highest around downtown Seattle, the port, and the major transportation corridors like Interstate 5.[102]

O_3 is a regional pollutant that is typically highest downwind of urban areas. In 2020-2022, the fourth-highest daily O_3 value in the Seattle area was 0.050 ppm. This is below the national standard of 0.070 ppb. The mean level of O_3 during ozone season (May-September) is 0.029 ppb. O_3 in Seattle is usually in the "good" AQI range, although it rarely goes into the "moderate" or "unhealthy for sensitive groups" range during extreme heat and wildfire smoke events.

Design values for both CO and PM_{10} are reported in exceedances above certain concentration thresholds. There have been zero exceedances of either pollutant in the last three years at any of the sites where they are monitored. Measured levels of SO_2 at Beacon Hill also tend to be very low, around 3 ppb, which is 4% of the national standard.

PSCAA has conducted several local air monitoring, mobile monitoring, and air toxics studies in this area, particularly in its two focus communities: The Duwamish Valley and the Chinatown-International District. During a year-long air toxics study in 2021-2022, PSCAA monitored lead for a year at the Duwamish monitoring station. The rolling 3-month average was 0.0092 $\mu g/m^3$ and the highest daily lead level recorded during that time was 0.035 $\mu g/m^3$. This is about 6% and 23% of the national standard, respectively. Comparatively, the rolling 3-month average lead concentration at Beacon Hill in 2020-2022 was 0.0033 $\mu g/m^3$ and the maximum was 0.0157 $\mu g/m^3$.

[102] Blanco, Magali N., Amanda Gassett, Timothy Gould, Annie Doubleday, David L. Slager, Elena Austin, Edmund Seto, Timothy V. Larson, Julian D. Marshall, and Lianne Sheppard. "Characterization of Annual Average Traffic-Related Air Pollution Concentrations in the Greater Seattle Area from a Year-Long Mobile Monitoring Campaign." *Environmental Science & Technology* 56, no. 16 (2022): 11460-11472.

Table 70. Criteria air pollutant annual and 3-year summary statistics for South Seattle monitoring sites for 2020-2022. A red box indicates a value above the NAAQS. Numbers in brackets [] indicate wildfire days >35.4 µg/m³ $PM_{2.5}$ have been removed.

Pollutant & averaging time	Form	NAAQS Level	Site Name	2020	2021	2022	3-year Design Value
$PM_{2.5}$ 24-hour (µg/m³)	98th percentile	35	Seattle-10th & Weller*	60.5 [18.4]	14.7 [14.6]	*29.7 [28.2]*	*35 [20]*
			Seattle-Beacon Hill	53.0 [12.5]	11.8 [10.7]	27.7 [23.3]	31 [16]
			Seattle-Duwamish	46.3 [18.9]	16.2 [15.7]	25.9 [25.0]	29 [20]
			Seattle-South Park**	19.1 [16.5]	15.4 [14.3]	31.1 [24.3]	22 [18]
			Tukwila Allentown	56.5 [17.6]	17.7 [14.4]	30.5 [26.3]	35 [19]
PM_{10} 24-hour (µg/m³)	# of annual exceedances >150 µg/m³	1	Seattle-Beacon Hill	0	0	0	0
O_3 8-hour (ppm)	Annual fourth-highest daily maximum	0.070	Seattle-Beacon Hill	0.052	0.052	0.047	0.050
CO 1-hour (ppm)	# of exceedances >35 ppm	1	Seattle-10th & Weller*	0	0	0	0
			Seattle-Beacon Hill	0	0	0	0
SO_2 1-hour (ppb)	99th percentile	75	Seattle-Beacon Hill	4.1	2.5	3.4	3

Pollutant & averaging time	Form	NAAQS Level	Site Name	2020	2021	2022	3-year Design Value
Lead (µg/m³)	3-month rolling average	0.15	Seattle-Beacon Hill	N/A	N/A	N/A	0.0033
			Seattle-Duwamish***	N/A	N/A	N/A	*0.0092*
NO_2 1-hour (ppb)	98th percentile	100	Seattle-10th & Weller*	56.8	48.6	54.0	53
			Seattle-Beacon Hill	39.4	41.6	43.0	41

CO = carbon monoxide, NAAQS = national ambient air quality standards, NO_2 = nitrogen dioxide, O_3 = ozone, PM = particulate matter, ppb = parts per billion, ppb = parts per million, SO_2 = sulfur dioxide, µg/m³ = micrograms per cubic meter

*$PM_{2.5}$ monitor operation at Seattle-10th & Weller was down 11/1/22-12/22/22 (incomplete data are denoted in italics)

**Operation at the Seattle-South Park monitoring site was down from 8/31/20-9/13/20, during a smoke event, which led to lower recorded DVs

***Lead monitoring at the Tacoma-Alexander site was conducted by Puget Sound Clean Air Agency for their Community-Scale Air Toxics Study from August 2021 – September 2022.

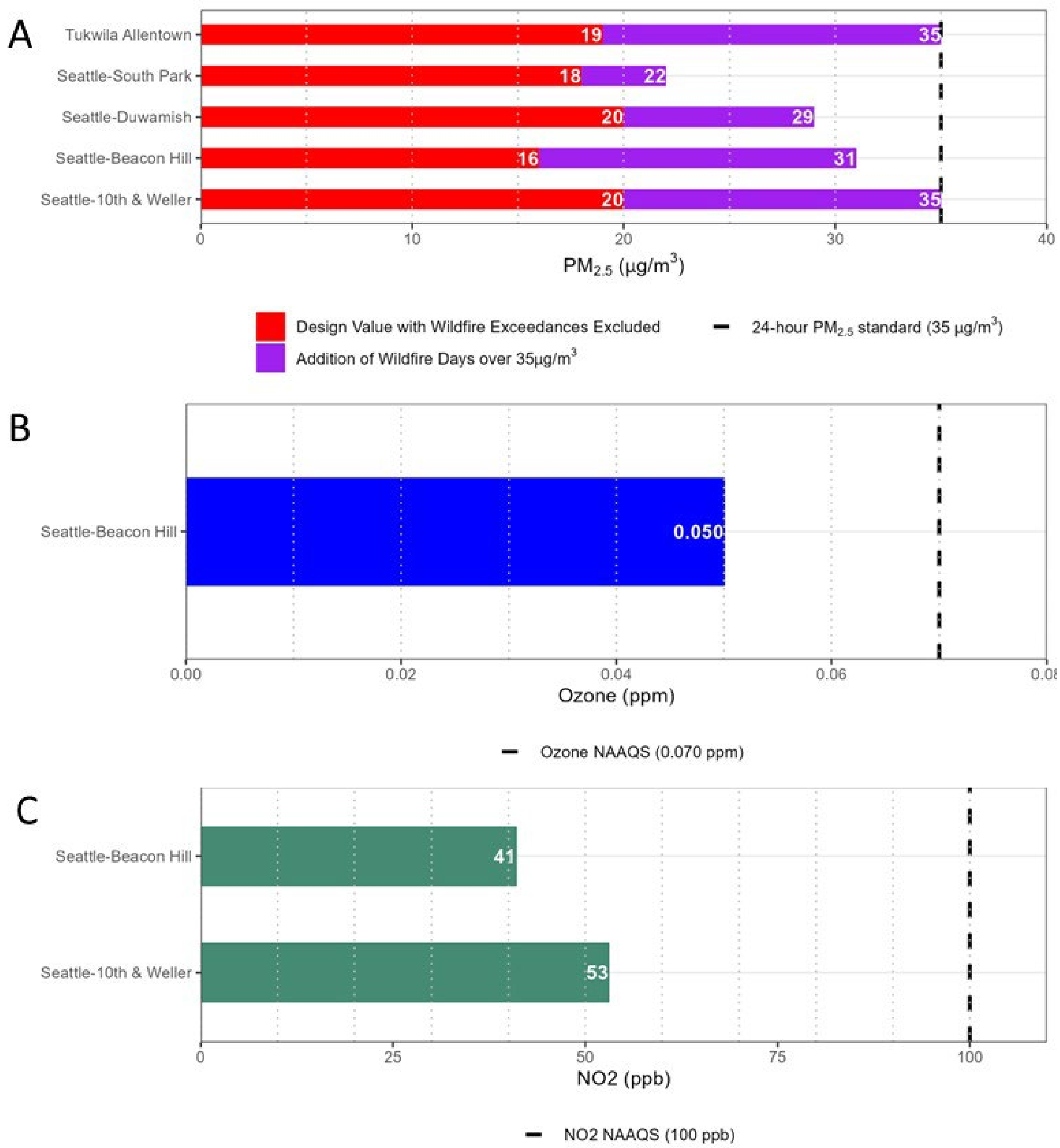

Figure 49. 2022 design values for A) 24-hour $PM_{2.5}$ and B) Ozone and C) 1-hour NO_2 at South Seattle monitoring sites. Note that $PM_{2.5}$ design value at Seattle-10th and Weller and Seattle-South Park may be biased because of missing data (see Table 70)

Particle pollution in Washington varies seasonally. Whether it is worse in warmer months or cooler months mainly depends on the severity of wildfire smoke for that year. Across South Seattle, there has been substantial fluctuation in warm season $PM_{2.5}$ means, whereas cold season $PM_{2.5}$ means remain more consistent. The calendar plot (Figure 50) also shows more AQI spikes in the "unhealthy for sensitive groups" range in the summer through early fall when wildfire activity is highest, whereas the winter months have a higher proportion of days in the "moderate" AQI range when more $PM_{2.5}$ comes from residential wood-burning.

Annual $PM_{2.5}$ means across the neighborhood-scale sites in South Seattle were all very close, between 8-9 µg/m^3 (Table 71). However, the annual $PM_{2.5}$ mean at the urban-scale site at Beacon Hill was lower, at 5.9 µg/m^3.

Table 71. Seasonal and annual means for $PM_{2.5}$ and seasonal means for O_3 for South Seattle monitoring sites, 2020-2022

Pollutant	Site	Season/annual mean	2020	2021	2022*	3-year mean
$PM_{2.5}$ (µg/m^3)	Seattle-10th & Weller**	Warm Season (April-September)	12.08	6.82	9.62	9.5
		Cold Season (October-March)	6.78	6.27	*7.85*	*7.0*
		Annual	9.49	6.53	*10.53*	*8.9*
$PM_{2.5}$ (µg/m^3)	Seattle-Beacon Hill	Warm Season (April-September)	8.39	4.72	8.17	7.1
		Cold Season (October-March)	4.07	4.00	5.76	4.6
		Annual	6.21	4.36	7.00	5.9
$PM_{2.5}$ (µg/m^3)	Seattle-Duwamish	Warm Season (April-September)	11.92	6.16	8.55	8.9
		Cold Season (October-March)	8.36	7.12	9.14	8.2
		Annual	10.13	6.64	8.77	8.5
$PM_{2.5}$ (µg/m^3)	Seattle-South Park***	Warm Season (April-September)	*9.59*	7.38	10.45	*9.1*
		Cold Season (October-March)	8.25	7.36	8.42	8.0
		Annual	*9.03*	7.37	9.52	*8.6*

Pollutant	Site	Season/annual mean	2020	2021	2022*	3-year mean
$PM_{2.5}$ (µg/m³)	Tukwila Allentown	Warm Season (April-September)	12.60	6.50	8.62	9.2
		Cold Season (October-March)	7.00	6.17	7.60	6.9
		Annual	9.69	6.33	8.11	8.0
O_3 (ppm)	Seattle-Beacon Hill	Ozone Season (May-September)	0.029	0.030	0.028	0.029

PM = particulate matter, O_3 = ozone, ppm = parts per million, µg/m³ = micrograms per cubic meter

*In 2022, seasonal means are adjusted April-October 21 and October 22-March due to wildfires in October.

**$PM_{2.5}$ monitor operation at Seattle-10th & Weller was down 11/1/22-12/22/22 (incomplete data are denoted in italics)

***Operation at the Seattle-South Park monitoring site was down from 8/31/20-9/13/20, during a smoke event (incomplete data are denoted in italics)

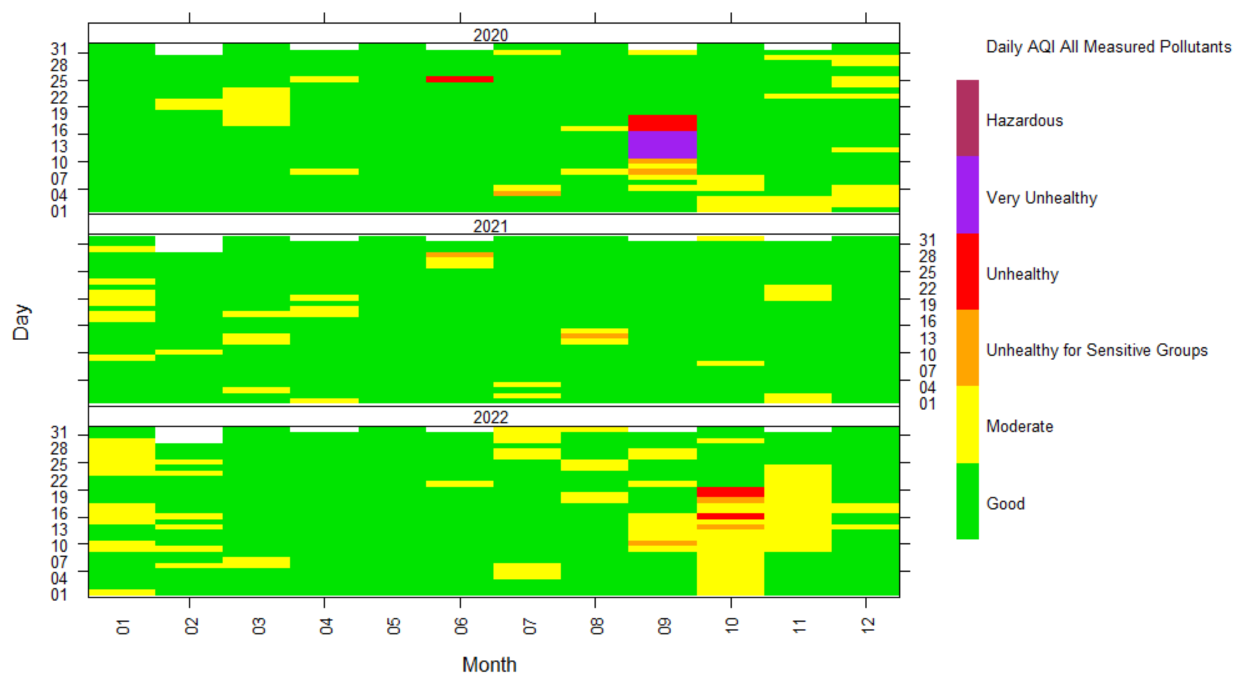

Figure 50. Calendar plot of daily maximum recorded air quality index from 2020-2022 for the South Seattle community

The dominant pollutant measured in South Seattle with the highest daily AQI is $PM_{2.5}$ for the majority of the time. In the summertime, when O_3 is at its peak and $PM_{2.5}$ is usually lower, O_3 it is often the dominant pollutant. NO_2 has less seasonal variation than either $PM_{2.5}$ or O_3 and is the dominant pollutant on days when those two pollutants are particularly low. SO_2 and CO tend to be lower, and all days between 2020-2022 were in the “good” AQI category for these pollutants. Thus, they can be considered or lower concern for health impacts in this community.

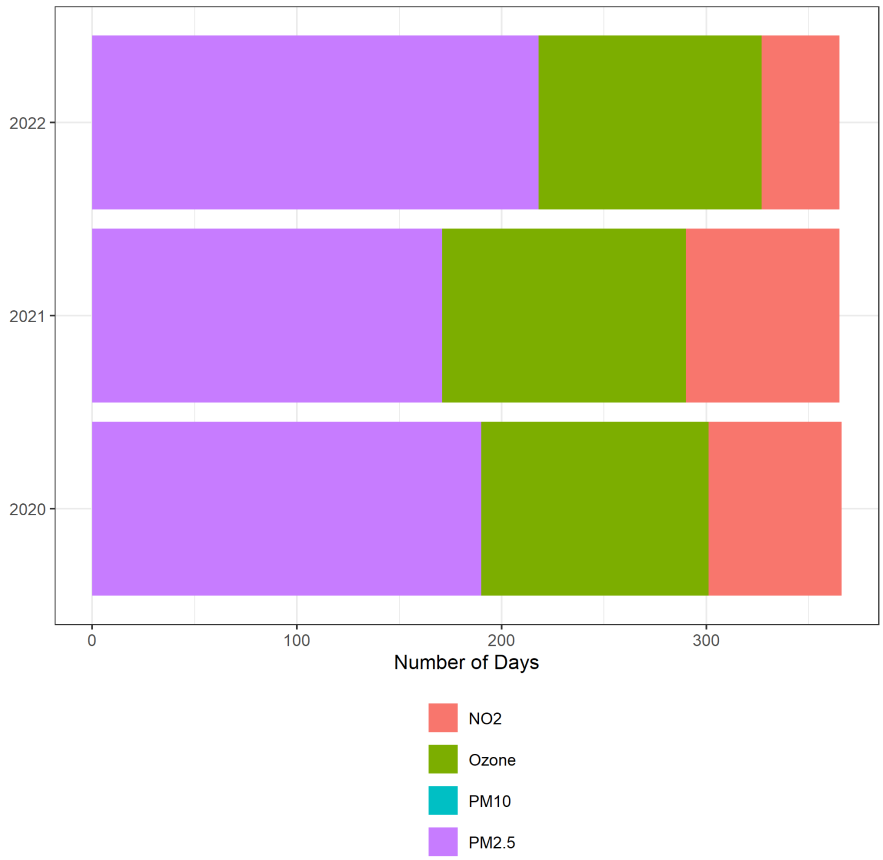

Figure 51. Dominant pollutant by AQI measured each day at monitoring sites for South Seattle (SO_2 and CO are also monitored in this community but they were not the dominant pollutant for any days in 2020-2022)

Air quality modeling

Roadway NO_2

We modeled ambient 1-hour NO_2 concentrations from on-road mobile sources, which are the primary sources of NO_2 in Washington communities. Model parameters were selected to represent the conditions under which NO_2 concentrations would be highest (e.g., peak traffic volume, stable atmospheric conditions). The average modeled 1-hour NO_2 concentration across the area is 30.6 ppb. The modeled concentration representing peak near-road conditions, is 49.4 ppb. Figure 52 shows the relative distribution of roadway NO_2 across South Seattle. Modeling results show that the 10^{th} and Weller monitoring site is likely in one of the best places to capture the maximum levels of roadway NO_2 for this community. According to EPA guidelines, the Beacon Hill monitor is sited to measure the area wide NO_2 concentrations that occur more broadly across communities.

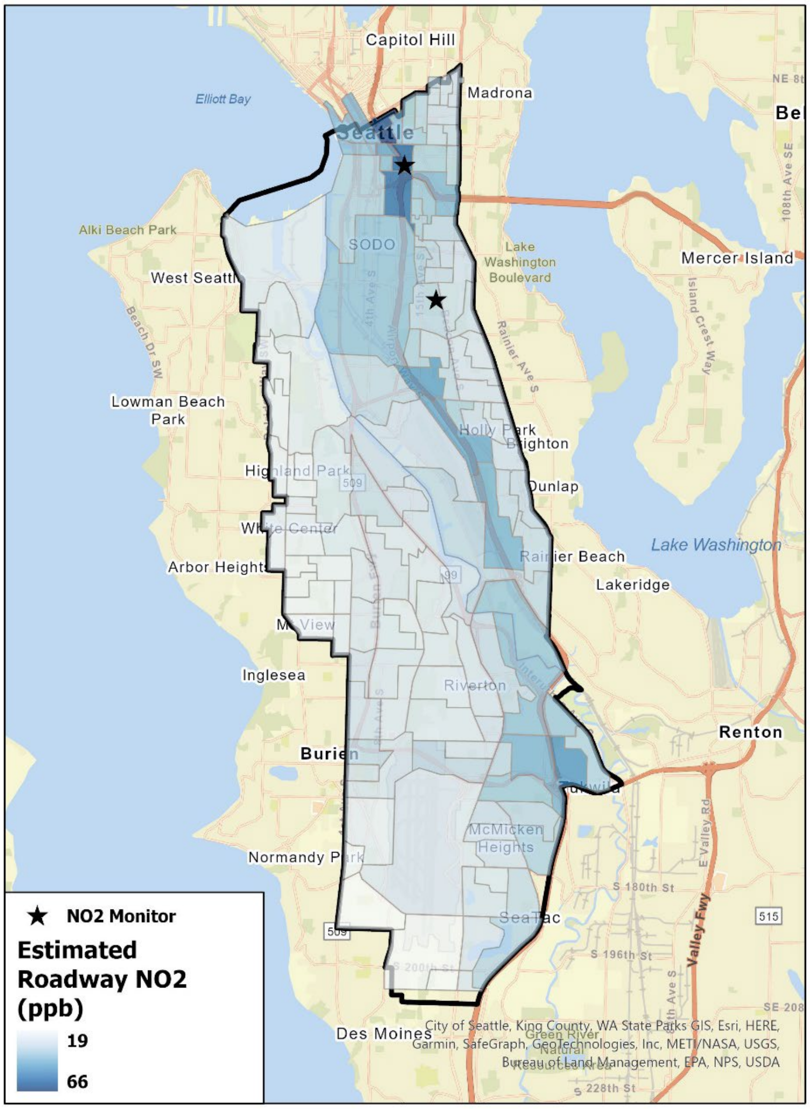

Figure 52. Average estimated 1-hour NO_2 concentration from on-road mobile sources by 2010 census block group in South Seattle during weekday afternoon peak traffic under wintertime stable atmospheric conditions

Potential health impacts

Several socioeconomic factors indicate that populations within the South Seattle community may be at greater risk of health impacts from air pollution, including people of color, low-income, and linguistically isolated populations. The community on average also experiences higher rates of asthma and lower life expectancy, compared to the rest of Washington State. The community has a high density of locations where occupants may be more vulnerable to the adverse effects of pollution exposure, such as childcare facilities, schools, and healthcare facilities.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 72). We estimated 68 all-cause deaths among all adults (0.40 deaths per 1,000 18-84-year-olds) each year associated with $PM_{2.5}$ in this community. Older adults living in South Seattle are significantly impacted by $PM_{2.5}$, with much higher rates of death than all overburdened communities highly impacted by air pollution combined. For ages 65-99, we estimated 27 all-cause deaths (1.04 deaths per 1,000 65–99-year-olds) each year associated with $PM_{2.5}$. For all other reported causes of death, the estimated rates are similar to those for all overburdened communities highly impacted by air pollution.

Table 72. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in South Seattle census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	67.2 [12.2 to 117.1]	0.40 [0.07 to 0.69]
Di et al.[54]	65 to 99	All	All-causes	26.1 [23 to 29]	1.04 [0.91 to 1.15]
Krewski et al. [52]	30 to 99	All	All-causes	31.0 [21 to 40]	0.24 [0.16 to 0.32]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	9.0 [7.4 to 11]	0.07 [0.06 to 0.08]
Krewski et al. [52]	30 to 99	All	Lung cancer	3.5 [1.5 to 5.3]	0.03 [0.01 to 0.04]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in South Seattle. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

Nine facilities in or nearby South Seattle emitted a total of 735,383 MT CO_2e in 2020 and 774,207 MT CO_2e in 2021 (see Table 73).

