South Portland / Portland 24-Hour Volatile Organic Compounds Air Monitoring Results Analysis and Summary Report Update

Analysis and Summary Update for Sampling Period from November 2019 to November 2025

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Prepared by the Maine Center for Disease Control and Prevention

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1 Summary of Major Findings

From June 2019 to November 2025, the Maine Department of Environmental Protection (DEP) collected 2,770 individual air samples to measure volatile organic compound (VOC) levels in ambient air in South Portland and Portland communities. Each air sample represented a 24-hour average ambient air concentration, collected once every six days to capture different days of the week. There were 12 different sampling locations evaluated over the duration of the study, with individual monitoring locations having between 74 and 354 collected air samples depending on how long the monitoring location was operational. In each air sample DEP measures 47 VOCs. Measured concentrations of the semi-volatile organic compound (SVOC) naphthalene are not evaluated in this report due to ongoing measurement challenges and data quality concerns. DEP is investigating methods to better assess ambient air concentrations of naphthalene and these results are pending.

In this report, Maine Center for Disease Control and Prevention (Maine CDC) presents findings for short-term and long-term health assessments of the 24-hour sampling results. The short-term health assessment compares each individual 24-hour sample result to available health guidelines for short-term exposure (i.e., 1 to 14 days). The long-term health assessment compares averaged VOC levels for each monitoring location to the available health guidelines for lifetime exposure (i.e., 70 years).

Major findings of these health assessments are:

- None of the monitoring locations in South Portland or Portland had any individual 24-hour sample results for any of the measured VOCs that exceeded available health-based guidelines for short-term exposures. This result indicates there is minimal health risk to the residents of these two communities from short-term exposure to the daily variations in ambient air levels of the measured VOCs.

- Comparison of long-term average concentrations of measured VOCs to Maine's Ambient Air Guidelines (AAGs), which are intended to be protective for lifetime exposure, identified two VOCs of possible public health concern: acrolein and benzene.

- All monitoring locations had long-term average ambient air levels of acrolein that were substantially higher than the AAG for lifetime exposure.
    - The average ambient air concentrations of acrolein in South Portland and Portland are similar to measured levels in Bangor, Lewiston, Presque Isle, and Rumford.
    - There is evidence that at most locations, ambient air levels of acrolein decreased over the six-year study, though the decrease in concentrations were relatively small over this time.

- With the exception of Pearl Street, all locations had long-term average ambient air levels of benzene that fell below the AAG.
    - The Pearl Street location had a long-term average ambient air concentration for benzene above the AAG. This monitoring location is sited on the fenceline of a petroleum storage facility, but there are also homes located close to this monitoring location and the fenceline.

- Average benzene ambient air concentrations for the Portland monitoring locations and the South Portland locations of Red Bank and Cash Corner are similar to benzene levels measured in Bangor, Lewiston, Presque Isle, and Rumford. The other South Portland locations have average benzene concentrations slightly higher than the statewide sampling locations outside of the Portland/South Portland area.
- There is evidence that ambient air benzene concentrations at all the monitoring locations in Portland and some monitoring locations in South Portland decreased over the six-year study. A decreasing trend in benzene concentrations was also observed for locations in Bangor, Lewiston, Presque Isle, and Rumford. Benzene concentrations at locations closer to petroleum storage facilities with four or more years of observations (Mechanic Street and Bug Light) remained consistent and did not show either decreasing or increasing trends.

- AAGs for individual cancer-causing chemicals (e.g., benzene) are set using a minimal increased cancer risk threshold of 1 per 100,000 exposed people, assuming 70 years of continuous exposure. Cumulative cancer risk was computed to assess the combined exposure to co-occurring VOCs by summing their individual cancer risk estimates to obtain a total cumulative cancer risk. The cumulative cancer risk was fairly consistent across the monitoring locations, typically ranging from a combined incremental cancer risk of between 1.5 and 2.0 per 100,000 exposed people, with the exception of Pearl Street, which was higher at 2.8 per 100,000. These results are likely an underestimate of cumulative cancer risk compared to prior reported results because they do not include the contribution of naphthalene, which was not included in this report due to data quality concerns. Including naphthalene could increase estimates more than 2-fold at some locations (e.g., Cash Corner, West Commercial Street), less at other locations.