Emissions are in units of metric tons of carbon dioxide equivalents (MT CO_2e) using AR4 global warming potentials as specified in WAC 173-441.

Table 73. Facilities and greenhouse gas emissions (MT CO_2e) in or nearby[103] South Seattle

Facility Name and City	Facility Sector	Inside Community Boundary?	CCA-Covered Entity?	Major Source of CAPs?[104]	2020 Emissions [biogenic] (MT CO_2e)	2021 Emissions [biogenic] (MT CO_2e)
Ardagh Glass Inc. - Seattle	Minerals	Yes	Yes	Yes	58,653 [0]	57,881 [0]
Ash Grove Cement Company - Seattle	Minerals	Yes	Yes	Yes	346,185 [0]	359,054 [0]
CenTrio Energy Seattle LLC - Seattle	Power Plant	Nearby	Yes	Yes	63,699 [0]	66,389 [0]
CertainTeed Gypsum - Seattle	Manufacturing	Yes	Yes	No	49,936 [0]	55,216 [0]
Nucor Steel Seattle, Inc. - Seattle	Metals	Yes	Yes	Yes	83,972 [0]	97,512 [0]
Seattle-Tacoma International Airport - Seattle	Government	Yes	No	No	14,508 [0]	14,979 [0]
The Boeing Company: Boeing Plant 2 - Seattle	Manufacturing	Yes	No	Yes	18,837 [0]	21,233 [0]
The Boeing Company: DC/MFC - Tukwila	Manufacturing	Yes	No	No	12,613 [0]	12,319 [0]
University of Washington Seattle Campus - Seattle	Government	Nearby	Yes	Yes	86,980 [0]	89,624 [0]

CAPs = criteria air pollutants, CCA = Climate Commitment Act, MT CO_2e = metric tons of carbon dioxide equivalent

Table 74. GHG estimates from mobile sources in South Seattle

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
192,634	903,291	4.7

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future .

Additional resources

- Exploring the Patterns of People in Seattle and the Region, City of Seattle
- Air pollution resources:
    - Puget Sound Clean Air Agency
        - PSCAA Air Sensor Map
        - PSCAA studies, reports, plans, etc.
            - Air Quality in the Duwamish Valley, 2016 Overview
            - Tukwila-Allentown Air Quality Study Community Report (2018)
            - 2014 Summer Ozone Study
        - Focus Communities:
            - Chinatown-International District
            - Duwamish Valley
- Other air pollution reports and studies:
    - Action towards health equity and improved air quality in the Duwamish Valley: A multilevel asthma intervention (ongoing), University of Washington/Duwamish River Community Coalition
    - Mobile ObserVations of Ultrafine Particles (MOV-UP) study (2019), University of Washington, – analyzed the potential air quality impacts from aircraft traffic on communities near and underneath Seattle-Tacoma International Airport (Sea-Tac) flight paths
    - Diesel Exhaust Exposure in Duwamish Valley (DEEDS) Study (2013), University of Washington – studied diesel exhaust gradient (including NO_x, $PM_{2.5}$) in South Park & Georgetown neighborhoods of Seattle
    - Blanco, Magali N., Amanda Gassett, Timothy Gould, Annie Doubleday, David L. Slager, Elena Austin, Edmund Seto, Timothy V. Larson, Julian D. Marshall, and Lianne Sheppard. "Characterization of Annual Average Traffic-Related Air

Pollution Concentrations in the Greater Seattle Area from a Year-Long Mobile Monitoring Campaign." *Environmental Science & Technology* 56, no. 16 (2022): 11460-11472.

- Health resources:
  - Seattle and King County Public Health
  - HealthierHere
  - Health studies and reports:
    - Cumulative Health Impact Assessment (CHIA) (2013), Just Health Action/Duwamish River Community Coalition – compared cumulative health impacts across ten Seattle ZIP codes
- Greenhouse gas resources:
  - Greenhouse gas emissions, King County
  - One Seattle Climate Portal, City of Seattle
  - Understanding Our Emissions - Environment, City of Seattle
  - Measuring Greenhouse Gas Emissions at Port of Seattle
  - Puget Sound Clean Air Agency GHG Emissions Inventory, 2018

South King County

Geographic description

Air quality in South King County is managed by the Puget Sound Clean Air Agency. This community is about 67.6 square miles and has approximately 204,300 residents. It contains all or part of the following cities: Tukwila, Renton, Des Moines, SeaTac, Kent, Auburn, Algona, Pacific, and Federal Way. A corridor of manufacturing facilities, distribution centers, and other businesses, as well as rail lines, runs north-south down the center of this community. Other parts are mostly residential, although there is also some agricultural land and nature areas along the Green River.

Levels of criteria air pollutants

The main pollutant of concern that we identified for some of this area is short-term $PM_{2.5}$. This is also the greatest pollutant of concern during wildfire events. In the absence of wildfire smoke, we don't expect any single criteria pollutant to be elevated for most of this area, but cumulative criteria pollutants, particularly $PM_{2.5}$, O_3, and NO_2, may lead to some health impacts. Previous modeling or air emissions inventory results have also shown that concentrations of other criteria air pollutants (CO, lead, SO_2) are likely to be low in this area.[105,106] Wood smoke

[105] https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe
[106] https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory

associated with home heating is a significant source of particle pollution in the wintertime, particularly in residential areas. The whole community is crisscrossed by multiple transportation routes, rail lines, and is home to many warehouses, and distribution centers. It is also situated close to several airports. We will be examining the sources of pollution in South King County in greater detail in future analyses.

Air quality monitoring

The community has two $PM_{2.5}$ monitors in Ecology's network in Kent and Auburn, although the Kent-Central & James monitoring site was discontinued as of July 2023 and will be moved to a new location sometime next year (Figure 53; Table 75). Several additional monitors are nearby in Tukwila and Tacoma (see South Seattle and South and East Tacoma monitoring sections for nearby monitoring results). PSCAA does more localized monitoring and studies within this area, particularly in their focus community, Auburn-Algona-Pacific.

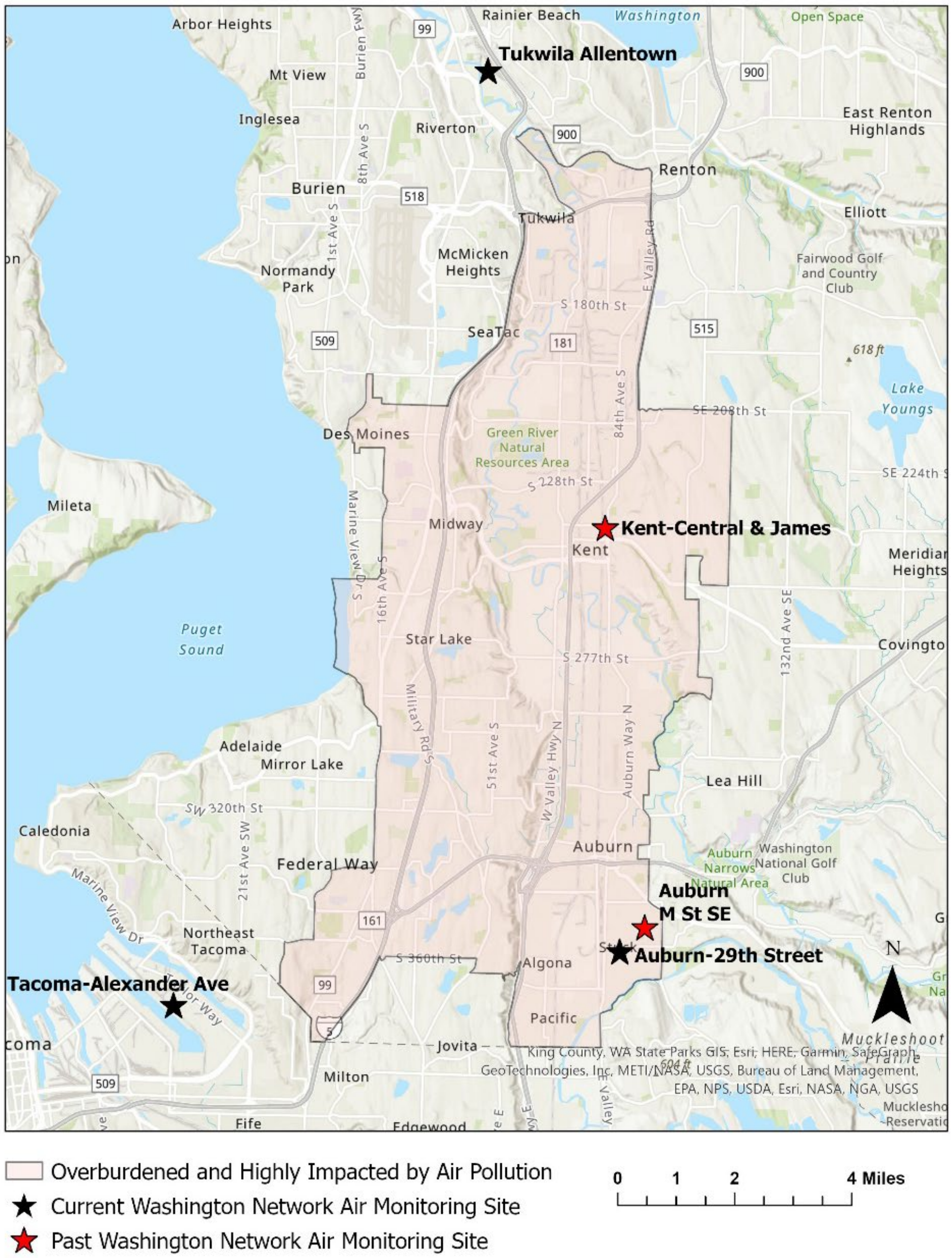

Figure 53. South King County community boundaries and air monitoring sites

Table 75. South King County monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
Kent-Central & James	Puget Sound Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	Yes
Auburn-29th Street*	Puget Sound Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	No
Auburn-M St*	Puget Sound Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	Yes

*The M St monitoring site was discontinued in April 2020 and replaced with the 29th Street site in March 2021. PM = particulate matter

This area routinely experiences some large spikes in $PM_{2.5}$. In 2020 and 2022, annual 98th percentile concentrations exceeded the 24-hour NAAQS for $PM_{2.5}$ at least one South King County monitoring site. These elevated concentrations, and the variability in short-term $PM_{2.5}$ year-to-year, are attributable primarily to wildfire smoke events. With wildfire excluded, the annual 98th percentile concentrations for $PM_{2.5}$ were around 20-22 $\mu g/m^3$. While lower than the national air quality standard of 35 $\mu g/m^3$, they are sometimes higher than Ecology's healthy air goal of 20 $\mu g/m^3$.

The University of Washington conducted a recent air pollution study in this area where they collected mobile monitoring data for a year in 2019-2020. Results from that study showed that $PM_{2.5}$ and NO_2 pollution concentrations were highest near major roadways, like Interstate 5 and state route 167.[107]

[107] Blanco, Magali N., Amanda Gassett, Timothy Gould, Annie Doubleday, David L. Slager, Elena Austin, Edmund Seto, Timothy V. Larson, Julian D. Marshall, and Lianne Sheppard. "Characterization of Annual Average Traffic-Related Air Pollution Concentrations in the Greater Seattle Area from a Year-Long Mobile Monitoring Campaign." *Environmental Science & Technology* 56, no. 16 (2022): 11460-11472.

Table 76. Criteria air pollutant annual and 3-year summary statistics for South King County monitoring sites for 2020-2022. A red box indicates a value above the NAAQS. Numbers in brackets [] indicate wildfire days >35.4 µg/m³ $PM_{2.5}$ have been removed.

Pollutant	Form	NAAQS Level	Site Name	2020	2021	2022	3-year Design Value*
$PM_{2.5}$ 24-hour (µg/m³)	98th percentile	35	Kent-Central & James	42.2 [21.1]	17.6 [17.1]	33.7 [28.0]	31 [22]
			Auburn-29th Street*	DNC	*15.9 [14.1]*	38.5 [26.2]	*27 [20]*
			Auburn-M St*	*13.5 [13.5]*	DNC	DNC	N/A

DNC = data not collected, NAAQS = national ambient air quality standards, PM = particulate matter, µg/m³ = micrograms per cubic meter

*The M St monitoring site was discontinued in April 2020 and replaced with the 29th Street site in March 2021. As such, DVs for 2020 and 2021 are incomplete (incomplete data are denoted in italics).

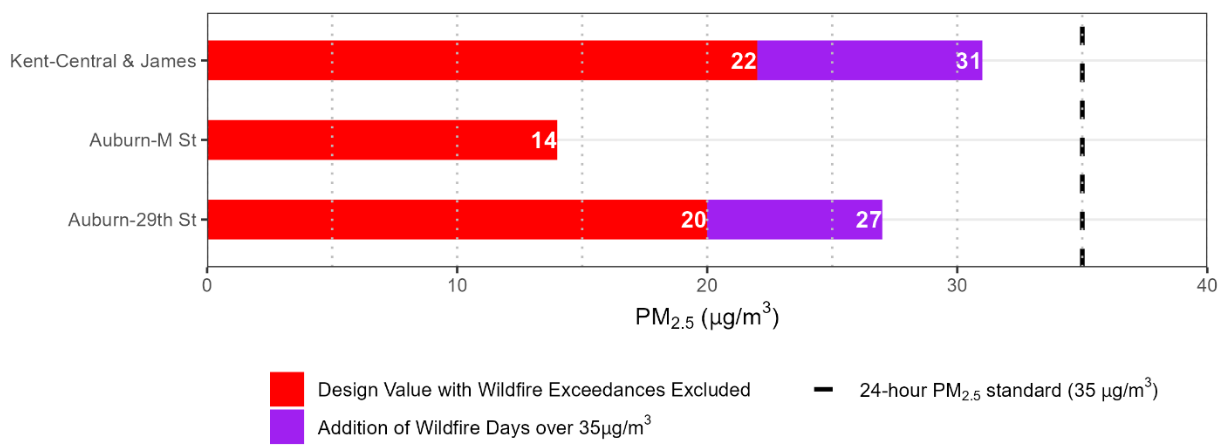

Figure 54. 24-hour $PM_{2.5}$ 2022 design values at South King County monitoring sites. Note that design values at Auburn-M St and Auburn-29th St are biased because of missing data (see Table 76)

Fluctuations in $PM_{2.5}$ levels due to wildfires, and relocation of air monitors make it more difficult to discern air quality trends in this area during the 2020-2022 time period. In years with lower wildfire activity, such as 2021, levels of $PM_{2.5}$ are more consistently elevated in the cold season when residential wood burning activity is highest. The calendar plot (Figure 55) shows more air pollution spikes with unhealthy AQIs during wildfire season in August-October, but more days with moderate AQI during the winter months.

Table 77. Seasonal and annual means for $PM_{2.5}$ for South King County monitoring sites, 2020-2022

Pollutant	Site	Season/annual mean	2020	2021	2022*	3-year mean
$PM_{2.5}$ ($\mu g/m^3$)	Kent-Central & James	Warm Season (April-September)	10.65	6.91	9.62	9.1
		Cold Season (October-March)	6.94	7.23	9.01	7.7
		Annual	8.57	7.08	9.25	8.3
$PM_{2.5}$ ($\mu g/m^3$)	Auburn-29th Street**	Warm Season (April-September)	DNC	5.99	9.87	*7.9*
		Cold Season (October-March)	DNC	*6.04*	7.81	*6.9*
		Annual	DNC	*6.07*	8.88	*7.5*
$PM_{2.5}$ ($\mu g/m^3$)	Auburn-M St**	Warm Season (April-September)	*4.07*	DNC	DNC	DNC
		Cold Season (October-March)	*4.33*	DNC	DNC	DNC
		Annual	*4.20*	DNC	DNC	DNC

DNC = data not collected, PM = particulate matter, O_3 = ozone, ppm = parts per million, $\mu g/m^3$ = micrograms per cubic meter

*In 2022, seasonal means are adjusted April-October 21 and October 22-March due to wildfires in October.

**The M St monitoring site was discontinued in April 2020 and replaced with the 29th Street site in March 2021 (incomplete data denoted in italics).

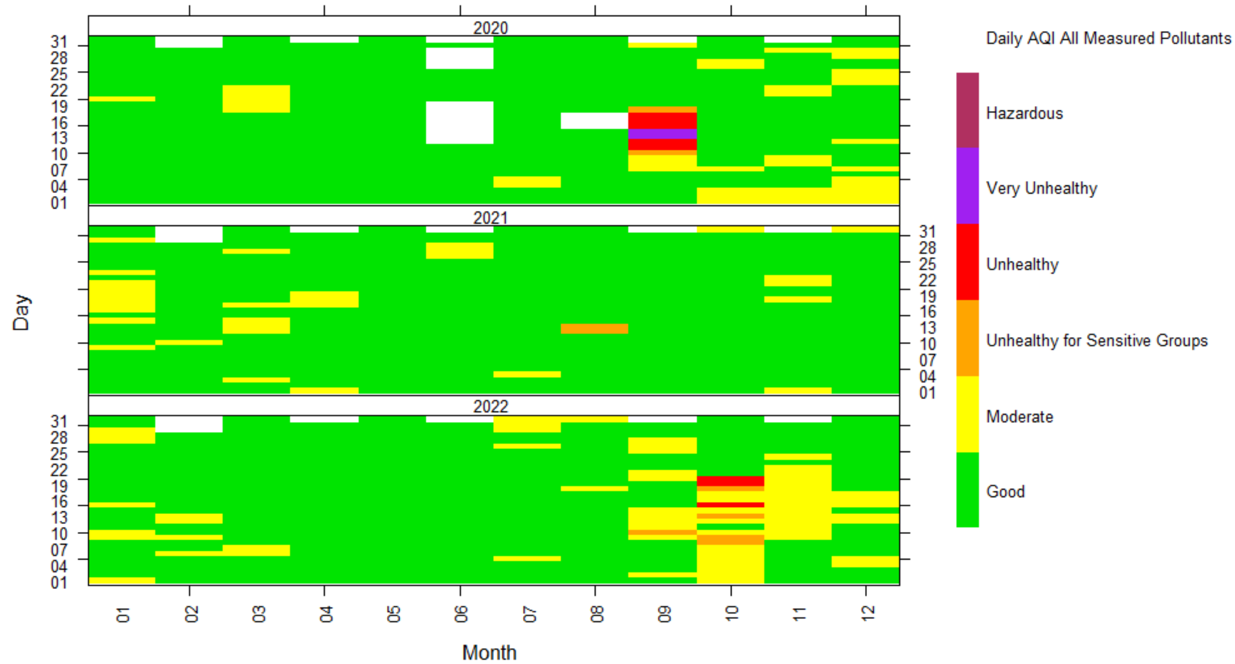

Figure 55. Calendar plot of daily maximum recorded air quality index from 2020-2022 for the South King County community

Air quality modeling

Roadway NO_2

We modeled ambient 1-hour NO_2 concentrations from on-road mobile sources, which are the primary sources of NO_2 in Washington communities. Model parameters were selected to represent the conditions under which NO_2 concentrations would be highest (e.g., peak traffic volume, stable atmospheric conditions). The average modeled 1-hour NO_2 concentration across the area is 13.7 ppb. The modeled concentration representing peak near-road conditions, is 34.9 ppb. Figure 56 shows the relative distribution of roadway NO_2 across the South King County community.

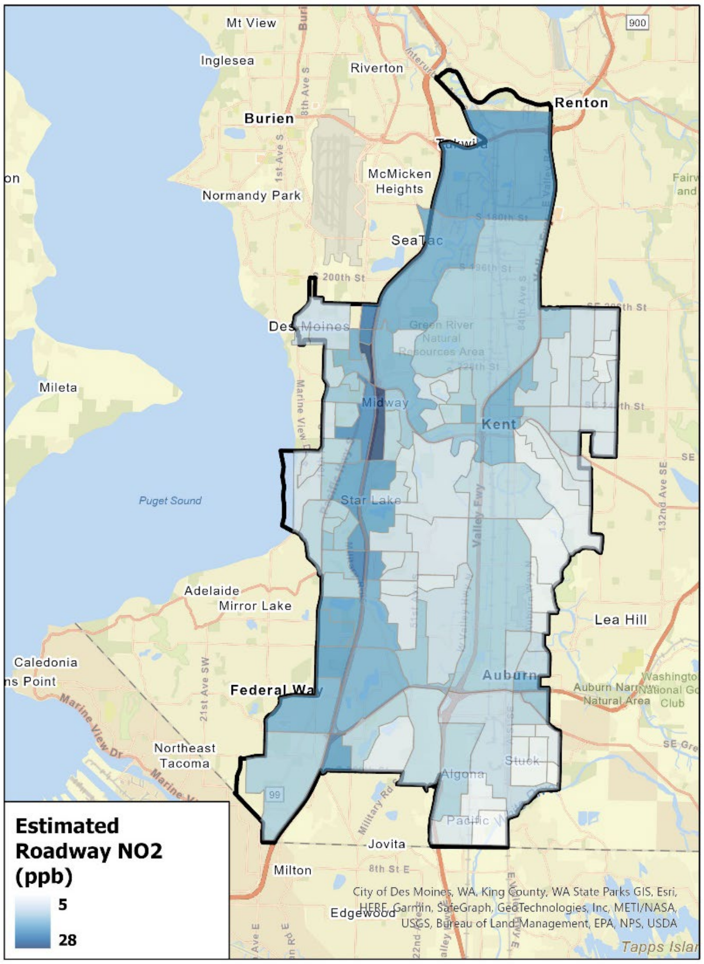

Figure 56. Average estimated 1-hour NO_2 concentration from on-road mobile sources by 2010 census block group in South King County during weekday afternoon peak traffic under wintertime stable atmospheric conditions

Ozone

For South King County, the average estimated 8-hour O_3 design value during July 2014 through June 2017 was 0.053 ppm. Long-term O_3 monitoring across the state has shown that O_3 levels in Washington have stayed relatively consistent over time, although spikes may occur during severe heat, drought, or wildfire events.

Potential health impacts

Several socioeconomic factors indicate that people in parts of South King County may be more vulnerable to health impacts from air pollution, including people of color, linguistically isolated, and low-income populations. The community also has several locations where occupants may be more vulnerable to the adverse effects of pollution exposure, such as childcare facilities, schools, healthcare facilities, and nursing homes.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 78). We estimated 55 all-cause deaths among all adults (0.35 deaths per 1,000 18-84-year-olds) each year associated with $PM_{2.5}$ in this community. Older adults living in South King County are significantly impacted by $PM_{2.5}$. Among 65–99-year-olds, we estimated 19 all-cause deaths (0.80 deaths per 1,000 65–99-year-olds) each year associated with $PM_{2.5}$, which is higher than the rate for all overburdened communities highly impacted by air pollution. For all other reported causes of death, the estimated rates are lower than for all overburdened communities highly impacted by air pollution.

Table 78. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in South King County census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	54.4 [21.2 to 85.3]	0.35 [0.14 to 0.55]
Di et al.[54]	65 to 99	All	All-causes	18.2 [16.7 to 19.6]	0.80 [0.73 to 0.87]
Krewski et al. [52]	30 to 99	All	All-causes	25 [17 to 33]	0.22 [0.15 to 0.29]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	6.0 [4.9 to 7.0]	0.05 [0.04 to 0.06]
Krewski et al. [52]	30 to 99	All	Lung cancer	2.3 [1.0 to 3.5]	0.02 [0.01 to 0.03]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in South King County. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

Three facilities in or nearby South King County emitted a total of 61,271 MT CO_2e in 2020 and 63,505 MT CO_2e in 2021 (see Table 79).

Emissions are in units of metric tons of carbon dioxide equivalents (MT CO_2e) using AR4 global warming potentials as specified in WAC 173-441.

Table 79. Facilities and greenhouse gas emissions (MT CO_2e) in or nearby[108] South King County

Facility Name and City	Facility Sector	Inside Community Boundary?	CCA-Covered Entity?	Major Source of CAPs? [109]	2020 Emissions [biogenic] (MT CO_2e)	2021 Emissions [biogenic] (MT CO_2e)
Starbucks Kent Flexible Plant - Kent	Food Production	Yes	No	No	11,513 [0]	12,492 [0]
The Boeing Company - Auburn	Manufacturing	Yes	Yes	Yes	34,964 [0]	34,746 [0]
The Boeing Company - Renton	Manufacturing	Nearby	No	Yes	14,794 [0]	16,267 [0]

CAPs = criteria air pollutants, CCA = Climate Commitment Act, MT CO_2e = metric tons of carbon dioxide equivalent

Table 80. GHG estimates from mobile sources in South King County

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
204,300	957,995	4.7

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future .

Additional resources

- Air pollution resources:
  - Puget Sound Clean Air Agency
    - PSCAA Air Sensor Map
    - PSCAA Focus Communities: Auburn-Algona-Pacific

[108] For the purposes of this analysis, nearby is within 3 miles of the overburdened community boundary.
[109] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

        - PSCAA studies, reports, plans, etc.
            - 2012-2013 Winter Monitoring Study
            - 2014 Summer Ozone Study
    - Other air pollution reports and studies:
        - 2012 Airport Lead Study: Auburn Municipal Airport and Harvey Field, Ecology
        - Mobile ObserVations of Ultrafine Particles (MOV-UP) study (2019), University of Washington, – analyzed the potential air quality impacts from aircraft traffic on communities near and underneath Seattle-Tacoma International Airport (Sea-Tac) flight paths
        - Blanco, Magali N., Amanda Gassett, Timothy Gould, Annie Doubleday, David L. Slager, Elena Austin, Edmund Seto, Timothy V. Larson, Julian D. Marshall, and Lianne Sheppard. "Characterization of Annual Average Traffic-Related Air Pollution Concentrations in the Greater Seattle Area from a Year-Long Mobile Monitoring Campaign." *Environmental Science & Technology* 56, no. 16 (2022): 11460-11472.
- Health resources:
    - Seattle and King County Public Health
    - HealthierHere
- Greenhouse gas resources:
    - Greenhouse gas emissions, King County
    - Puget Sound Clean Air Agency GHG Emissions Inventory, 2018

Northeast Puyallup

Geographic description

Northeast Puyallup is in Pierce County. Air quality is managed by Puget Sound Clean Air Agency. It is approximately 2.8 square miles and has an estimated population of 9,574. The community is bounded by State Route 512 on the west and the Puyallup River to the north. This community is primarily residential with some limited manufacturing along a rail line near the river.

Levels of criteria air pollutants

We did not identify any particular pollutants of concern for this community. Rather, Northeast Puyallup was identified as highly impacted by air pollution based on modeled levels of cumulative criteria air pollution, which is primarily driven by levels of $PM_{2.5}$, O_3, and NO_2.

Previous modeling or air emissions inventory results have shown that concentrations of other criteria air pollutants (CO, lead, SO_2) are likely to be low in this area.[110,111]

Air quality monitoring

Puget Sound Clean Air Agency previously had a $PM_{2.5}$ monitoring site several miles away at 128th St in South Hill that ran through November 2020 (Figure 57; Table 81). That data was included in Ecology's dataset to identify areas with an elevated level of pollution. Puget Sound Clean Air Agency has also done several studies around the area, one of which included an additional temporary monitoring site in Puyallup (links below). Their results show similar or lower concentrations of $PM_{2.5}$ and O_3 to Ecology's data and did not find any previously unknown hotspots. Additional air quality monitoring stations will be added in 2024, with community engagement.

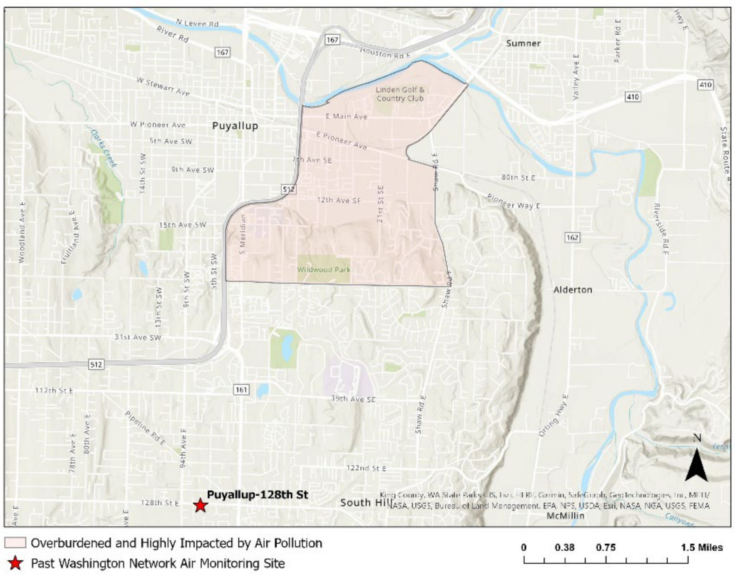

Figure 57. Northeast Puyallup community boundaries and air monitoring sites

Table 81. Former Puyallup monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
Puyallup-128th St	Puget Sound Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	No

PM = particulate matter

110 https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe
111 https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory

The Puyallup area routinely experiences some large spikes in $PM_{2.5}$ due to wildfires. In 2020, which was a particularly bad year for wildfires, the 98th percentile concentrations exceeded the 24-hour NAAQS for $PM_{2.5}$ by a wide margin. With wildfire excluded, the annual 98th percentile concentration for $PM_{2.5}$ in Puyallup was 16.7 µg/m^3. This is lower than both the national air quality standard of 35 µg/m^3, and the Ecology's healthy air goal of 20 µg/m^3.

Table 82. Criteria air pollutant summary statistics for the former Puyallup monitoring site in 2020. A red box indicates a value above the NAAQS. Numbers in brackets [] indicates wildfire days >35.4 µg/m^3 have been removed.

Pollutant	Form	NAAQS Level	Site Name	2020
$PM_{2.5}$ 24-hour (µg/m^3)	98th percentile	35	Puyallup-128th St*	*72.8 [16.7]*

NAAQS = national ambient air quality standards, PM = particulate matter, µg/m^3 = micrograms per cubic meter

*Monitor discontinued in November 2020 (incomplete data denoted in italics)

The calendar plot below shows that, except for the wildfire event in September, the air quality index for $PM_{2.5}$ was usually in the "good" and occasionally in the "moderate" ranges throughout 2020. As a result of the wildfire, the average $PM_{2.5}$ concentration was higher in the warm season than the cold season.

Table 83. Seasonal and annual means for $PM_{2.5}$ for the former Puyallup monitoring site in 2020

Pollutant	Site	Season/annual mean	2020
$PM_{2.5}$ (µg/m^3)	Puyallup-128th St*	Warm Season (April-September)	9.03
		Cold Season (October-March)	*4.83*
		Annual	*7.2*

PM = particulate matter, µg/m^3 = micrograms per cubic meter

*Monitor discontinued in November 2020 (incomplete data denoted in italics)

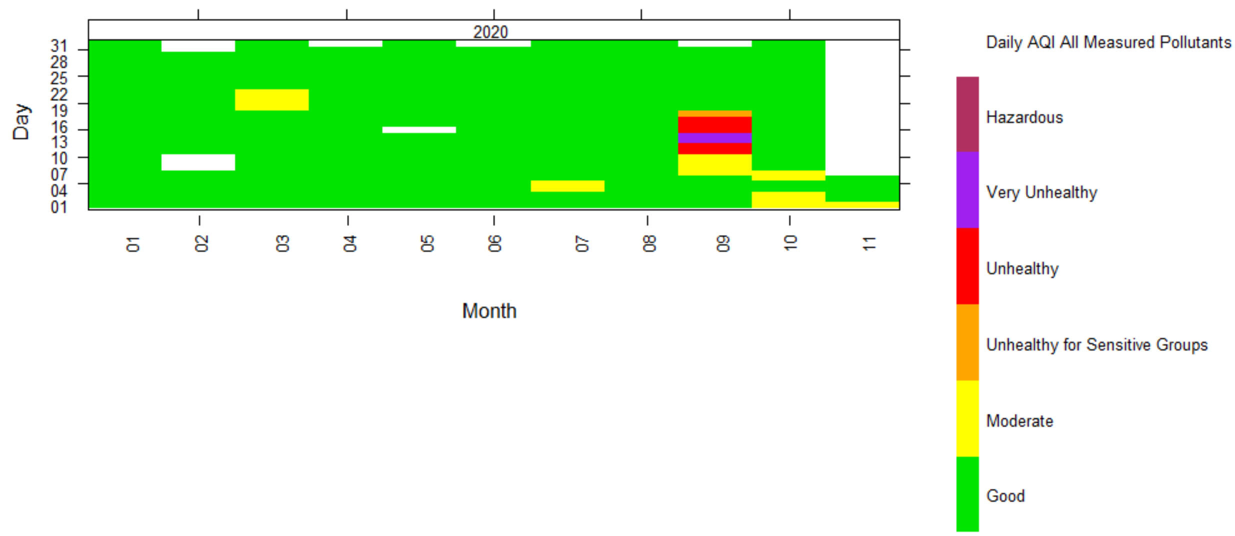

Figure 58. Calendar plot of daily maximum recorded air quality index from 2020 for the former Puyallup monitoring site

Air quality modeling

Roadway NO_2

We modeled ambient 1-hour NO_2 concentrations from on-road mobile sources, which are the primary sources of NO_2 in Washington communities. Model parameters were selected to represent the conditions under which NO_2 concentrations would be highest (e.g., peak traffic volume, stable atmospheric conditions). The average modeled 1-hour NO_2 concentration across the area is 22.8 ppb. The modeled concentration representing peak near-road conditions, is 54.5 ppb. Figure 59 shows the relative distribution of roadway NO_2 across the Northeast Puyallup community.

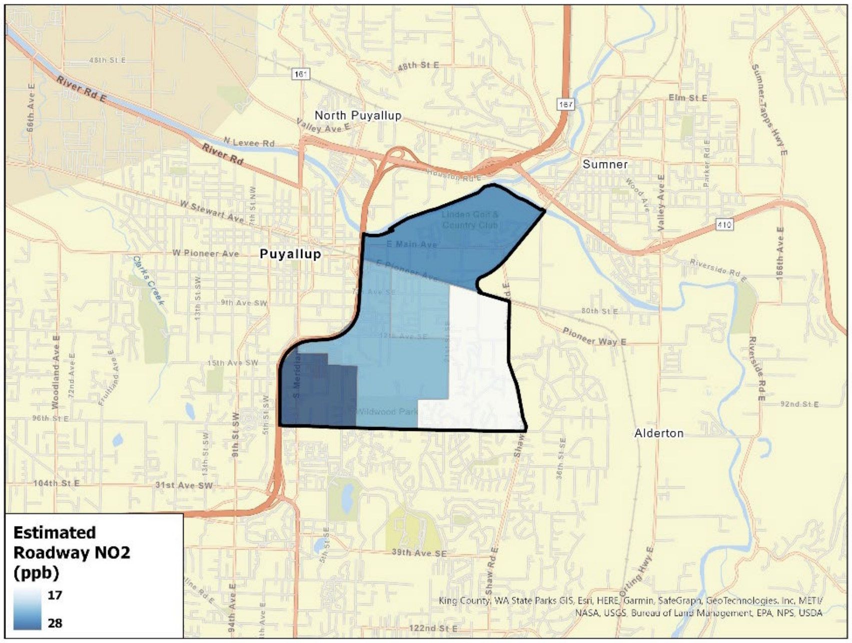

Figure 59. Average estimated 1-hour NO_2 concentration from on-road mobile sources by 2010 census block group in Northeast Puyallup during weekday afternoon peak traffic under wintertime stable atmospheric conditions

Ozone

For Northeast Puyallup, the average estimated 8-hour O_3 design value during July 2014 through June 2017 was 0.055 ppm. Long-term O_3 monitoring across the state has shown that O_3 levels in Washington have stayed relatively consistent over time, although spikes may occur during severe heat, drought, or wildfire events.

Potential health impacts

The Northeast Puyallup community is included in this initiative based on cumulative impacts for both environmental health disparities in general and criteria air pollution. Thus, this community may not experience a particularly high level of any one pollutant or be especially vulnerable because of any one single factor. However, the cumulative impact of all these factors may mean an increased risk of health impacts from air pollution in this community. Data indicates disparities in both life expectancy and cardiovascular disease deaths in this area. The community also has several schools, childcare facilities, long term care facilities, clinics, and a hospital. These are locations where occupants may be more vulnerable to the adverse effects of pollution exposure.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 84). The largest impact associated with $PM_{2.5}$ was all-cause deaths among all adults (0.27 deaths per 1,000 18-99-year-olds), followed by older adults with an estimated 1 all-cause death (0.18 deaths per 1,000 65–99-year-olds) each year. The lower rate of all-cause deaths among older adults compared to all adults may be due to differences in the age distribution in this community.

Furthermore, all-cause death rates in Northeast Puyallup were lower than those across all overburdened communities highly impacted by air pollution.

Table 84. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in Northeast Puyallup census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	2.0 [1 to 2.9]	0.27 [0.14 to 0.40]
Di et al.[54]	65 to 99	All	All-causes	0.2 [0.2 to 0.2]	0.18 [0.17 to 0.19]
Krewski et al. [52]	30 to 99	All	All-causes	1.5 [1.0 to 1.9]	0.27 [0.18 to 0.36]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	0.4 [0.3 to 0.5]	0.08 [0.06 to 0.09]
Krewski et al. [52]	30 to 99	All	Lung cancer	0.2 [0.1 to 0.3]	0.03 [0.01 to 0.05]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in Northeast Puyallup. We will strive to include more information on health impacts in future analyses. Specifically, we will continue to learn more about methods for understanding cumulative impacts as this work progresses.

Greenhouse gas emissions

Two facilities nearby Northeast Puyallup emitted a total of 21,185 MT CO_2e in 2020 and 39,423 MT CO_2e in 2021 (see Table 85).

Emissions are in units of metric tons of carbon dioxide equivalents (MT CO_2e) using AR4 global warming potentials as specified in WAC 173-441.

Table 85. Facilities and greenhouse gas emissions (MT CO_2e) in or nearby[112] Northeast Puyallup

Facility Name and City	Facility Sector	Inside Community Boundary?	CCA-Covered Entity?	Major Source of CAPs? [113]	2020 Emissions [biogenic] (MT CO_2e)	2021 Emissions [biogenic] (MT CO_2e)
Northwest Pipeline Compressor Station - Sumner	Natural Gas Systems	Nearby	Yes	No	9,603 [0]	27,943 [0]
Sonoco Products - Sumner	Pulp and Paper	Nearby	No	No	11,582 [0]	11,480 [0]

CAPs = criteria air pollutants, CCA = Climate Commitment Act, MT CO_2e = metric tons of carbon dioxide equivalent

Table 86. GHG estimates from mobile sources in Northeast Puyallup

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
9,574	42,943	4.5

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future .

Additional resources

- Pierce County Equity Index, City of Tacoma
- Air pollution resources:
  - Puget Sound Clean Air Agency
    - PSCAA Air Sensor Map
    - PSCAA studies, reports, plans, etc.
      - 2012-2013 Winter Monitoring Study
      - 2013-2014 Special Winter Intensive Monitoring Campaign

[112] For the purposes of this analysis, nearby is within 3 miles of the overburdened community boundary.
[113] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

        - 2014 Summer Ozone Study
    - Tacoma-Pierce County Health Department air quality webpage
    - Tacoma-Pierce County $PM_{2.5}$ Nonattainment Area Study
- Health resources:
    - Tacoma - Pierce County Health Department
    - Elevate Health
- Greenhouse gas resources:
    - Pierce County Communitywide Geographic Greenhouse Gas Emissions (2022), Cascadia Consulting Group
    - Puget Sound Clean Air Agency GHG Emissions Inventory, 2018

South and East Tacoma

Geographic description

South and East Tacoma is in Pierce County and air quality is managed by Puget Sound Clean Air Agency. The community identified for this initiative is about 28.4 square miles and has approximately 147,407 residents. It includes all or part of the following neighborhoods: New Tacoma, Central, Eastside, South End, and South Tacoma. It also includes parts of Lakewood, Parkland, and Midland to the south. The community includes the manufacturing and industrial areas at the Port of Tacoma, in South Tacoma, and downtown Tacoma.

Levels of criteria air pollutants

The main pollutants of concern that we identified for this community are short-term $PM_{2.5}$, as well as cumulative criteria air pollution, which is primarily driven by levels of $PM_{2.5}$, O_3, and NO_2. Previous modeling or air emissions inventory results have shown that concentrations of other criteria air pollutants (CO, lead, SO_2) are likely to be low in this area.[114,115] An Ecology study of $PM_{2.5}$ pollution resulting from a violation of the $PM_{2.5}$ standard in 2009 found that $PM_{2.5}$, the criteria pollutant of greatest health concern, primarily came from residential wood smoke.[116] We will be examining the sources of pollution in South and East Tacoma in greater detail in future analyses.

Air quality monitoring

There are currently three monitoring sites in Ecology's network at the Port of Tacoma (Alexander Ave), near the junction of Interstate 5 and Highway 16 (S 36th St) representing near-road conditions, and in the South End neighborhood (L Street) (Figure 60; Table 87).

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114 https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe
115 https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory
116 Sources of Fine Particles in the Wapato Hills-Puyallup River Valley $PM_{2.5}$ Nonattainment Area, Department of Ecology

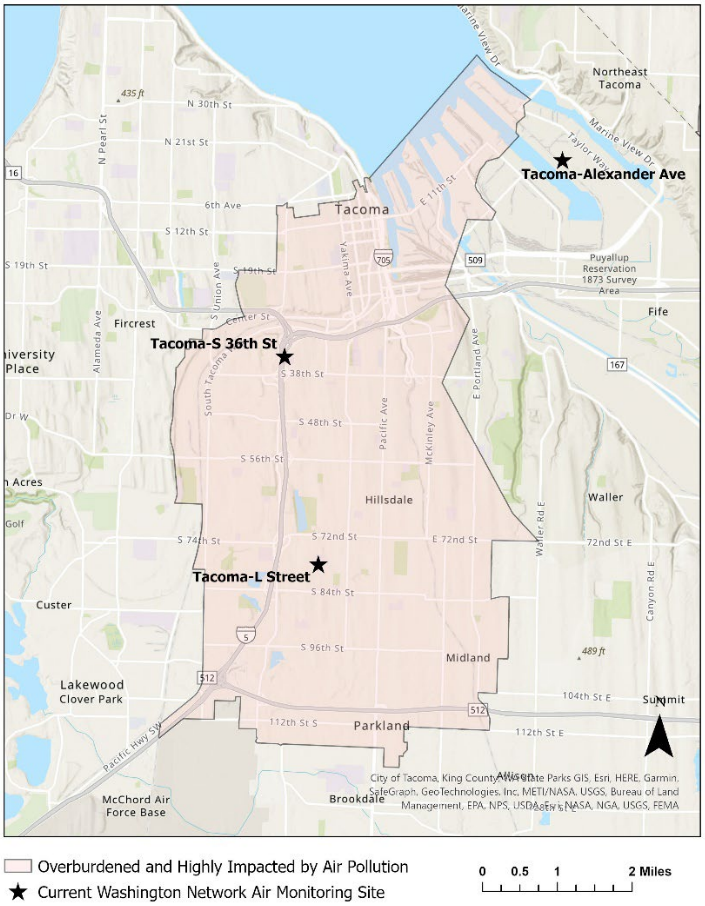

Figure 60. South and East Tacoma community boundaries and air monitoring sites

Table 87. South and East Tacoma monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
Tacoma-Alexander Ave	Puget Sound Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	Yes
Tacoma-L Street	Puget Sound Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	Yes
Tacoma-S 36th St	Ecology	$PM_{2.5}$, NO_2	Microscale (≤100 m)	Yes

NO_2 = nitrogen dioxide, PM = particulate matter

The Tacoma area routinely experiences some large spikes in $PM_{2.5}$. In 2020 and 2022, the 98th percentile concentrations exceeded the 24-hour NAAQS for $PM_{2.5}$ at one or all Tacoma sites.

These elevated concentrations and the variability year to year are attributable primarily to wildfire smoke events. With wildfire excluded, the annual 98th percentile concentrations for $PM_{2.5}$ were between 15-32 µg/m^3. While lower than the national air quality standard of 35 µg/m^3, they were sometimes higher than Ecology's healthy air goal of 20 µg/m^3.

NO_2 is measured at the junction of Interstate 5 and Highway 16, representing near-road conditions. This is an area where we would expect near-peak emissions from on-road vehicles (the primary source of NO_2) in Tacoma. The 1-hour design value for NO_2 at this site is 39 ppb, which is less than half of the national standard of 100 ppb. Only 2 days in 2020-2022 years had NO_2 levels higher than the "good" AQI range (i.e., >54 ppb) at this location.

PSCAA has conducted several local air monitoring, mobile monitoring, and air toxics studies in this area (see "additional resources" section for South and East Tacoma below). During a year-long air toxics study in 2021-2022, PSCAA monitored lead for a year at the Alexander Ave monitoring station. The rolling 3-month average was 0.0057 µg/m^3 and the highest lead level recorded during that time was 0.028 µg/m^3. This is about 4% and 19% of the national standard, respectively.

Table 88. Criteria air pollutant annual and 3-year summary statistics for South and East Tacoma monitoring sites for 2020-2022. A red box indicates a value above the NAAQS. Numbers in brackets [] indicates wildfire days >35.4 µg/m^3 $PM_{2.5}$ have been removed.