2 Background

This report provides a health assessment of the results from six years of measuring ambient air levels of VOCs at a total of 12 locations in South Portland and Portland from June 2019 to November 2025. The DEP started an ambient air VOC monitoring project in South Portland and Portland in response to community concerns about odors and emissions thought to be from petroleum storage facilities located along the South Portland waterfront. VOCs are carbon-based chemicals that readily evaporate into the air. VOCs are major components of gasoline and other petroleum fuels, including the chemicals called propane and butane that are the most abundant by mass, as well as chemicals such as benzene, toluene, ethylbenzenes, xylenes, 1-3 butadiene, and the semi-volatile organic compound (SVOC) naphthalene that are of concern due to their toxicity. VOCs are also emitted by a wide array of household products. Examples include paints and lacquers, cleaning supplies, pesticides, building materials and furnishings, glues, and adhesives. Industrial solvents can contain chlorinated VOCs such as trichloroethylene, and the chlorination in water treatment can result in the formation of VOCs such as chloroform.

VOCs were selected as the focus of these ambient air quality studies because they constitute a large majority of the compounds associated with the types of odors being reported, as well as air emissions that come from petroleum storage facilities of concern to the community. VOCs were also chosen because the DEP had the ability to measure the concentrations of these chemicals in ambient air using methods developed and standardized by the U.S. Environmental Protection Agency (U.S. EPA), and the DEP was experienced with the appropriate sample collection and laboratory analysis methods.

The DEP uses U.S. EPA Method TO-15[1] for the collection and analysis of VOCs in ambient air, both for the South Portland/Portland (SoPo/Po) ambient air VOC study and for the statewide hazardous air pollutant (HAP) monitoring program. Briefly described, a sample of ambient air is drawn into a specially prepared stainless-steel canister over a 24-hour period. The VOC concentration in the resulting canister sample represents the average ambient air concentration of VOCs over the 24-hour sample collection period. At each monitoring location, air samples are collected every six days so that over time, samples are repeatedly collected on each day of the week. The sample collection frequency of once every sixth day is a standard used nationally by U.S. EPA supported ambient air monitoring programs.[2] The collected air samples are analyzed in the DEP laboratory using gas chromatography/mass spectroscopy (GC/MS) – an analytical technique that uses gas chromatography to separate a mixture of VOCs prior to their introduction into the mass spectrometer, which identifies and quantifies individual VOCs. The DEP used a target list of 47 individual VOCs that are analyzed using method TO-15 in the SoPo/Po study. A list of the 47 VOCs the DEP measured for this study is provided in Appendix Table A-1.

Sampling has occurred at a total of 12 monitoring locations over the past six years. The five initial locations in South Portland were placed in each of the city's five voting districts at the request of the City of South Portland, with specific locations selected from city-identified options to meet siting requirements for access, power, and security. These five locations were Bug Light Park, South Portland City Assessor's Office, South Portland High School, South Portland School Administration building (also referred to as Central Receiving),

[1] https://www.epa.gov/quality/analysis-volatile-organic-compounds-air-contained-canisters-method-15-sop-no-hw-31-revision
[2] Section 2.1.1 of https://www.epa.gov/system/files/documents/2022-08/NATTS-TAD-Revision-4-Final-July-2022-508.pdf

and the Red Bank Community Center. At the request of the City of Portland, two additional monitoring sites were established to augment the previously established long-term HAPs site at Deering Oaks Park. These two Portland locations were West Commercial Street and Ocean Gateway; locations selected in part due to the proximity to the waterfront and across the Fore River from the petroleum storage facilities.