Pollutant & averaging time	Form	NAAQS Level	Site Name	2020	2021	2022	3-year Design Value
$PM_{2.5}$ 24-hour (µg/m^3)	98th percentile	35	Tacoma-Alexander Ave	35.4 [15.8]	16.2 [16.2]	33.6 [28.7]	28 [20]
			Tacoma-L Street	36.8 [23.8]	21.4 [21.4]	38.1 [32.0]	32 [26]
			Tacoma-S 36th St	40.5 [19.5]	17.2 [17.2]	30.7 [25.7]	29 [21]
Lead* (µg/m^3)	3-month rolling average	0.15	Tacoma-Alexander Ave	N/A	N/A	N/A	*0.0057*
NO_2 1-hour (ppb)	98th percentile	100	Tacoma-S 36th St	39.8	37.7	39.0	39

NAAQS = national ambient air quality standards, PM = particulate matter, ppb = parts per billion, µg/m^3 = micrograms per cubic meter

*Lead monitoring at the Tacoma-Alexander site was conducted by Puget Sound Clean Air Agency for their Community-Scale Air Toxics Study from August 2021 – September 2022 (incomplete data denoted in italics)

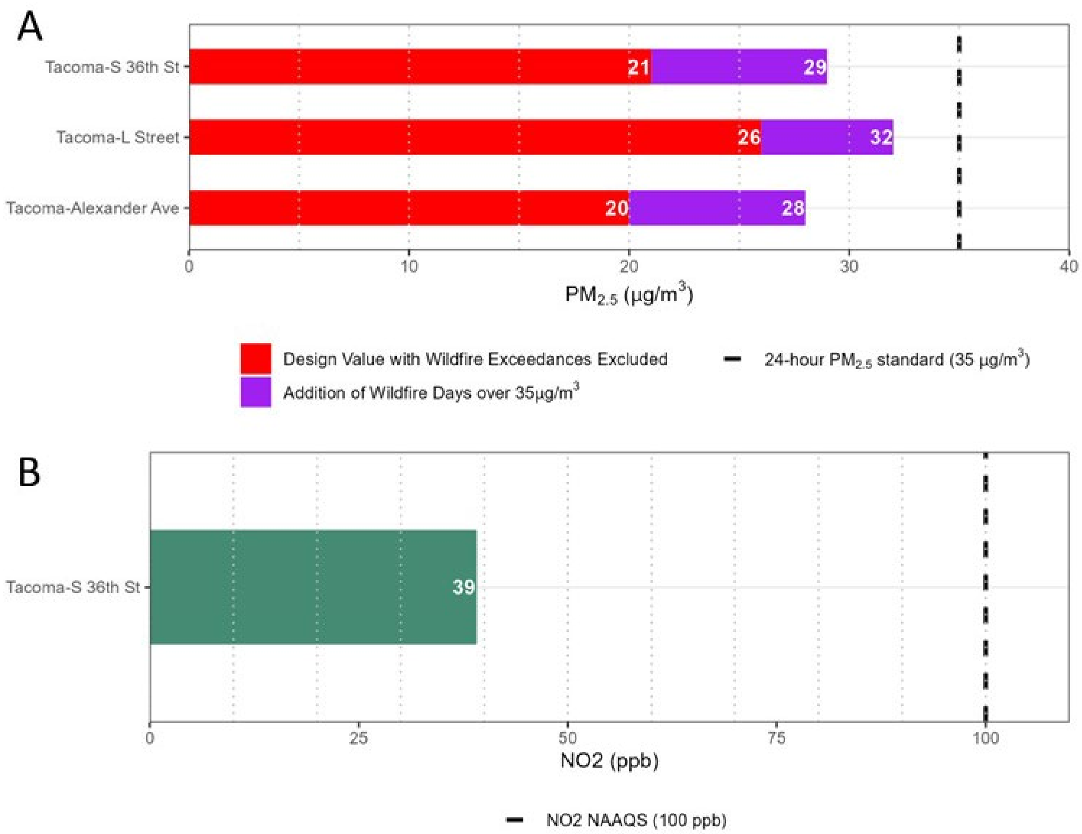

Figure 61. 2022 design values for A) 24-hour $PM_{2.5}$ and B) 1-hour NO_2 at South and East Tacoma monitoring sites

Over the past three years, the highest $PM_{2.5}$ concentrations in the area have been measured during wildfire events in September 2020 and October 2022. This is clearly visible on the calendar plot (Figure 62). However, when there is less wildfire activity, $PM_{2.5}$ is usually higher in the cold season (Table 89), particularly in residential areas. Figure 62 shows that, throughout the winter months, AQI is usually more consistently elevated in the moderate range, occasionally reaching levels unhealthy for sensitive groups. This is usually indicative of woodsmoke from home heating, which is consistent with past studies in Tacoma.

Levels of $PM_{2.5}$ measured from site to site were fairly consistent across the area. The three-year design values between all three sites were 28-32 µg/m^3 for 24-hour $PM_{2.5}$ and 7.2-8.1 µg/m^3 for annual $PM_{2.5}$. The highest levels of $PM_{2.5}$ were measured at the L Street monitoring station in South End, particularly in the cold season. This makes sense because the L street monitor is in a residential area and the primary source of particle pollution in winter is residential wood smoke.[117]

[117] https://apps.ecology.wa.gov/publications/SummaryPages/1002009.html

Table 89. Seasonal and annual means for $PM_{2.5}$ for South and East Tacoma monitoring sites, 2020-2022

Pollutant	Site	Season/annual mean	2020	2021	2022*	3-year mean
$PM_{2.5}$ (µg/m^3)	Tacoma-Alexander Ave	Warm Season (April-September)	9.17	5.47	8.65	7.8
		Cold Season (October-March)	5.75	5.49	8.70	6.6
		Annual	7.46	5.48	8.56	7.2
$PM_{2.5}$ (µg/m^3)	Tacoma-L Street	Warm Season (April-September)	10.56	5.28	7.94	7.9
		Cold Season (October-March)	8.29	6.94	9.63	8.3
		Annual	9.41	6.1	8.7	8.1
$PM_{2.5}$ (µg/m^3)	Tacoma-S 36th St	Warm Season (April-September)	11.30	6.24	8.34	8.6
		Cold Season (October-March)	6.96	7.05	8.36	7.5
		Annual	9.12	6.64	8.34	8.0

PM = particulate matter, µg/m^3 = micrograms per cubic meter

*In 2022, seasonal means are adjusted April-October 21 and October 22-March due to wildfires in October.

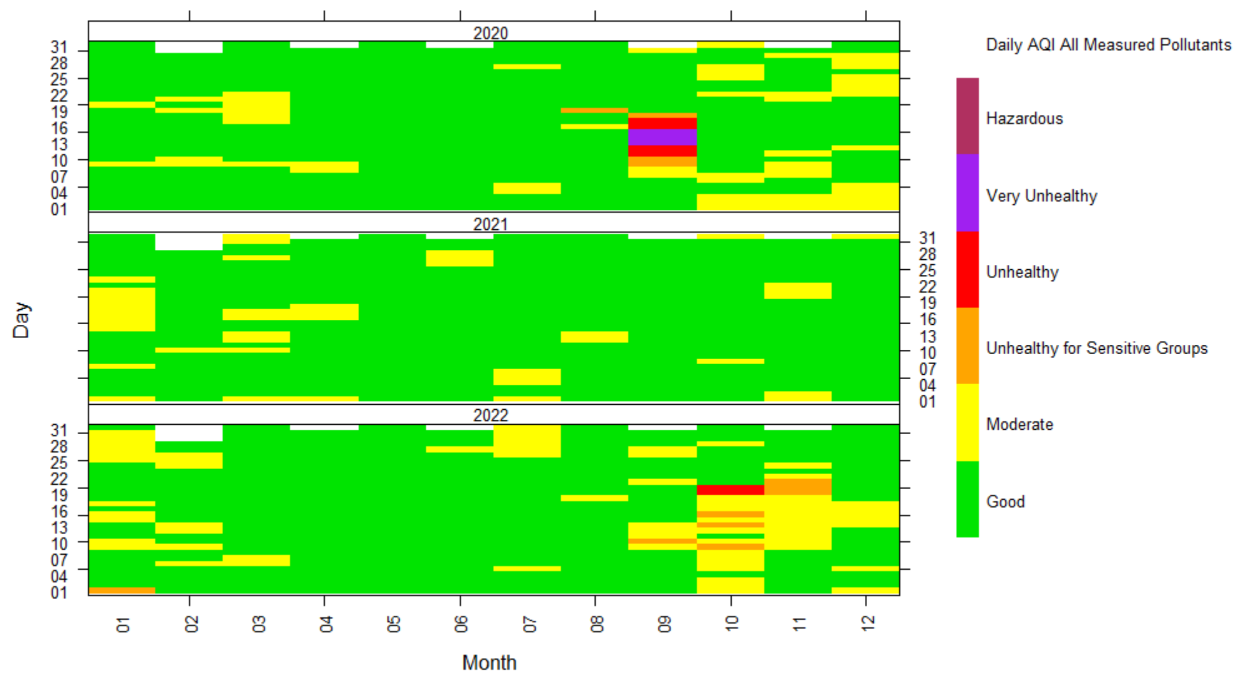

Figure 62. Calendar plot of daily maximum recorded air quality index from 2020-2022 for the South and East Tacoma community

Of the two types of pollutants monitored here, $PM_{2.5}$ is usually the dominant pollutant with the highest daily AQI (Figure 63). NO_2 is less seasonal and more consistent day to day and is only the dominant pollutant on days when $PM_{2.5}$ is particularly low.

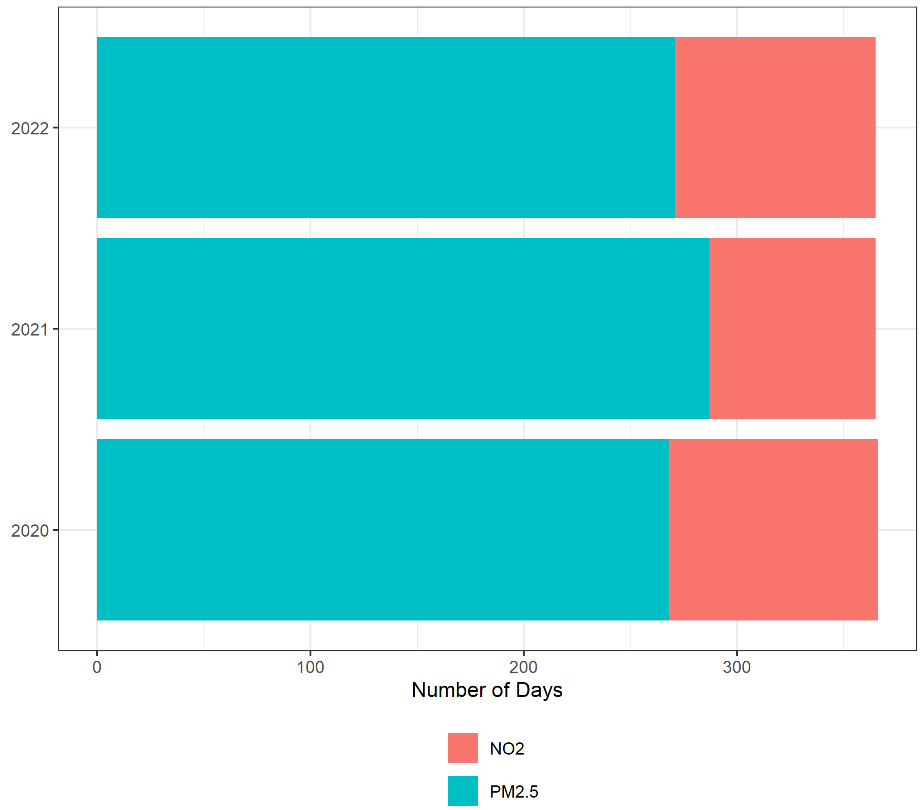

Figure 63. Dominant pollutant by AQI measured each day at monitoring sites for South and East Tacoma

Air quality modeling

Roadway NO_2

We modeled ambient 1-hour NO_2 concentrations from on-road mobile sources, which are the primary sources of NO_2 in Washington communities. Model parameters were selected to represent the conditions under which NO_2 concentrations would be highest (e.g., peak traffic volume, stable atmospheric conditions). The average modeled 1-hour NO_2 concentration across the area is 30.5 ppb. The modeled concentration representing peak near-road conditions, is 49.2 ppb. Figure 64 shows the relative distribution of roadway NO_2 across the South and East Tacoma community. Modeling results show that the Tacoma-36th Street monitoring site is likely in the best place to capture the maximum levels of roadway NO_2 in this community.

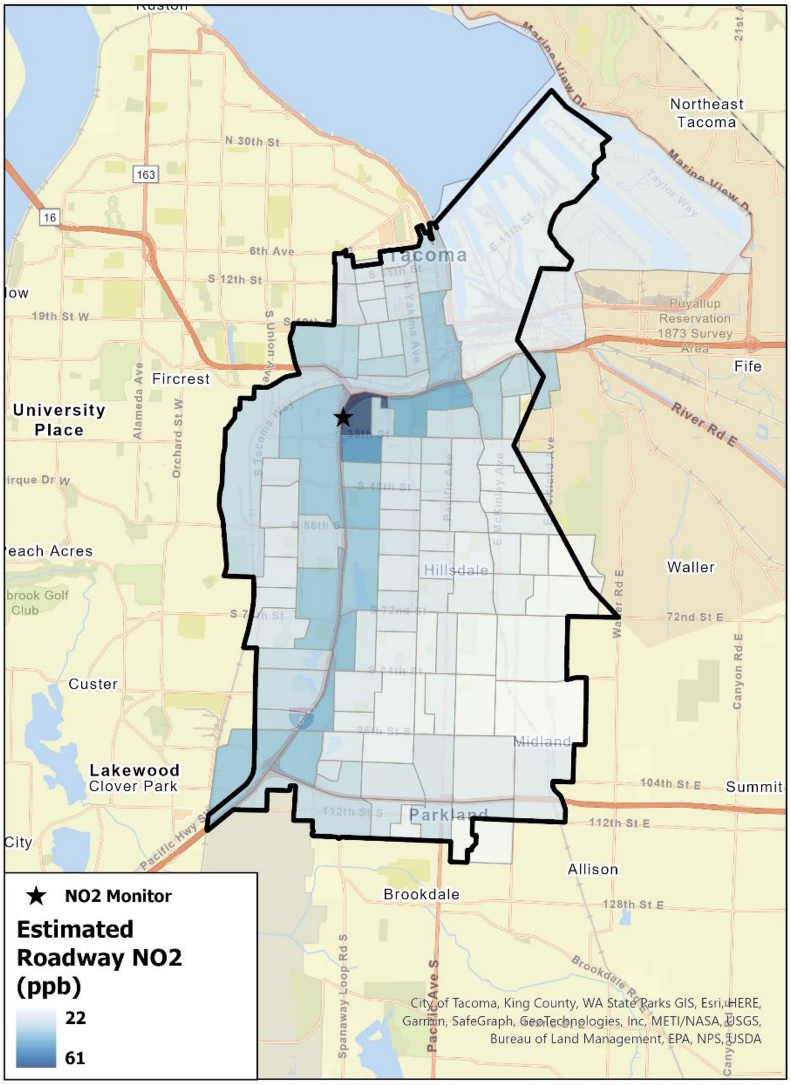

Figure 64. Average estimated 1-hour NO_2 concentration from on-road mobile sources by 2010 census block group in South and East Tacoma during weekday afternoon peak traffic under wintertime stable atmospheric conditions

Ozone

For South and East Tacoma, the average estimated 8-hour O_3 design value during July 2014 through June 2017 was 0.054 ppm. Long-term O_3 monitoring across the state has shown that O_3 levels in Washington have stayed relatively consistent over time, although spikes may occur during severe heat, drought, or wildfire events.

Potential health impacts

Several groups in this community may be at higher risk to health impacts from air pollution, such as people of color, low-income, and linguistically isolated populations. Data show that the community experiences relatively high rates of asthma, death from cardiovascular disease, and lower life expectancy compared to the statewide average. The community has many schools, childcare facilities, healthcare facilities, and a detention centers. These are locations where occupants may be more vulnerable to the adverse effects of pollution exposure.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 90). We estimated 51 all-cause deaths among all adults (0.46 deaths per 1,000 18-84-year-olds) associated with $PM_{2.5}$ in this community. Older adults living in South and East Tacoma are significantly impacted by $PM_{2.5}$. Among older adults, we estimated 19 all-cause deaths (1.00 deaths per 1,000 65–99-year-olds) each year associated with $PM_{2.5}$. This is much higher than the all-cause death rate among older adults across all overburdened communities highly impacted by air pollution, and nearly three times the statewide rate. All other reported causes of death in South and East Tacoma have estimated rates similar to those for all overburdened communities highly impacted by air pollution.

Table 90. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in South and East Tacoma census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	50.4 [17.3 to 81]	0.46 [0.16 to 0.74]
Di et al.[54]	65 to 99	All	All-causes	18.1 [16.2 to 19.8]	1.00 [0.90 to 1.10]
Krewski et al. [52]	30 to 99	All	All-causes	25 [17 to 33]	0.31 [0.21 to 0.41]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	7.1 [5.7 to 8.3]	0.09 [0.07 to 0.10]
Krewski et al. [52]	30 to 99	All	Lung cancer	2.8 [1.2 to 4.3]	0.03 [0.01 to 0.05]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in South and East Tacoma. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

Six facilities in or nearby South and East Tacoma emitted a total of 1,345,630 MT CO_2e in 2020 and 1,285,290 MT CO_2e in 2021 (see Table 91).

Emissions are in units of metric tons of carbon dioxide equivalents (MT CO_2e) using AR4 global warming potentials as specified in WAC 173-441.

Table 91. Facilities and greenhouse gas emissions (MT CO_2e) in or nearby[118] South and East Tacoma

Facility Name and City	Facility Sector	Inside Community Boundary?	CCA-Covered Entity?	Major Source of CAPs?[119]	2020 Emissions [biogenic] (MT CO_2e)	2021 Emissions [biogenic] (MT CO_2e)
City of Tacoma Solid Waste Facility - Tacoma	Waste	Nearby	Exempt	No	11,002 [0]	6,247 [0]
Darling Ingredients Inc - Tacoma	Food Production	Nearby	No	No	9,953 [0]	10,230 [0]
Georgia-Pacific Gypsum LLC - Tacoma	Manufacturing	Nearby	Yes	Yes	38,732 [0]	39,502 [0]
Greif, Tacoma Mill - Tacoma	Pulp and Paper	Yes	No	No	13,941 [0]	14,196 [0]
U.S. Oil & Refining Co. - Tacoma	Petroleum Systems	Nearby	Yes	Yes	163,311 [0]	134,326 [0]
WestRock CP, LLC - Tacoma	Pulp and Paper Kraft Mill	Yes	Yes	Yes	1,108,691 [965,097]	1,080,789 [928,981]

CAPs = criteria air pollutants, CCA = Climate Commitment Act, MT CO_2e = metric tons of carbon dioxide equivalent

As of 2023, WestRock CP LLC in Tacoma is shutdown. In 2021, this facility accounted for 84% of GHG emissions from stationary sources in this community.

[118] For the purposes of this analysis, nearby is within 3 miles of the overburdened community boundary.
[119] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

Table 92. GHG estimates from mobile sources in South and East Tacoma

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
133,463	598,636	4.5

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future .

Additional resources

- Tacoma Equity Index; Pierce County Equity Index, City of Tacoma
- Air pollution resources:
  - Puget Sound Clean Air Agency
    - PSCAA Air Sensor Map
    - PSCAA Focus Communities: Lakewood
    - PSCAA studies, reports, plans, etc.
      - 2012-2013 Winter Monitoring Study
      - 2013-2014 Special Winter Intensive Monitoring Campaign
      - 2014 Summer Ozone Study
  - Tacoma-Pierce County Health Department air quality webpage
  - Tacoma-Pierce County $PM_{2.5}$ Nonattainment Area Study
- Health resources:
  - Tacoma - Pierce County Health Department
  - Elevate Health
- Greenhouse gas resources:
  - Greenhouse gas emissions, City of Tacoma
  - Pierce County Communitywide Geographic Greenhouse Gas Emissions (2022), Cascadia Consulting Group
  - Puget Sound Clean Air Agency GHG Emissions Inventory, 2018

Vancouver

Geographic description

Vancouver is in Clark County and air quality is managed by Southwest Clean Air Agency. The part identified as overburdened and highly impacted by air pollution includes most of the city of

Vancouver which is about 29 square miles and has about 103,388 residents. The community includes most of the city of Vancouver and is bounded by Interstate 205 on the east, and the Columbia River in the south and west.

Levels of criteria air pollutants

The main pollutants of concern that we identified for this community are short-term (24-hour) $PM_{2.5}$, as well as cumulative criteria air pollution, which is primarily driven by levels of $PM_{2.5}$, O_3, and NO_2. Previous modeling or air emissions inventory results have shown that concentrations of other criteria air pollutants (CO, lead, SO_2) are likely to be low in this area.[120,121] Some of the sources of pollution include wildfire, residential wood burning, mobile sources like cars, trucks, trains, and port activity. Air quality is also likely influenced by pollution sources in the more populated city of Portland across the Columbia River. We will be examining the sources of pollution in Vancouver in greater detail in future analyses.

Air quality monitoring

Vancouver currently has two air quality monitors in Ecology's network (Figure 65; Table 93). One near Peter S. Ogden Park in central Vancouver (NE 84th Ave), which measures $PM_{2.5}$ and one at Mountain View High School (Blairmont Dr) in east Vancouver, which measures O_3. A $PM_{2.5}$ sensor was also recently installed at this site in August 2022. Additional air quality monitoring will be added in Vancouver, following community engagement.

[120] https://idahodeq.maps.arcgis.com/apps/MapSeries/index.html?appid=0c8a006e11fe4ec5939804b873098dfe
[121] https://ecology.wa.gov/Air-Climate/Air-quality/Air-quality-targets/Air-emissions-inventory

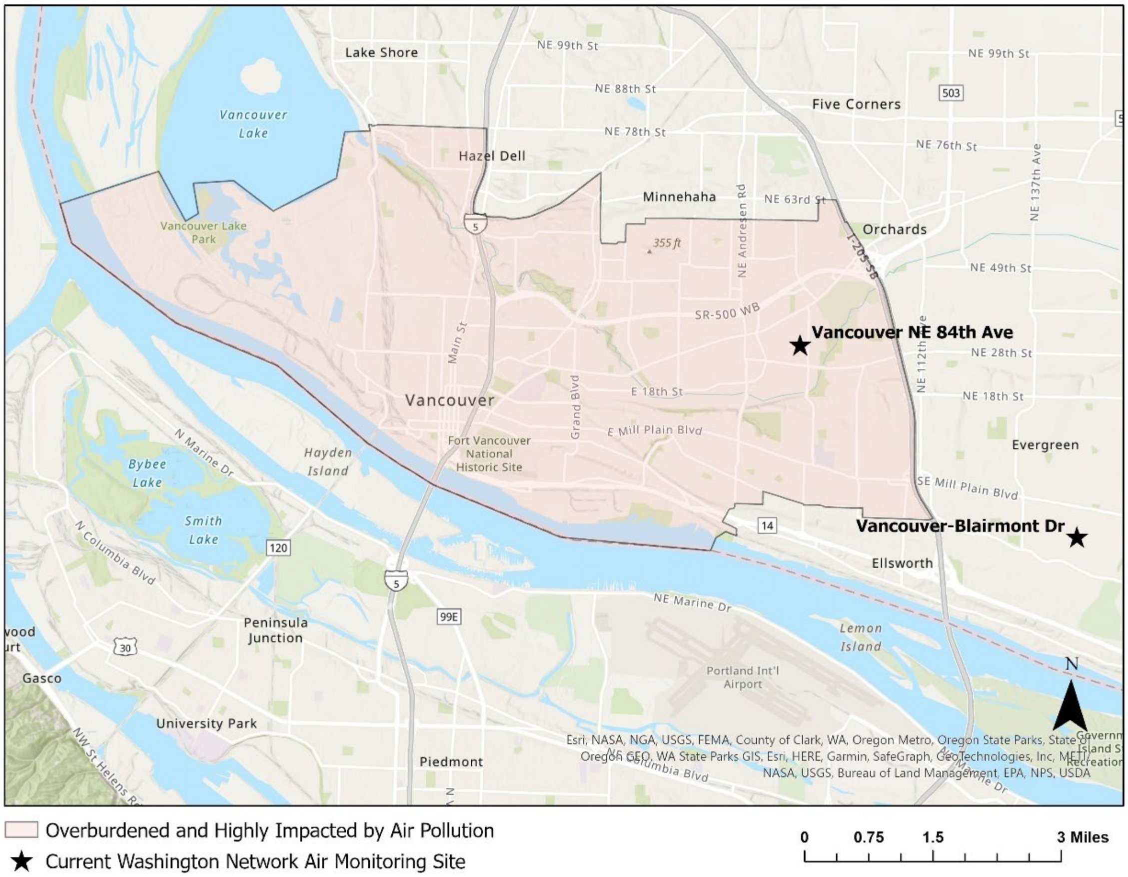

Figure 65. Vancouver community boundaries and air monitoring sites

Table 93. Vancouver monitoring site information

Site Name	Site owner	Criteria pollutants monitored	Scale	Regulatory?
Vancouver-NE 84th Ave	Southwest Clean Air Agency	$PM_{2.5}$	Neighborhood (0.5-4 km)	Yes
Vancouver-Blairmont Dr	Ecology	O_3	Urban (4-50 km)	Yes
		$PM_{2.5}$	Neighborhood (0.5-4 km)	No

PM = particulate matter, O_3 = ozone

The Vancouver area is currently in attainment with the national ambient air quality standards. However, the area experienced an extreme wildfire smoke event in 2020 with hazardous air quality conditions over the course of about a week. Thus, the annual 98th percentile concentration exceeded the 24-hour NAAQS for $PM_{2.5}$, which is likely to be more frequent in the future as wildfire risk increases with climate change. Much of the variability in $PM_{2.5}$ year-to-year is attributable to wildfire events as well. With wildfire excluded, the annual 98th percentile concentrations for $PM_{2.5}$ were 16.4-26.5 µg/m^3. While below the national air quality standards, they are sometimes higher than Ecology's healthy air goal of 20 µg/m^3.

O_3 is a regional pollutant that is typically highest downwind of urban areas. From 2020-2022, the fourth-highest daily O_3 value in the Vancouver area was 0.055 ppm. This is below the national standard of 0.070 ppm. The mean level of O_3 during ozone season (May-September) was 0.035 ppm.

Table 94. Criteria air pollutant annual and 3-year summary statistics for Vancouver monitoring sites for 2020-2022. A red box indicates a value above the NAAQS. Numbers in brackets [] indicates wildfire days >35.4 µg/m^3 $PM_{2.5}$ have been removed.

Pollutant	Form	NAAQS Level	Site Name	2020	2021	2022	3-year Design Value
$PM_{2.5}$ 24-hour (µg/m^3)	98th Percentile	35	Vancouver-NE 84th Ave	147.4 [21.3]	16.4 [16.4]	29.4 [26.5]	64 [21]
O_3 8-hour (ppm)	Annual fourth-highest daily maximum	0.070	Vancouver-Blairmont Dr*	*0.054*	0.057	0.056	*0.055*

NAAQS = national ambient air quality standards, PM = particulate matter, O_3 = ozone, ppm = parts per million, µg/m^3 = micrograms per cubic meter

*The Blairmont Dr was temporarily relocated in 2020 so data is incomplete for that year (denoted by italics)

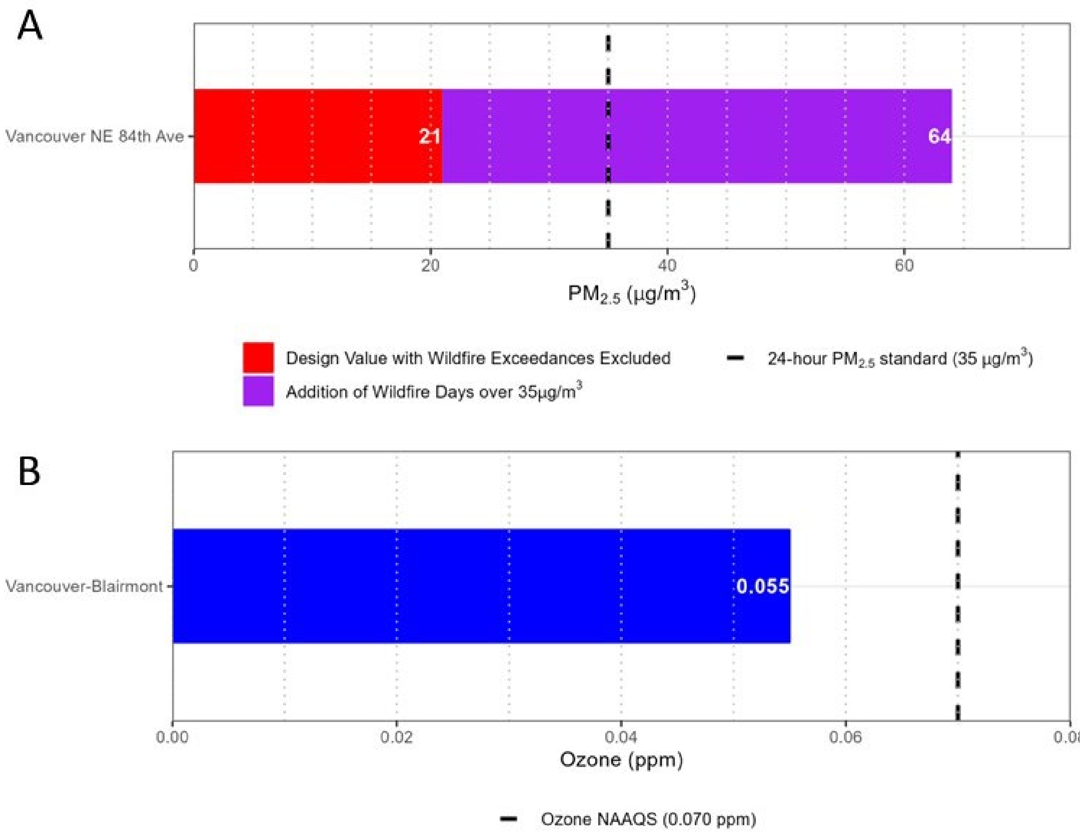

Figure 66. 2022 design values for A) 24-hour PM2.5 and B) Ozone at Vancouver monitoring sites

Over the past three years, the highest $PM_{2.5}$ concentrations in the area have been measured during wildfire events in September 2020 and October 2022. This is visible on the AQI calendar plot for Vancouver (Figure 67). However, when there is less wildfire activity, $PM_{2.5}$ is usually higher in the cold season (Table 95). Figure 67 shows that, throughout the winter months, AQI is usually more consistently elevated in the moderate range. This is usually indicative of wood smoke from home heating, which is consistent with the emission inventory for Clark County.

Table 95. Seasonal and annual means for $PM_{2.5}$ and seasonal means for O_3 for Vancouver monitoring sites, 2020-2022

Pollutant	Site	Season/annual mean	2020	2021	2022*	3-year mean
$PM_{2.5}$ (µg/m^3)	Vancouver-NE 84th Ave	Warm Season (April-September)	18.79	4.39	6.67	9.9
		Cold Season (October-March)	8.33	6.91	9.15	8.1
		Annual	13.91	5.66	7.7	9.1
O_3 (ppm)	Vancouver-Blairmont Dr	Ozone Season (May-September)	*0.031*	0.037	0.037	*0.035*

PM = particulate matter, O_3 = ozone, ppm = parts per million, µg/m^3 = micrograms per cubic meter

*In 2022, seasonal means are adjusted April-October 21 and October 22-March due to wildfires in October.

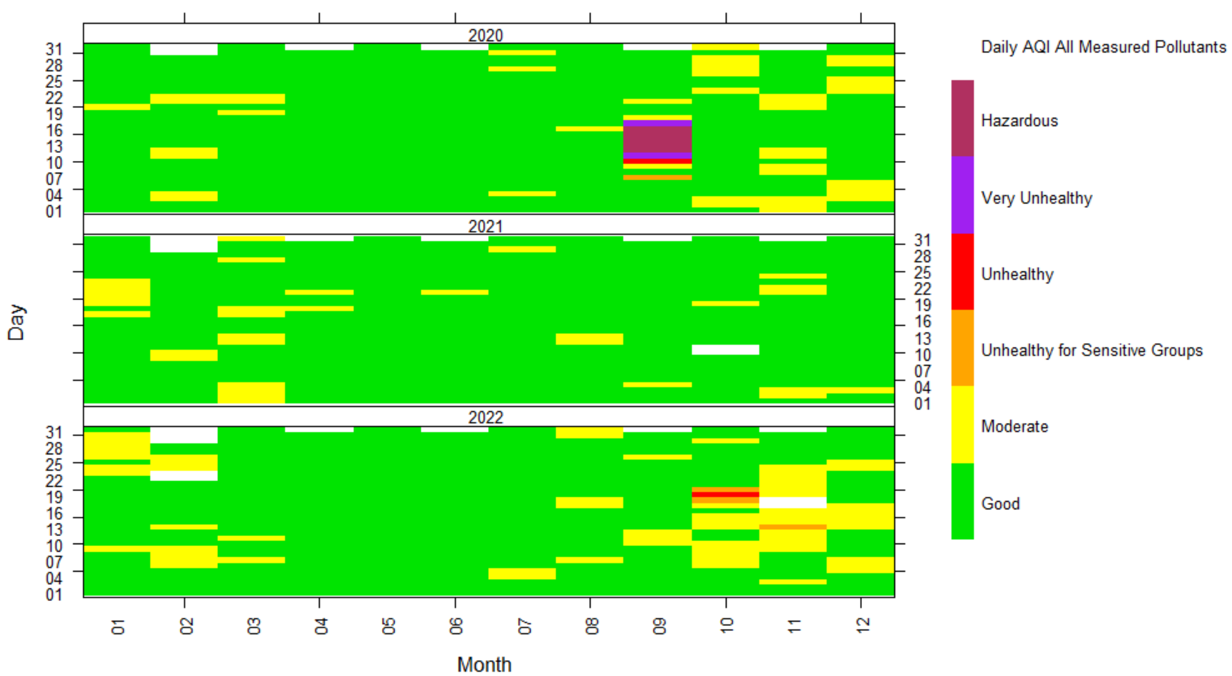

Figure 67. Calendar plot of daily maximum recorded air quality index from 2020-2022 for the Vancouver community

Of the two pollutants measured in Vancouver, $PM_{2.5}$ is the dominant pollutant for most of the year, with the higher daily AQI (Figure 68). However, during the summer months, O_3 is dominant because it is at its peak while $PM_{2.5}$ is generally lower during that time.

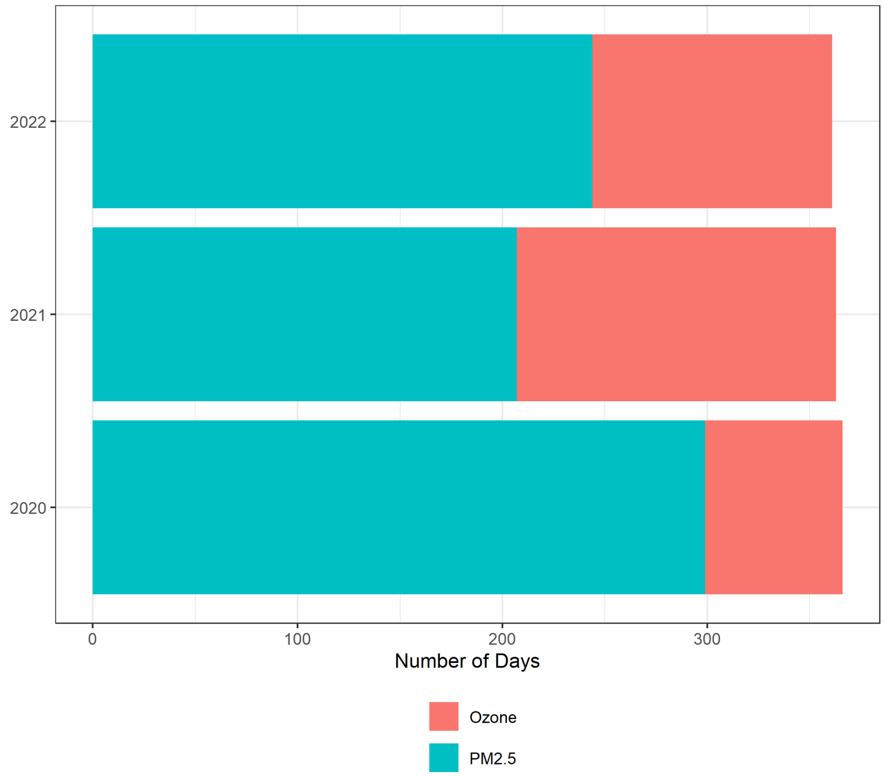

Figure 68. Dominant pollutant by AQI measured each day at monitoring sites for Vancouver

Air quality modeling

Roadway NO_2

We modeled ambient 1-hour NO_2 concentrations from on-road mobile sources, which are the primary sources of NO_2 in Washington communities. Model parameters were selected to represent the conditions under which NO_2 concentrations would be highest (e.g., peak traffic volume, stable atmospheric conditions). The average modeled 1-hour NO_2 concentration across the area is 24.7 ppb. The modeled concentration representing peak near-road conditions, is 42.2 ppb. Figure 69 shows the relative distribution of roadway NO_2 across the Vancouver community.

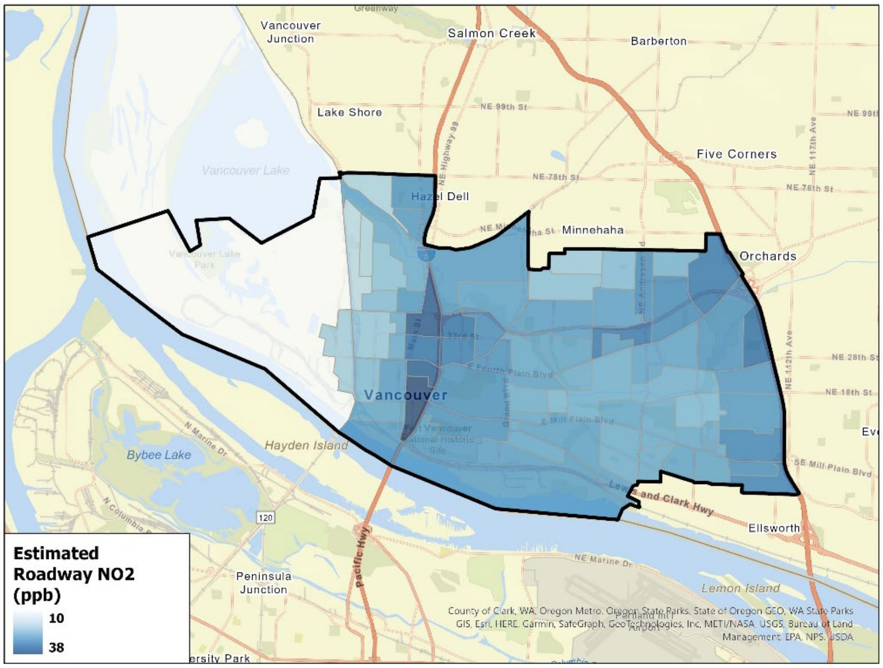

Figure 69. Average estimated 1-hour NO_2 concentration from on-road mobile sources by 2010 census block group in Vancouver during weekday afternoon peak traffic under wintertime stable atmospheric conditions

Potential health impacts

Several socioeconomic factors indicate that parts of Vancouver may be at greater risk of health impacts from air pollution, including poverty, linguistic isolation, and unaffordable housing. The community has many schools, childcare facilities, healthcare facilities, and long-term care facilities. These are locations where occupants may be more vulnerable to the adverse effects of pollution exposure.

We estimated the number and rate of deaths by age range and cause of death using health effect estimates for $PM_{2.5}$ from three different peer-reviewed studies (Table 96). We estimated 30 all-cause deaths among all adults (0.35 deaths per 1,000 18-84-year-olds) each year associated with $PM_{2.5}$ in this community. By age, we found the largest impact on older adults, with an estimated 9 all-cause deaths (0.44 deaths per 1,000 65–99-year-olds) each year associated with $PM_{2.5}$, though this is substantially lower than the rate across all overburdened communities highly impacted by air pollution. For lung cancer, the rate of death is higher than many other identified overburdened communities highly impacted by air pollution.

Table 96. Annual number and crude rate of deaths associated with $PM_{2.5}$ air pollution in Vancouver census tracts fully or partially identified as overburdened and highly impacted by air pollution. Uncertainty range is in [] brackets.

Study	Age group	Ethnicity & race group	Cause of death	Annual number of deaths [uncertainty]	Crude annual death rate per 1,000 people [uncertainty]
Pope et al. [53]	18 to 84	All	All-causes	30.0 [16 to 42.4]	0.35 [0.19 to 0.49]
Di et al.[54]	65 to 99	All	All-causes	8.7 [8.1 to 9.3]	0.44 [0.41 to 0.47]
Krewski et al. [52]	30 to 99	All	All-causes	18.0 [12 to 24]	0.27 [0.18 to 0.35]
Krewski et al. [52]	30 to 99	All	Ischemic heart disease	6.7 [5.4 to 7.8]	0.1 [0.08 to 0.12]
Krewski et al. [52]	30 to 99	All	Lung cancer	3.2 [1.4 to 4.9]	0.05 [0.02 to 0.07]

We recognize that mortality associated with long-term $PM_{2.5}$ exposure is just one measure of the myriad ways air quality impacts health in Vancouver. We will strive to include more information on health impacts in future analyses.

Greenhouse gas emissions

Four facilities in or near Vancouver emitted a total of 675,053 MT CO_2e in 2020 and 782,861 MT CO_2e in 2021 (see Table 97).

Emissions are in units of metric tons of carbon dioxide equivalents (MT CO_2e) using AR4 global warming potentials as specified in WAC 173-441.

Table 97. Facilities and greenhouse gas emissions (MT CO_2e) in or nearby[122] Vancouver

Facility Name and City	Facility Sector	Inside Community Boundary?	CCA-Covered Entity?	Major Source of CAPs? [123]	2020 Emissions [biogenic] (MT CO_2e)	2021 Emissions [biogenic] (MT CO_2e)
Frito Lay - Vancouver	Food Production	Yes	No	No	13,787 [0]	14,350 [0]
Great Western Malt - Vancouver	Food Production	Yes	No	No	15,286 [0]	20,016 [0]
River Road Generating Plant - Vancouver	Power Plant	Yes	Yes	No	635,084 [0]	737,163 [0]
SEH America, Inc - Vancouver	Manufacturing	Nearby	No	No	10,896 [0]	11,332 [0]

CAPs = criteria air pollutants, CCA = Climate Commitment Act, MT CO_2e = metric tons of carbon dioxide equivalent

Bonneville Power Administration (Washington only) is within the community, providing electrical transmission and distribution statewide. However, they are excluded from the table and facility GHG totals because they report GHG emissions on a statewide basis. Since the majority of Bonneville Power Administration's electricity portfolio is hydropower, it is mainly carbon free but still emits sulfur hexafluoride from electrical transmission and distribution equipment. It is not a CCA-covered entity, nor a source of CAP emissions. Statewide emissions were 10,395 CO_2e [0] in 2020 and 11,573 [0] in 2021.

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[122] For the purposes of this analysis, nearby is within 3 miles of the overburdened community boundary.

[123] Major sources of criteria air pollutants are designated in the Air Operating Permit program. For attainment areas, a major source is any stationary source that has the actual or potential to emit ≥100 tons per year for any air pollutant. More information can be found at https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Air-Quality-permits/Air-operating-permits

Table 98. GHG estimates from mobile sources in Vancouver

Population of Overburdened Community	MT CO_2e from Mobile Sources	Rate of MT CO_2e per Capita
103,388	414,005	4.0

MT CO_2e = metric tons of carbon dioxide equivalent

We did not collect information or model greenhouse gas emissions from other sources in this report, although we may do so in the future .

Additional resources

- Air pollution resources:
  - Southwest Clean Air Agency
- Health resources:
  - Clark County Public Health
  - Southwest Washington Accountable Community of Health (ACH)
- Greenhouse gas resources:
  - Climate Action, City of Vancouver
  - Climate Change Planning, Clark County

Next Steps

This report

We plan to publish additional materials related to this report later in 2024. These future materials will be oriented towards community members. The next biennial report of levels of pollution, subsequent health impacts, and greenhouse gas emissions in overburdened communities highly impacted by air pollution will be published by the end of 2025, as required by RCW 70A.65.020(2)(a).

Future reports

Ecology and our partners will continue to seek new and improved data sources, collect new information, and improve and expand our methods for future reports. While this report was a preliminary review of the most recent data, future reviews will focus more on trends and subsequent impacts to overburdened communities highly impacted by air pollution.

In future reports, we will aim to:

- Increase spatial granularity of monitoring data, as we expand our air monitoring network;

- Include estimates of health impacts from short-term $PM_{2.5}$ exposure, such as emergency department visits and hospitalizations;
- Include more years of mortality data to calculate more reliable mortality rates, and calculate age-adjusted mortality rates;
- Incorporate studies with region-specific risk estimates when modeling health impacts;
- Include greenhouse gas emissions information for more sectors;
- Evaluate impacts of cap-and-invest on emissions from covered entities within or nearby overburdened communities highly impacted by air pollution;
- Evaluate overall progress of climate and air quality policies and programs to reduce criteria air pollution and greenhouse gas emissions in overburdened communities highly impacted by air pollution;
- Incorporate methods for understanding impacts from cumulative pollution exposure;
- Include socio-cultural information along with the ways in which air quality intersects with other environmental and social issues;
- Incorporate qualitative and indigenous research methodologies; and
- Include community knowledge systems and assets, which reflect the community's resources, strength, and aspirations.