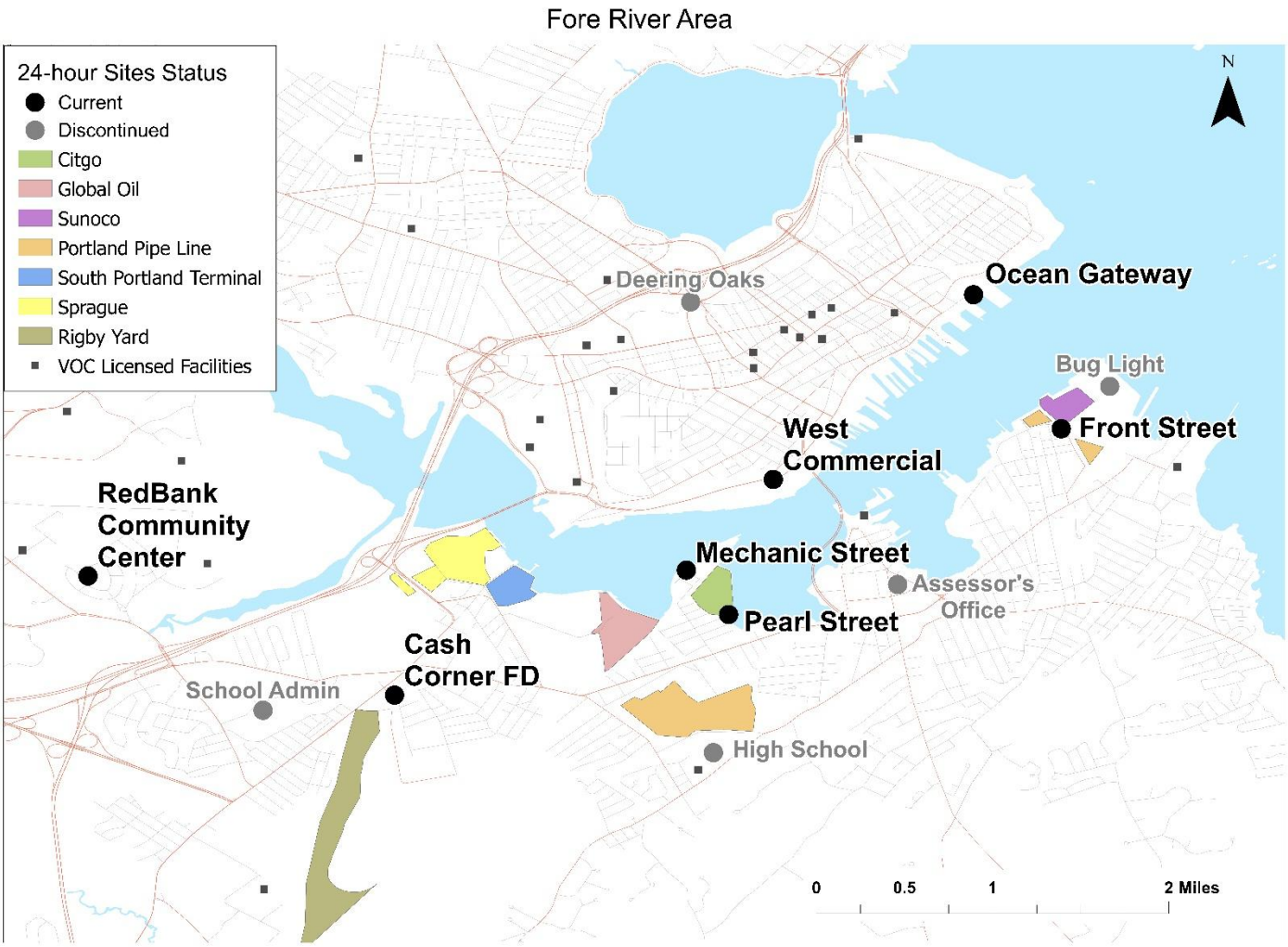
Some of these initial monitoring locations were phased out and the sample collection devices were relocated to address the South Portland community's interest in assessing VOC exposure among residents living in close proximity to petroleum storage facilities, while other stations were retained for long-term monitoring to better assess year-to-year variation and to estimate long-term average VOC concentrations. In anticipation of the scheduled demolition of the South Portland School Administration Building, the Central Receiving monitoring station was relocated to Mechanic Street, a site close to a petroleum storage facility. The monitoring station at the South Portland City Assessor's Office was discontinued. Cash Corner became a permanent station following a year of monitoring using a portable sampling platform at that location. In response to a recommendation of the South Portland Clean Air Advisory Committee[3] and the City of South Portland, the monitoring station at Bug Light was relocated to Front Street, retaining similar proximity to the same storage facility but closer to residences. The monitoring location at the South Portland High School was relocated to Pearl Street on the fenceline at a petroleum storage facility. Previous 24-hour sampling with a portable sampling platform at the Pearl Street location found higher ambient air VOC levels. Red Bank, Bug Light, and the three Portland stations are the stations that have operated for nearly the full six-year period. Table 1 summarizes the dates of operation and the total number of 24-hr samples collected for each monitoring location. A map showing the locations of each monitoring station, the petroleum storage facilities, and other DEP-licensed sources can be found in Figure 1.