Efforts that would facilitate these future analyses include:

- Frameworks for evaluating cumulative impacts from multiple pollutants and sources;
- Increasing granularity and accessibility of health data and greenhouse gas emissions data;
- Improving air pollution and health impact modeling methods to better account for and separate pollution from wildfire smoke; and
- Guidance on how to account for wildfire smoke in summary statistics for pollution and health impacts.

Further analysis

State law provides direction about next steps. RCW 70A.65.020(1)(c)(i) requires Ecology to, "within the identified overburdened communities, analyze and determine which sources are the greatest contributors of criteria pollutants and develop a high priority list of significant emitters." This will be a next step in our data analysis, identifying which categories of sources are contributing the most to criteria air pollution in overburdened communities.

Air quality targets

Following this 2023 report on the levels of pollution in an identified overburdened community, RCW 70A.65.020(2)(b)(i) requires Ecology, in consultation with local air pollution control authorities, to:

"Establish air quality targets to achieve air quality consistent with whichever is more protective for human health:

(A) National ambient air quality standards established by the United States environmental protection agency; or
(B) The air quality experienced in neighboring communities that are not identified as overburdened."

Pollution reduction

We will ensure that our pollution reduction work is conducted in alignment with the Healthy Environment for All Act. For any action that is considered a "significant agency action," we will conduct an Environmental Justice Assessment (RCW 70A.02.060), in accordance with Ecology's process.[124]

Grant program

Ecology is in the process of developing a grant program to fund projects that will reduce sources of pollution and mitigate impacts in overburdened communities highly impacted by air pollution. The legislature allocated $11.4 million for the 2023-2025 biennium for this grant program. Ecology anticipates working with communities to identify and develop projects.

Ecology also administers several other air quality grant programs that are available to clean air agencies, local and Tribal governments, and other local partners. Grant programs include wood smoke reduction, prevent nonattainment, diesel reduction, and zero emission transportation programs. Federal programs and initiatives for addressing air quality and environmental justice are also ongoing, including funding through the American Rescue Plan and the Inflation Reduction Act.

Rulemaking

We anticipate that some or all the efforts around identifying categories of sources, establishing targets, adopting emission control strategies, and reducing air pollution will include rulemaking. Before launching rulemaking, however, we will continue engagement with the 16 overburdened communities. As of December 2023, we are traveling to each of the 16 communities to discuss monitors and options for monitoring and are listening to communities' ideas, questions, and concerns. When this is complete, potential rulemaking timelines will be informed through this early engagement process.

[124] https://ecology.wa.gov/about-us/who-we-are/environmental-justice/heal/environmental-justice-assessments

For Tribes

A priority next step is to follow-up with Tribes whose lands and populations are the most impacted by criteria pollutants. In early 2023, Ecology staff overlayed a Washington State Tribal Lands map with maps that show elevated levels of criteria air pollution to identify the Tribal lands most highly impacted by air pollution. While this process resulted in seven Tribes identified for possible inclusion in this initiative, all Tribes are eligible for government-to-government consultation for potential self-identification in the program.

In 2024, we will conduct a concerted outreach effort to engage with different Tribes and Tribal organizations with every effort to continue being respectful and responsive to Tribal values, terminology, ecological knowledge, and governing principles and processes. For Tribes that self-identify, the services and resources available under the Climate Commitment Act include:

- Locate air monitors and sensors in consultation with participating Tribes;

- According to the discretion of Tribal governments, collect, analyze, and share data about criteria air pollutants affecting Tribal communities; and

- Work in partnership with Tribes to identify and implement criteria air pollution reduction strategies in the identified Tribal communities.

Ecology welcomes Tribal input on every stage of this work, including our emerging grantmaking program, as well as rulemaking activities, which will begin in 2024.

More Information

Please visit our website for more information about the Improving Air Quality in Overburdened Communities initiative, including information about how communities were selected for this initiative and public input opportunities. We provide translated materials in Spanish, Chinese, Korean, Vietnamese, and Russian.[125]

Additional resources

Ecology continuously works with local clean air agencies, the EPA, and Tribes to ensure healthy air to breathe for all Washingtonians.[126] Below are some additional statewide resources to access data or learn more about air quality, health impacts of criteria air pollution, and greenhouse gas information:

- Air quality:
    - Washington's air quality monitoring network

[125] https://ecology.wa.gov/Overburdened-communities
[126] Find your local clean air agency here: https://ecology.wa.gov/About-us/Accountability-transparency/Partnerships-committees/Clean-air-agencies

    - Washington smoke information blog
    - Air emissions inventory
    - Air quality standards
- Health impacts:
    - Washington tracking network
    - Department of Health air quality information
    - AirNow wildfire guide factsheets
    - EPA Eco-Health Relationship browser tool
    - University of Washington air pollution health effects studies
- Greenhouse gas emissions:
    - Washington state greenhouse gas inventory
    - Mandatory greenhouse reports

Contact information

For questions about this document, contact Rylie Ellison at rylie.ellison@ecy.wa.gov or (360) 790-2567.

Appendix A. National Ambient Air Quality Standards[127]

Pollutant	Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)	primary	8 hours	9 ppm	Not to be exceeded more than once per year
		1 hour	35 ppm	
Lead (Pb)	primary and secondary	Rolling 3-month average	0.15 µg/m^3	Not to be exceeded
Nitrogen Dioxide (NO_2)	primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	primary and secondary	1 year	53 ppb	Annual mean
Ozone (O_3)	primary and secondary	8 hours	0.070 ppm	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Fine Particle Pollution ($PM_{2.5}$)	primary	1 year	12.0 µg/m^3	annual mean, averaged over 3 years
	secondary	1 year	15.0 µg/m^3	annual mean, averaged over 3 years
	primary and secondary	24 hours	35 µg/m^3	98th percentile, averaged over 3 years
Coarse Particle Pollution (PM_{10})	primary and secondary	24 hours	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)	primary	1 hour	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

ppb = parts per billion, ppm = parts per million, µg/m^3 = micrograms per cubic meter

[127] https://www.epa.gov/criteria-air-pollutants/naaqs-table

Appendix B. Additional Air Pollution Tables and Figures

Lead monitoring results

Table B1. Lead monitoring results in South Seattle and Tacoma

Site	Monitoring period	Max 3-month mean* (µg/m³)	Max daily concentration (µg/m³)
Seattle-Beacon Hill	2020-2022	0.0033	0.0157
Seattle-Duwamish**	August 2021 – September 2022	0.0092	0.0352
Tacoma-Alexander**	August 2021 – September 2022	0.0057	0.0279

*The NAAQS level for lead is a max 3-month mean of 0.15 µg/m³

**Credit = Puget Sound Clean Air Agency's Community-Scale Air Toxics Studies

µg/m³ = micrograms per cubic meter

Number of unhealthy air quality days per year

The bar plots below show the number of days in each AQI category "Unhealthy for Sensitive Groups" and above (i.e., AQI >100) measured in each community with air monitors for 2020-2022. This also represents the number of days for which the federal ambient air quality standard was exceeded each year.

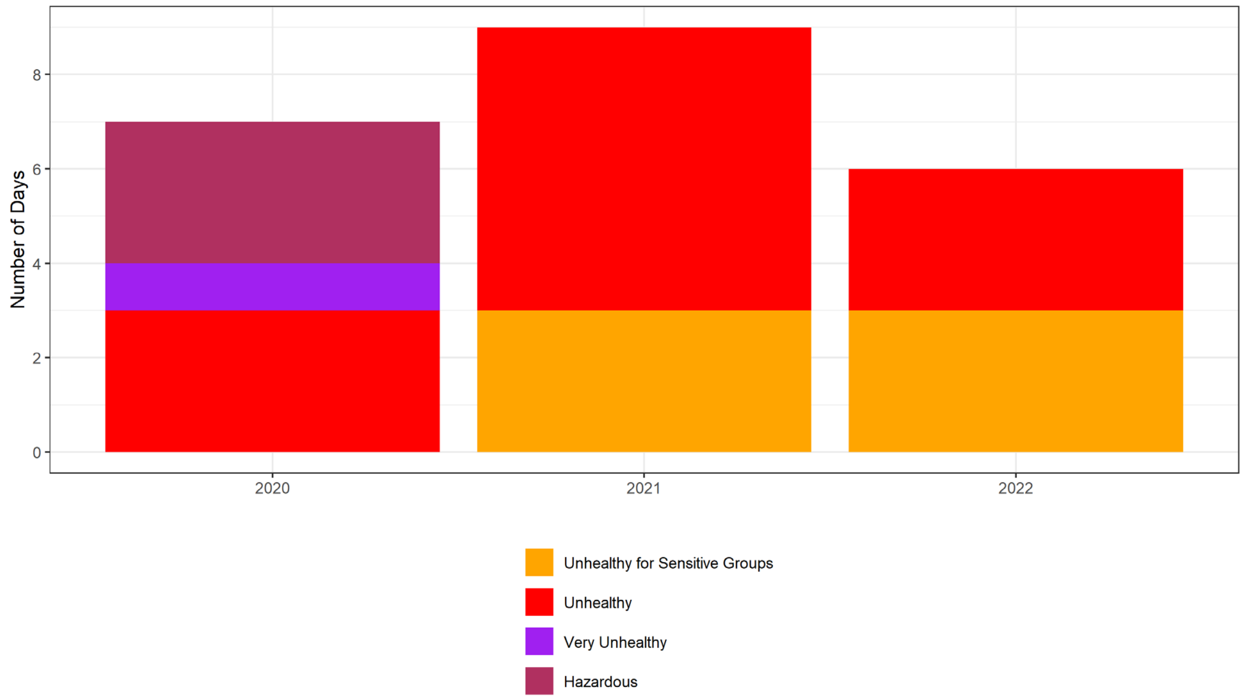

Figure B1. Bar chart of number of days per year for which the recorded air quality index was in the category “unhealthy for sensitive groups” or higher at Spokane and Spokane Valley monitoring sites, for 2020-2022

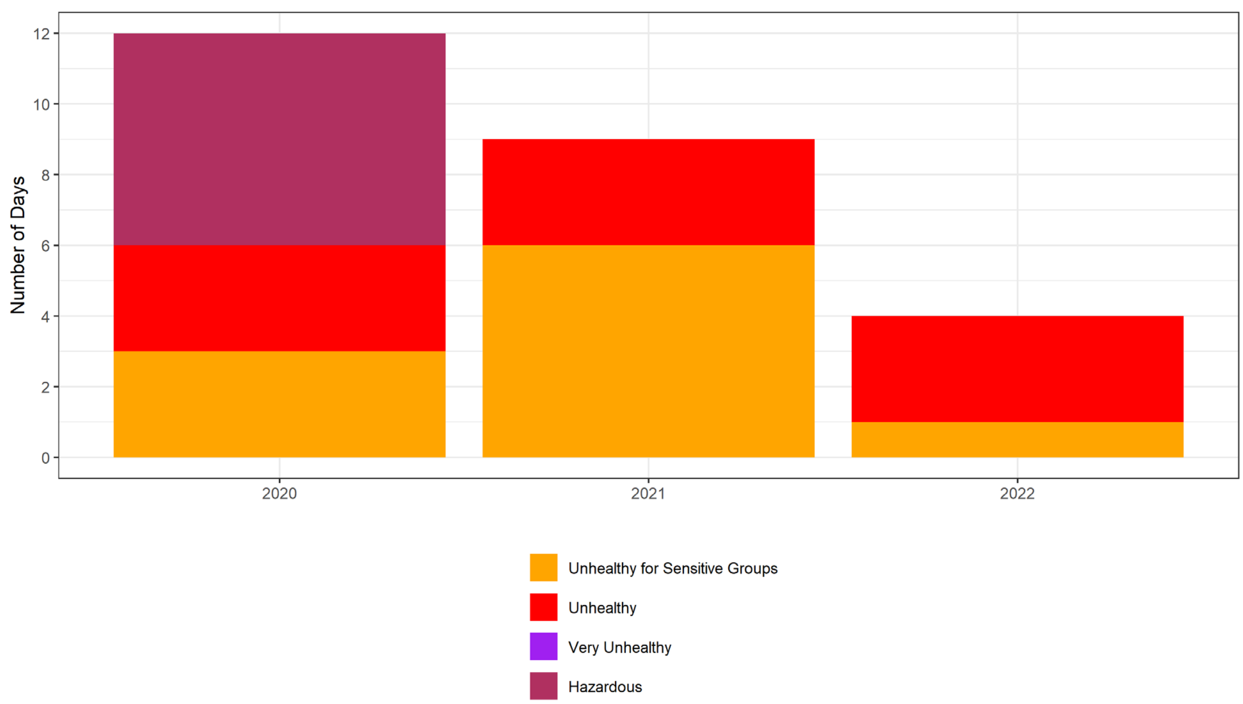

Figure B2. Bar chart of number of days per year for which the recorded air quality index was in the category “unhealthy for sensitive groups” or higher at Tri-Cities to Wallula monitoring sites, for 2020-2022

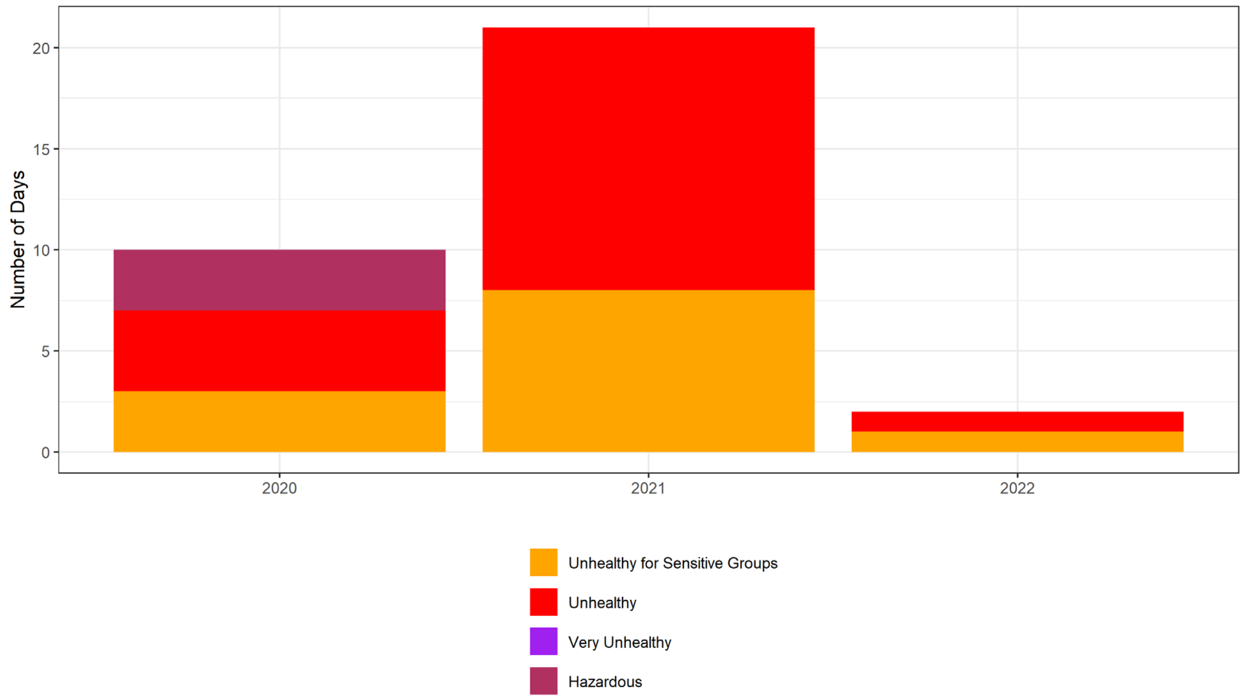

Figure B3. Bar chart of number of days per year for which the recorded air quality index was in the category “unhealthy for sensitive groups” or higher at the East Yakima monitoring site, for 2020-2022

Figure B4. Bar chart of number of days per year for which the recorded air quality index was in the category “unhealthy for sensitive groups” or higher at Lower Yakima Valley monitoring sites, for 2020-2022

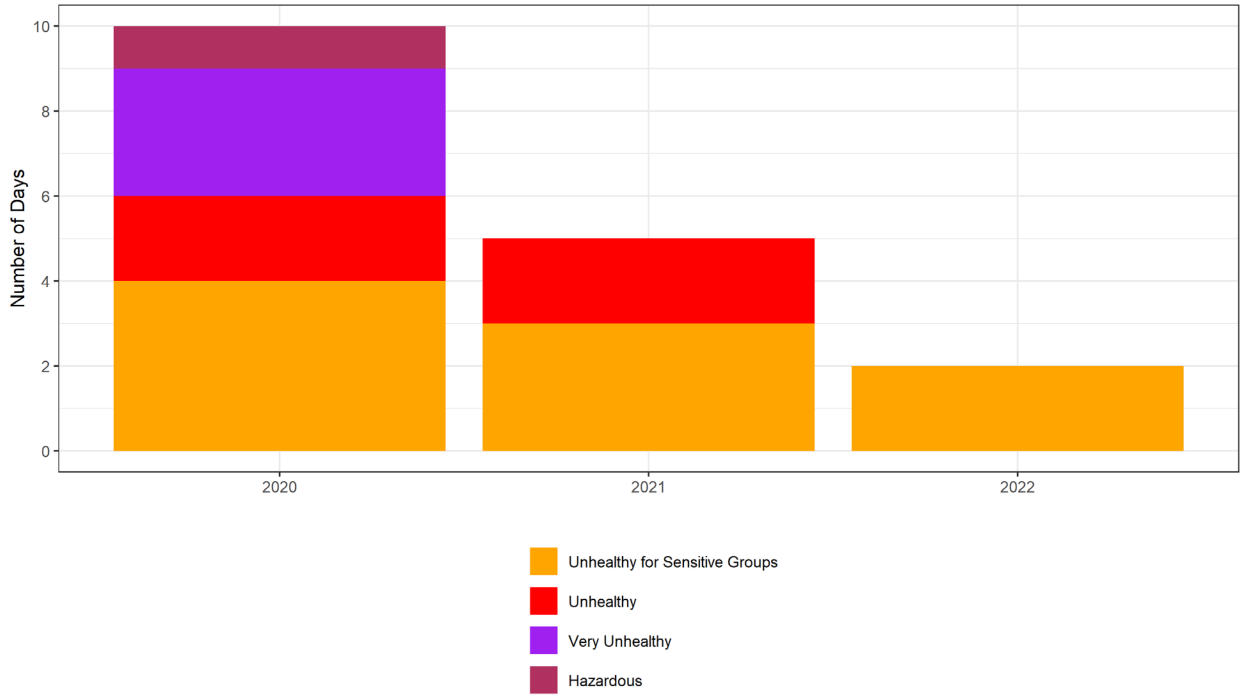

Figure B5. Bar chart of number of days per year for which the recorded air quality index was in the category “unhealthy for sensitive groups” or higher at the Ellensburg monitoring site, for 2020-2022

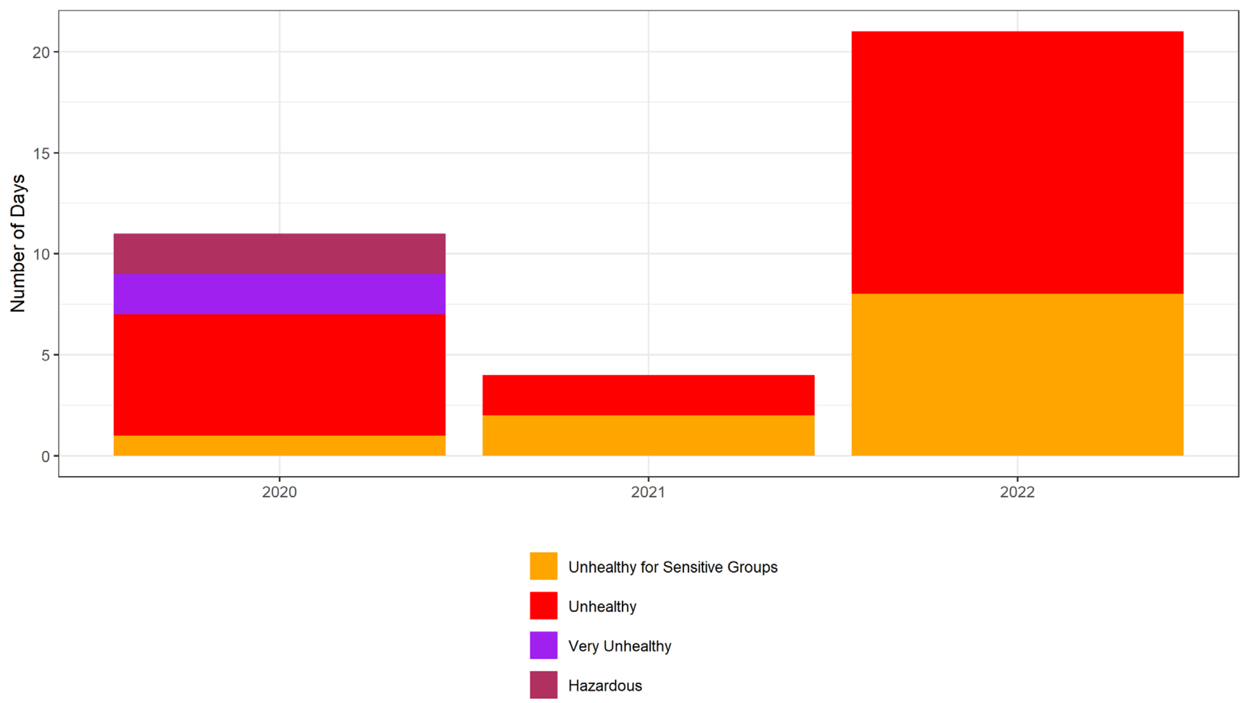

Figure B6. Bar chart of number of days per year for which the recorded air quality index was in the category “unhealthy for sensitive groups” or higher at the Wenatchee and East Wenatchee monitoring site, for 2020-2022

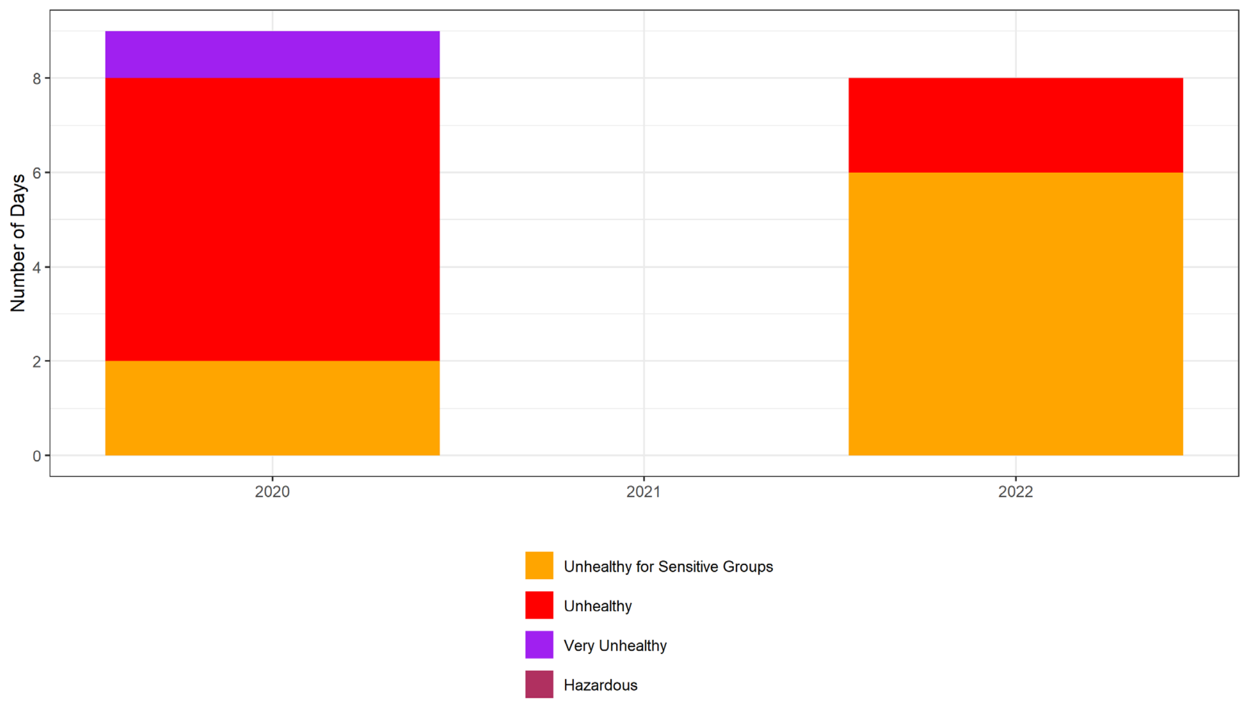

Figure B7. Bar chart of number of days per year for which the recorded air quality index was in the category “unhealthy for sensitive groups” or higher at the monitoring site nearby to Everett, for 2020-2022

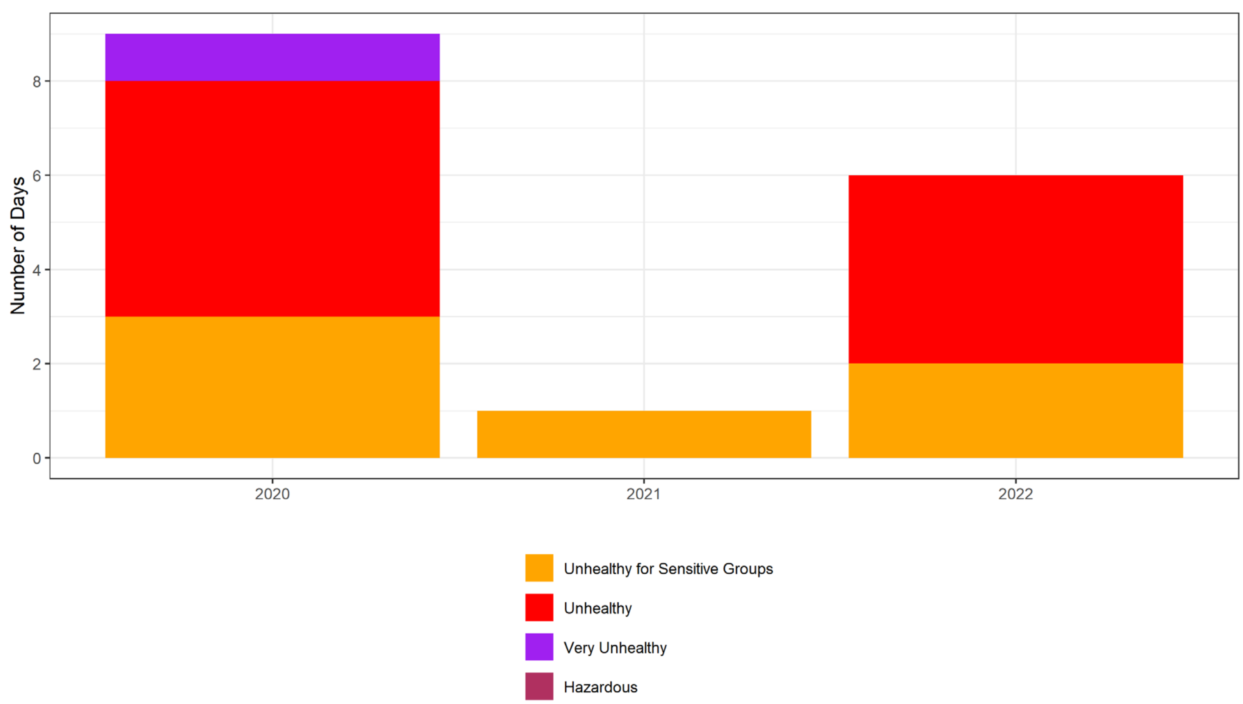

Figure B8. Bar chart of number of days per year for which the recorded air quality index was in the category “unhealthy for sensitive groups” or higher at the monitoring site nearby to North Seattle and Shoreline, for 2020-2022

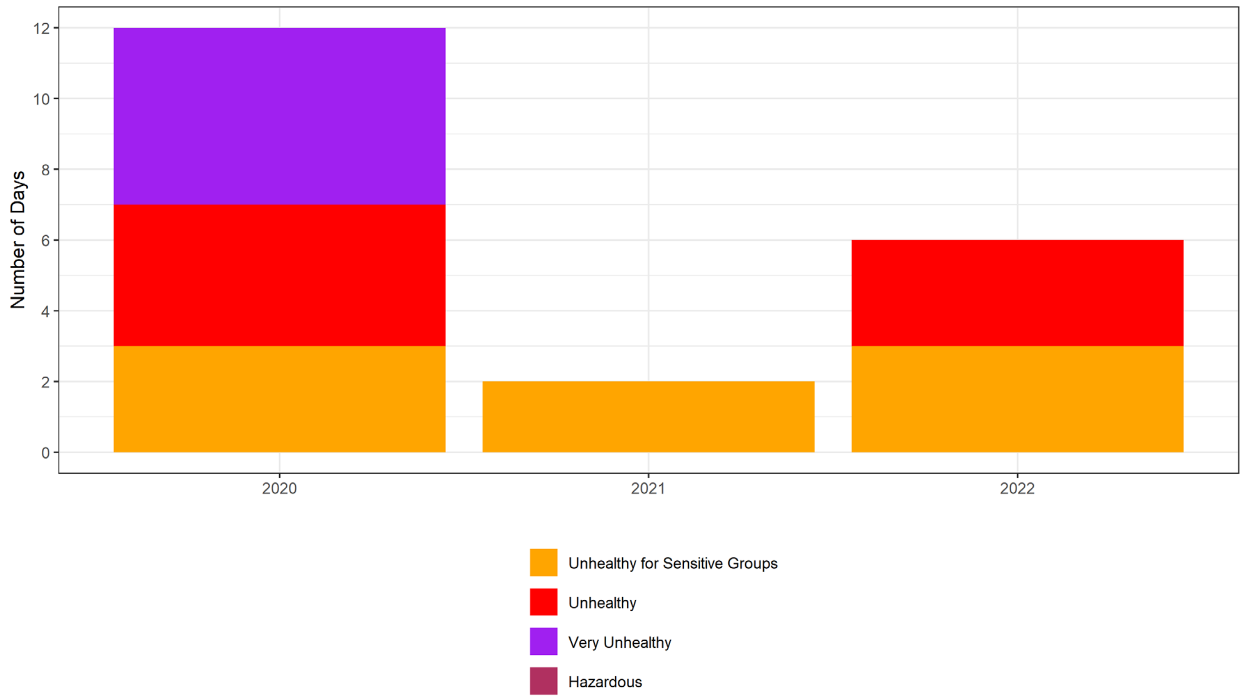

Figure B9. Bar chart of number of days per year for which the recorded air quality index was in the category “unhealthy for sensitive groups” or higher at South Seattle monitoring sites, for 2020-2022

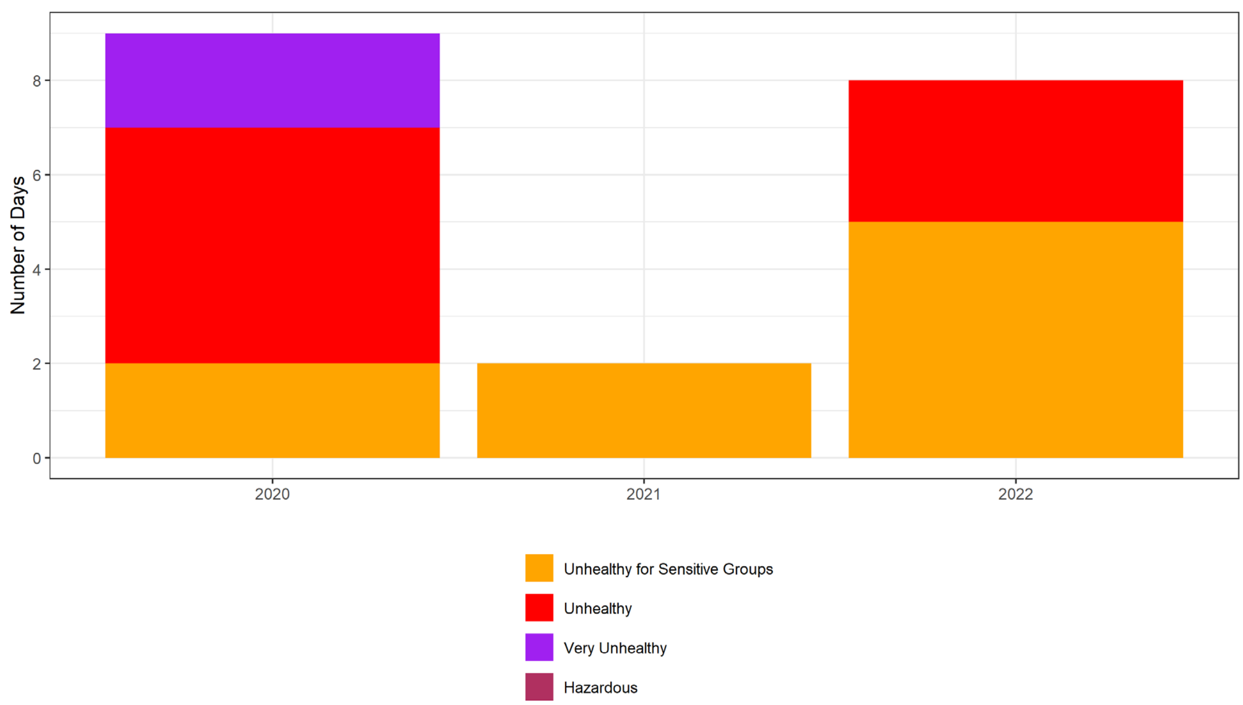

Figure B10. Bar chart of number of days per year for which the recorded air quality index was in the category “unhealthy for sensitive groups” or higher at South King County monitoring sites, for 2020-2022

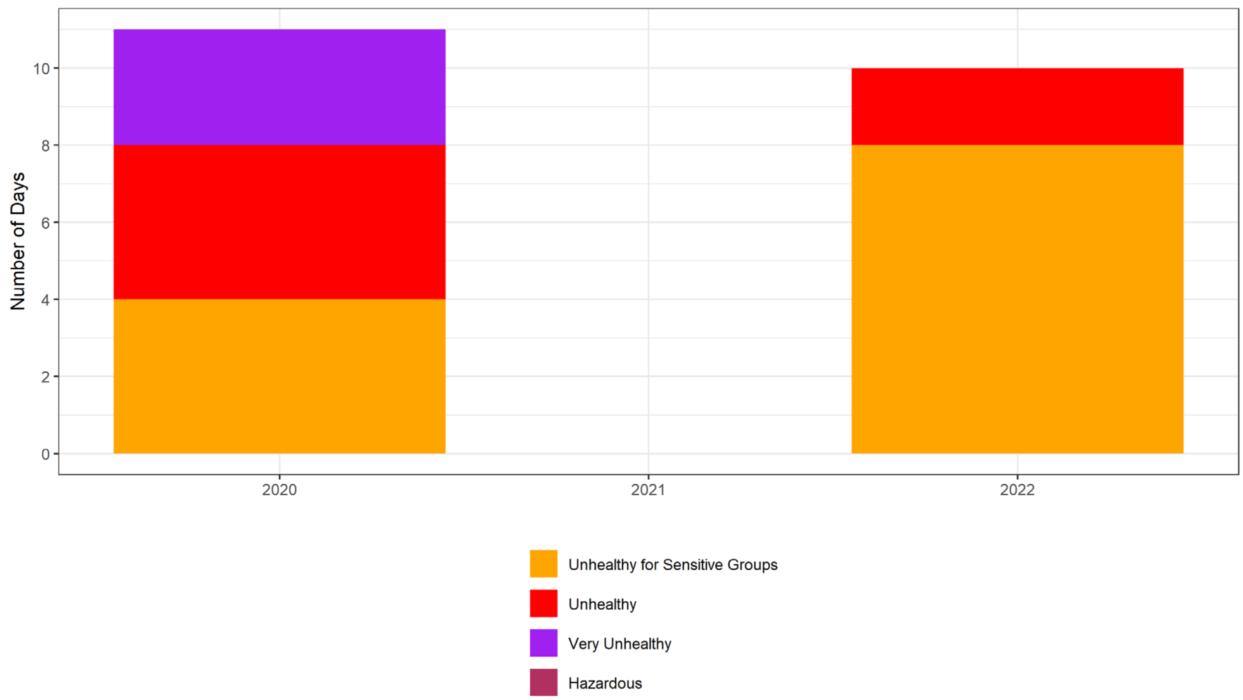

Figure B11. Bar chart of number of days per year for which the recorded air quality index was in the category “unhealthy for sensitive groups” or higher at South and East Tacoma monitoring sites, for 2020-2022

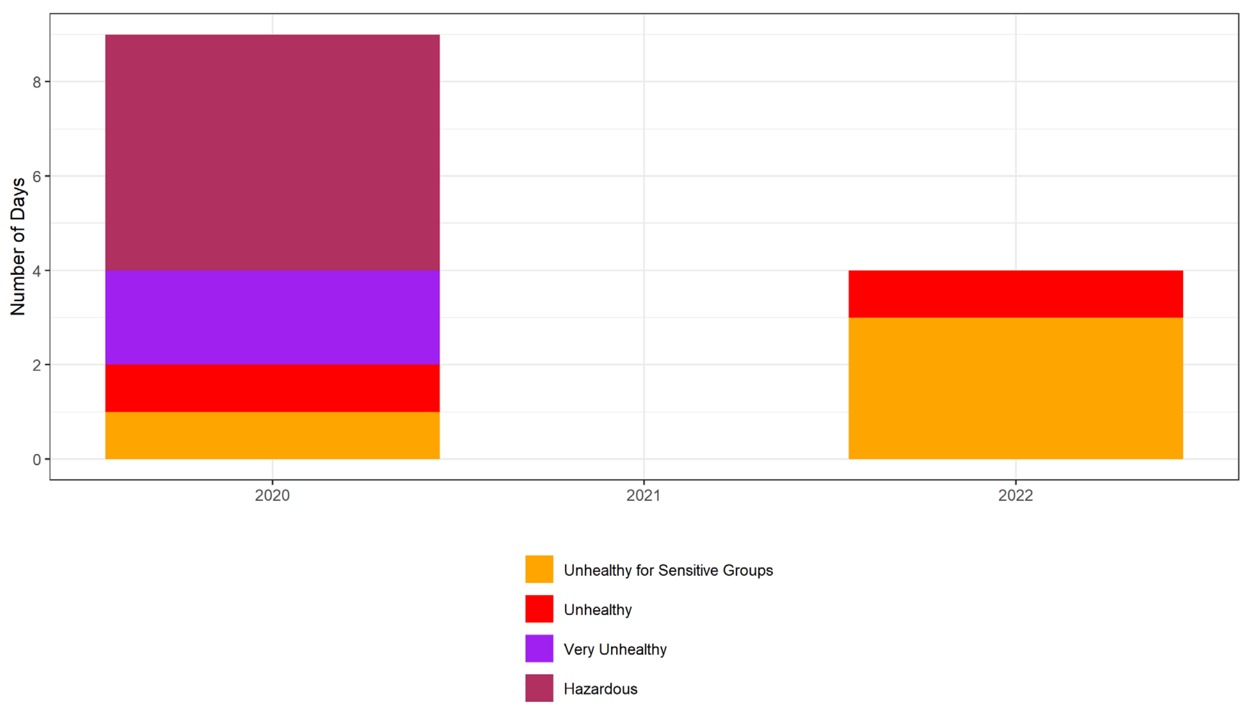

Figure B12. Bar chart of number of days per year for which the recorded air quality index was in the category “unhealthy for sensitive groups” or higher at Vancouver monitoring sites, for 2020-2022

Dominant site in each overburdened community highly impacted by air pollution

The bar plots below show where the highest AQI was measured each day for all monitoring sites each community with >1 site for 2020-2022. These plots are not necessarily indicative of which area in each community has worse air pollution, particularly when different pollutants are measured at different sites. Some sites also have incomplete data, which could affect the ratio between sites.

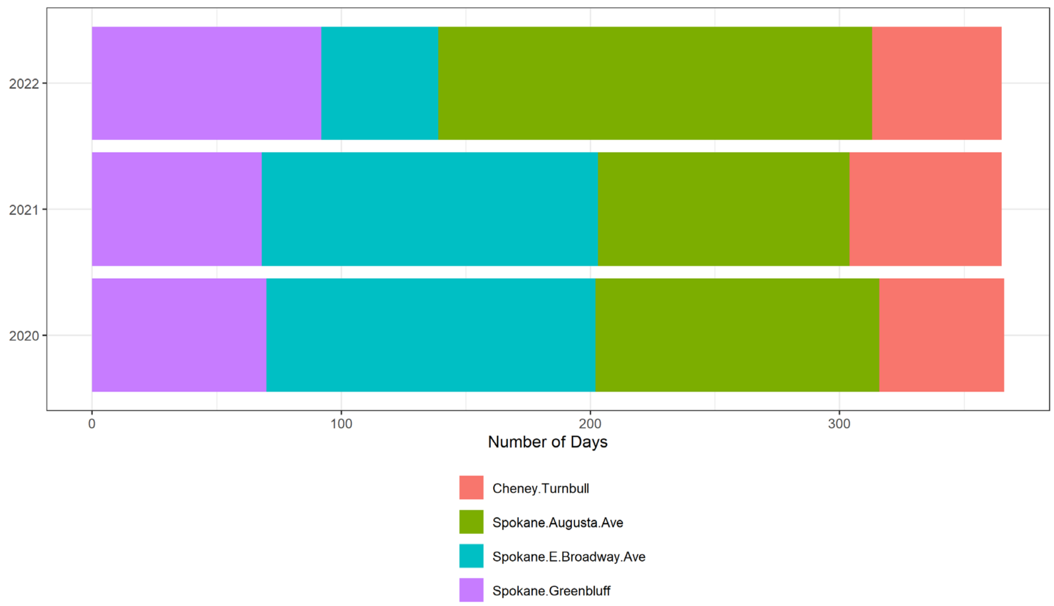

Figure B13. Bar plot of the number of days per year for which each monitoring site in or near Spokane and Spokane Valley had the highest recorded air quality index, for 2020-2022

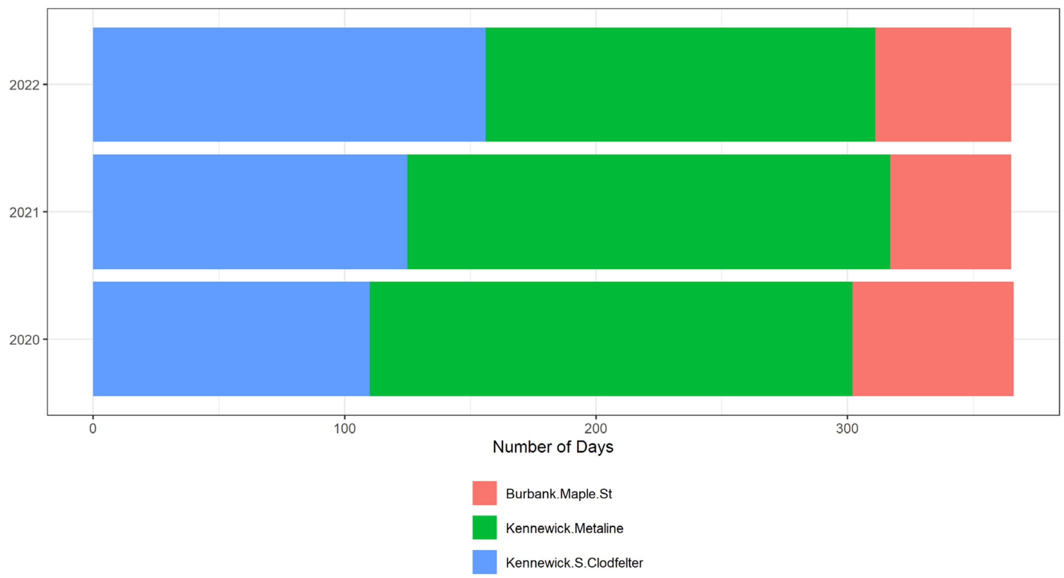

Figure B14. Bar plot of the number of days per year for which each monitoring site in or near Tri-Cities to Wallula had the highest recorded air quality index, for 2020-2022

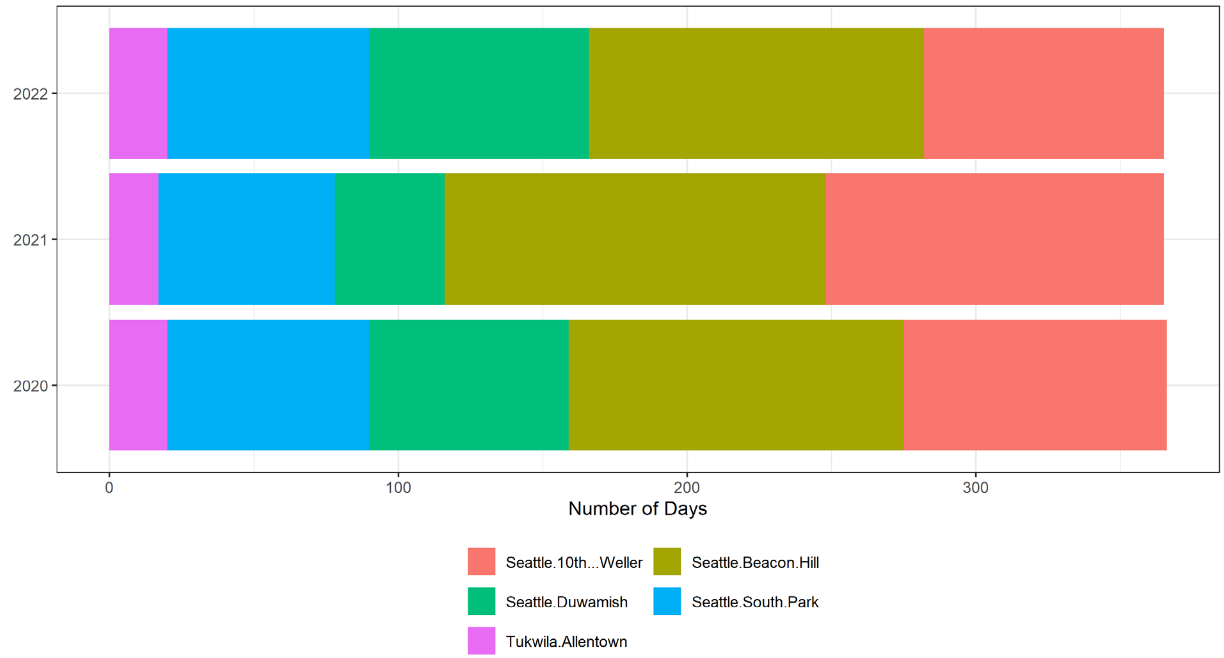

Figure B15. Bar plot of the number of days per year for which each monitoring site in South Seattle had the highest recorded air quality index, for 2020-2022

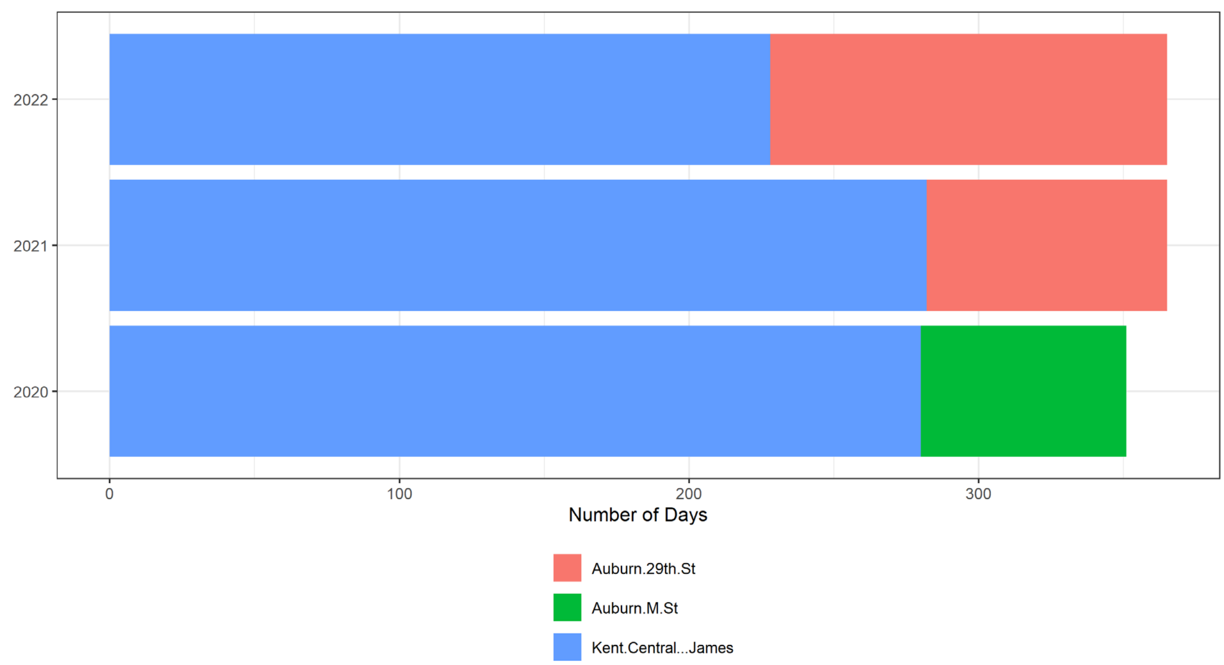

Figure B16. Bar plot of the number of days per year for which each monitoring site in South King County had the highest recorded air quality index, for 2020-2022

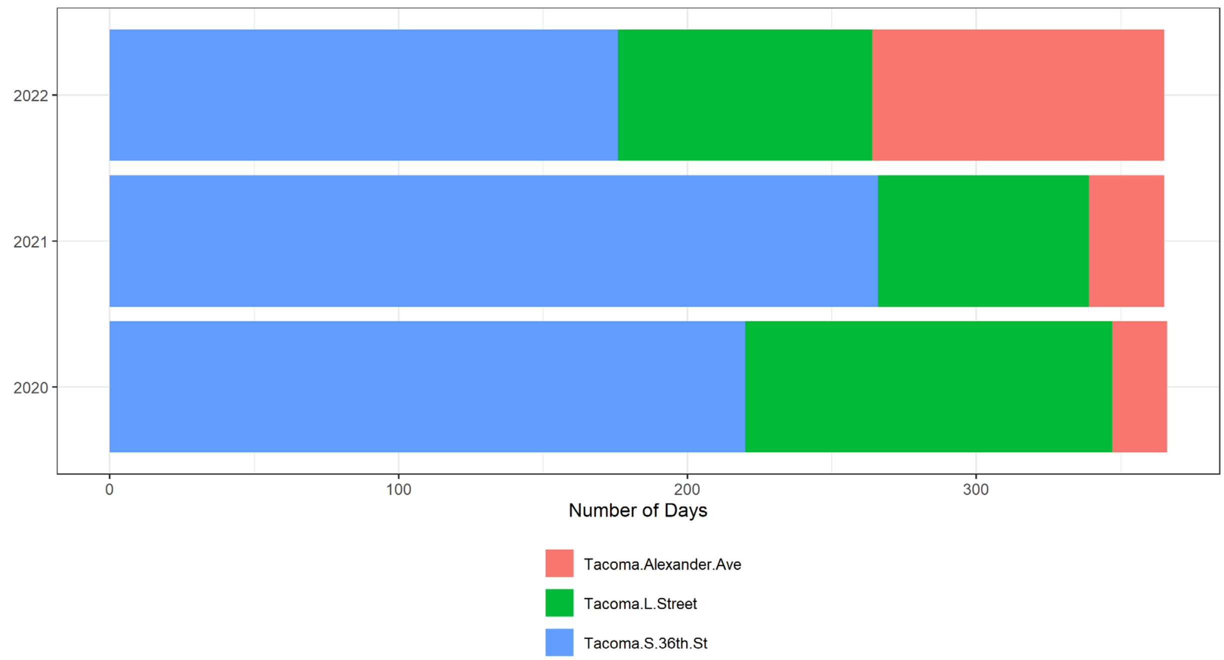

Figure B17. Bar plot of the number of days per year for which each monitoring site in or near South and East Tacoma had the highest recorded air quality index, for 2020-2022

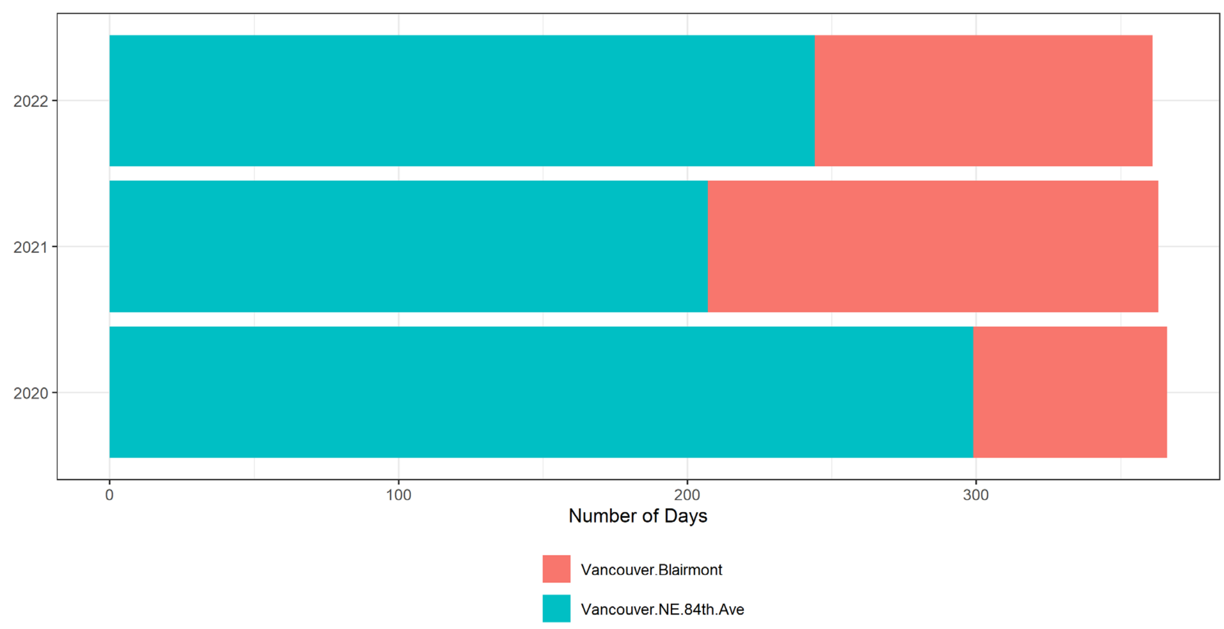

Figure B18. Bar plot of the number of days per year for which each monitoring site in or near Vancouver had the highest recorded air quality index, for 2020-2022

Appendix C. Detailed Methods and Data Sources

C-LINE

The community LINE (C-LINE) model is a freely available web-based tool that models line sources such as near-road and near-ground emissions to investigate the impact of air pollution on nearby communities. C-LINE is a screening level tool and takes the diurnal changes in traffic behavior such as vehicle speed, traffic volume, and/or fleet mix into account to do the simulation. C-LINE uses road data from the 2013 Highway Performance Monitoring System (HPMS) data for Washington State (Table C1). The Federal Highway Administration office administers the HPMS data. C-LINE performs two tasks when it runs, first simulating a case for a *modeling* domain and later *analyzing* results for visualization. It models the dispersion of criteria pollutants such as nitrogen dioxide (NO_2) and some other mobile air toxic pollutants.

In this project, the tool was used to compute the dispersion of NO_2 across communities in Washington to screen the magnitude and distribution of the pollutant as emitted from mobile sources. C-LINE is run for a representative short-term concentration (one hour) using a combination of meteorological conditions in atmospheric stability, season, and the seasonal average wind direction for the modeling domain (Table C2). Preprocessed meteorological data are made available to C-LINE from temperature, wind speed and direction, and atmospheric stability class through a statistical occurrence.[128] Stable and convective atmospheric stability classes with winter and summer seasons were tested, respectively. The day of the week and the hour of the day were also used to select emission parameters for vehicle mix and traffic volume (Table C1). C-LINE showed maximum NO_2 concentration when a stable class in a winter season matched for a weekday and afternoon (PM) traffic volume peak (Results shown in the report). To determine vehicular emissions, weather conditions such as diurnal temperature range, and several other vehicular factors including types of vehicles, vehicle speed, age range of vehicles, engine load and fuel consumed have been used. The Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator (MOVES-2014) model uses EPA's National Emissions Inventory (NEI-2011) to estimate emissions factors. NO_2 is estimated by an empirical relationship between NO_x (Oxides of Nitrogen) and NO_2 (Arunachalam et al. 2015 and Velencia et al. 2018).[129, 130]

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[128] Chang, S.-Y., W. Vizuete, A. Valencia, B. Naess, V. Isakov, T. Palma, M. Breen, S. Arunachalam. (**2015**) A Modeling Framework for Characterizing Near-Road Air Pollutant Concentration at Community Scales, *Sci*. *Total Environ*., 538:905-921.

[129] Arunachalam et al. (**2015**) Development and Evaluation of Model Algorithms to Account for Chemical Transformation in the Near-road Environment. Presented at the 25th Annual Meeting of the International Society of Exposure Science, Henderson, NV, October 18 – 22, 2015.

[130] Valencia, A., S. Arunachalam, D. Heist, D. Carruthers, and A. Venkatram (**2018**). Development and Evaluation of the R-LINE Model Algorithms to Account for Chemical Transformation in the Near-road Environment, *Transp*. *Res*. *Part D*: *Transp*. *Environ*., 59, 464-477.

Table C1. Model emission option for vehicle type and traffic volume used to estimate the representative hourly maximum NO_2 concentration due to roadway sources

Model Input – Vehicle Selections	Data source/option(s) selected	Remarks
Road data/types	Highway Performance Monitoring System[131] 2013: Function classes 2 – 5	Traffic volume, fleet mix, vehicle speed
Emission factors	MOVES[132] 2014; National emissions inventory[133] 2011	Emissions for each road
Day	Weekday	Affects traffic patterns
Hour	PM (afternoon) Peak	Affects traffic density
Analysis/display mode	Census Block Group 2010; Select Mode	Block group average estimate; Results at selected locations

Table C2. Meteorological conditions and parameters for dispersion implemented to estimate the representative hourly maximum NO_2 concentration due to roadway source emissions.

Meteorology	Parameters	Remarks
Atmospheric stability class	Stable	Lowest turbulence
Season	Winter	Cold, dry, and dense air
Wind direction	Seasonal average	Prevailing wind blowing from/to
Monitoring site	Meteorology station closest to center of domain	Station met data derived from
Averaging period	1-Hour	Short term representative

[131] https://www.fhwa.dot.gov/policyinformation/hpms.cfm
[132] https://www.epa.gov/moves
[133] https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei

BenMAP-CE

We used BenMAP-CE to determine health impacts from $PM_{2.5}$. In this report, we only focused on annual $PM_{2.5}$ and its impact on human health. Inputs into the BenMAP tool include changes in the amount of $PM_{2.5}$ concentration, effect estimates for the health event from peer-reviewed articles, the baseline rate of the health event, and the number of people exposed to $PM_{2.5}$ and at risk for health impacts (Figure 5). BenMAP was run at the 2010 census tract level, with results aggregated and reported at the community level.

Table C3. BenMAP-CE input data and sources

Inputs	Data source	Year	Scale	References
Baseline $PM_{2.5}$ concentration	AIRPACT model/monitor interpolation	July 2014-June 2017	Census Tract	[134]
Natural background $PM_{2.5}$ concentration	Monitor at Cheeka Peak, WA	2020-2022	Point	[135]
Population	WA Office of Financial Management	2020	Census Tract	[136]
Baseline mortality rate	WA Department of Health	2020-2021	Census Tract	[137]
Baseline health incidence	BenMAP-CE pre-loaded datasets	2020	County	[138]

PM = particulate matter

Changes in $PM_{2.5}$ concentrations

Health impact analyses were calculated by comparing baseline air quality data to the natural background $PM_{2.5}$ concentration level at Cheeka Peak, Washington.[139] The three-year average annual mean (i.e., 3.07 µg/m^3) at Cheeka Peak monitoring site was used to represent the natural background level of $PM_{2.5}$ concentration level without sources of air pollution from human activity. The baseline air quality data included in this analysis is July 2014-June 2017

[134] https://fortress.wa.gov/doh/wtn/WTNPortal#!q0=4734
[135] https://apps.ecology.wa.gov/publications/SummaryPages/2302043.html
[136] https://ofm.wa.gov/washington-data-research/population-demographics/population-estimates/small-area-estimates-program
[137] Center for Health Statistics (2023). Mortality Data. Division of Disease Control & Health Statistics, Washington State Department of Health
[138] https://www.epa.gov/benmap/benmap-ce-manual-and-appendices
[139] https://apps.ecology.wa.gov/publications/SummaryPages/2302043.html

model/monitor interpolated data at the census tract level. This $PM_{2.5}$ data only contains the annual mean $PM_{2.5}$ concentration that was adopted from the environmental public health data system managed by the Washington State Department of Health Washington.[140] See reference for more details on methodology.

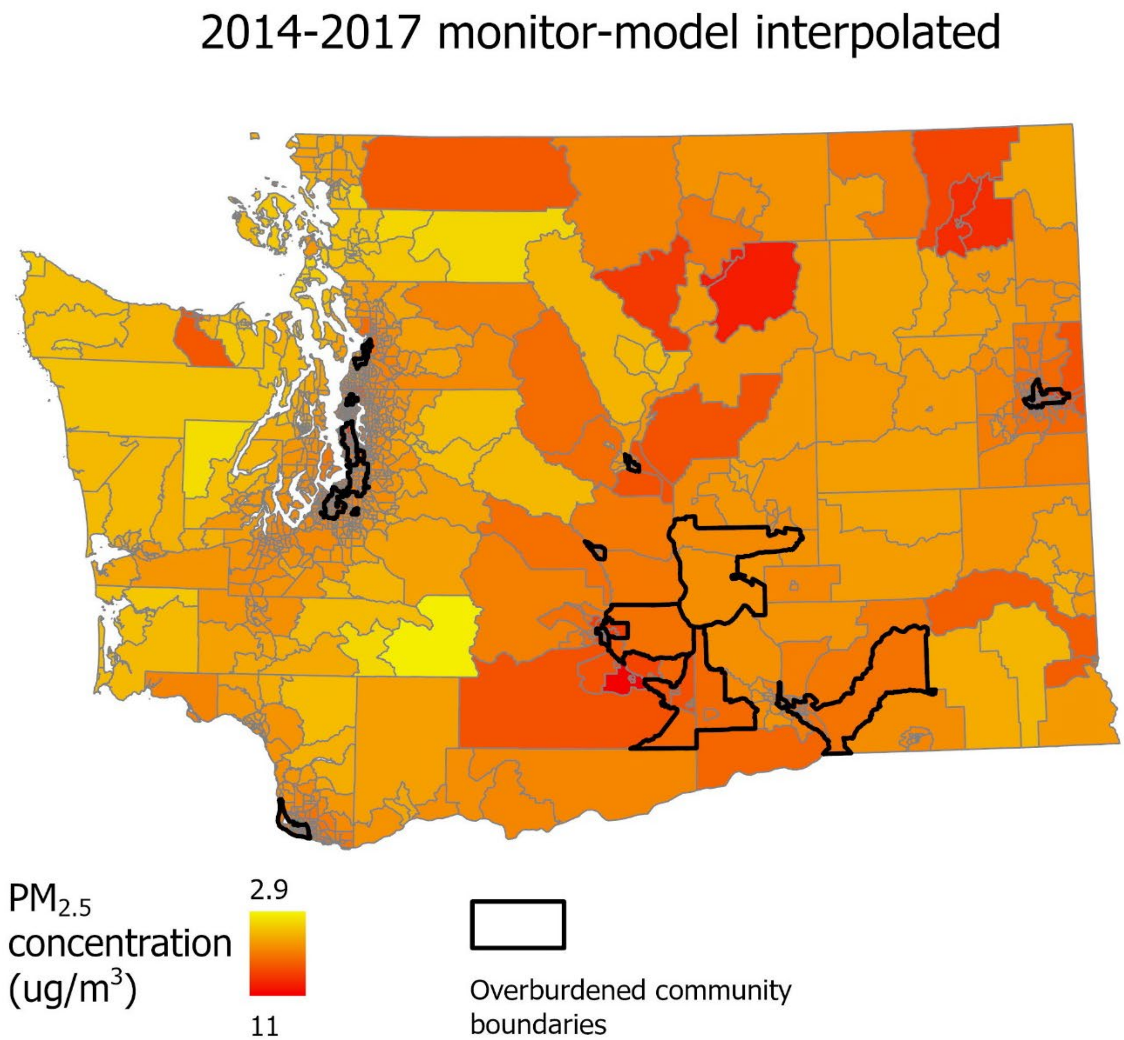

Figure C1. Census tract-level $PM_{2.5}$ concentrations used in the analysis

Population and death data

We used a combination of preloaded datasets available in BenMAP-CE,[141] the Office of Financial Management population 2015-2020 dataset with population estimates for 2010 census

[140] https://fortress.wa.gov/doh/wtn/WTNPortal#!q0=4734
[141] https://www.epa.gov/benmap/benmap-ce-manual-and-appendices

tracts,[142] and death data from the Center for Health Statistics at the Washington State Department of Health.[143] Baseline death data are 2020-2021 annual average rates for each of the census tracts fully and partially identified as overburdened. Outcomes included are all-cause deaths as well as the subset of those with ischemic heart disease and/or lung cancer listed as an underlying cause (Table C4). Annual average health outcome rates and counts were summarized by full year in 2020 for $PM_{2.5}$ impacts.

Table C4. Health effect and outcome definitions

Health effect	Age group
All-cause deaths	18 and above
Deaths from ischemic heart disease and lung cancer	30 and above

Health impact functions

Health impact functions used in the report are summarized in Table C5. We selected studies that investigated mortality among different age, race, and ethnicity groups associated with long-term exposure to $PM_{2.5}$. Krewski et al.[52] undertook a comprehensive investigation encompassing adult populations across 116 cities in the United States. Their measures of risk (e.g., risk and odds ratios) have garnered widespread recognition and serve as pivotal inputs in models quantifying the mortality consequences associated with prolonged exposure to $PM_{2.5}$. However, Krewski et al.[52] did not stratify based on race or ethnicity. Consequently, we selected another highly referenced study (Pope et al.)[53] that investigated nationwide mortality associated with long-term exposure to $PM_{2.5}$. Pope et al.[53] delved into the effects of mortality within distinct racial and ethnic cohorts. Racialized groups have historically been exposed to higher levels of air pollution due to the impacts of structural racism, which contributes to disparities in health impacts.[144] Therefore, we selected the study by Di et al.[54] as the most relevant for examining mortality effects associated with long-term exposure to $PM_{2.5}$ within four distinct racial and ethnic groups among older adults in the overburdened communities highly impacted by air pollution.

[142] https://ofm.wa.gov/washington-data-research/population-demographics/population-estimates/small-area-estimates-program

[143] Center for Health Statistics (2023). Mortality Data. Division of Disease Control & Health Statistics, Washington State Department of Health. https://doh.wa.gov/data-and-statistical-reports/health-statistics/death

[144] Colmer, Jonathan, Ian Hardman, Jay Shimshack, and John Voorheis. "Disparities in PM2. 5 air pollution in the United States." *Science* 369, no. 6503 (2020): 575-578.

Table C5. Annual health effect estimates used for $PM_{2.5}$

Health effect	Age group	Effect estimate (Death associated with 10 $\mu g/m^3$ increase in annual average $PM_{2.5}$)	Study region	Source
Death	18 to 84	1.04% increase in all-cause deaths among non-Hispanic whites; 1.40% increase among non-Hispanic Blacks; 0.95% increase among non-Hispanic Asians, AIAN, NHOPI, and two or more races; 1.82% increase among Hispanics	Nationwide U.S.	Pope et al.[53]
Death	65 to 99	0.61% increase in all-cause deaths among non-Hispanic whites; 1.89% increase among non-Hispanic Blacks; 0.92% increase among non-Hispanic Asians, AIAN, NHOPI, and two or more races; 1.1% increase among Hispanics	Nationwide U.S.	Di et al.[54]
Death	30 to 99	0.58% increase in all-cause death	116 U.S. cities	Krewski et al.[52]
Death	30 to 99	2.15% increase in death due to ischemic heart disease	116 U.S. cities	Krewski et al.[52]
Death	30 to 99	1.31% increase in death due to lung cancer	116 U.S. cities	Krewski et al.[52]

AIAN = American Indian and Alaska Native, NHOPI = Native Hawaiian and Other Pacific Islander, PM = particulate matter, $\mu g/m^3$ = micrograms per cubic meter