Table 1. Status of all Twelve VOC Air Monitoring Stations as of November 2025.

City	Monitoring Station	Online Date	Offline Date	Total Number of Samples Collected
South Portland	Assessor's Office	06/26/2019	06/28/2022	176
	Bug Light	08/13/2019	07/17/2024	264
	Cash Corner	09/19/2021	--	228
	Central Receiving	09/30/2019	03/17/2021	79
	Front Street	05/18/2024	--	76
	High School	10/06/2019	11/02/2023	203
	Mechanic Street	03/23/2021	--	265
	Pearl Street	10/27/2023	--	108
	Red Bank	10/06/2019	--	338
Portland	Deering Oaks	06/26/2019	09/04/2025	354
	Ocean Gateway	11/11/2019	--	344
	West Commercial Street	11/17/2019	--	335

[3] https://www.southportland.gov/DocumentCenter/View/2035/CAAC-2022-Report-to-City-Council---Final_Feb-2023

Figure 1. Map of all Former and Current VOC Monitoring Stations in South Portland and Portland.[4]



The past six years of ambient air monitoring for VOCs has produced a data set of approximately 60 individual 24-hour samples for each year a monitoring location was operating. The Maine Center for Disease Control and Prevention (Maine CDC) has been tasked with performing a public health assessment of these ambient air data. The public health assessment compares the measured ambient air VOC levels to appropriate health-based guidelines. The assessment evaluates health hazards for both short-term (acute) exposures and long-term (chronic) exposures. Maine CDC initially described methods and data displays for performing public health assessments in a January 2020 report.[5] These methods evaluated whether any individual 24-hour sampling results for any specific VOC exceeded published health guidelines for assessing short-term exposures to chemicals in air. These methods also evaluated whether long-term average ambient air levels (e.g., annual average or multi-year averages) exceeded published health guidelines for assessing long-term exposures to chemicals in air. Data updates for the first year of the ambient air monitoring program were prepared and

[4] For details on emissions from VOC licensed facilities: https://www.maine.gov/dep/ftp/AIR/DATA/CAP_SUMMARIES/
[5] https://www.maine.gov/dep/air/monitoring/docs/archive/S.Portland-Portland-24-hour-VOC-summary-report-03.19.20.pdf

released in August and December 2020. A report on the first two years of monitoring data was issued in July 2024, and this report extended Maine CDC's health assessment to include a cumulative cancer risk assessment.[6]

This report makes use of these same public health assessment methods to evaluate the results of the past six years of ambient air monitoring for VOCs. In the following sections, each public health assessment method evaluating short-term hazards, long-term hazards, and cumulative cancer risk will be briefly reviewed followed by a description of the results from sampling efforts to date. This report additionally includes an analysis of whether the concentrations of acrolein and benzene increased or decreased over the six-year study period.

This report differs from prior reports in that it no longer evaluates the measured concentrations of the chemical naphthalene due to data quality concerns. A substantial decrease in annual average ambient air concentrations of naphthalene was observed at every location in this study during the fifth year of monitoring relative to results from prior years. Further investigation revealed that a similar decrease in ambient air results for naphthalene was also apparent at the other 24-hr sample monitoring locations throughout the state. This statewide decrease in naphthalene was not observed for other VOCs such as benzene. Maine DEP performed a detailed review of historical data and laboratory quality control data, shared ambient air samples with both government agencies in other states and a commercial lab using the same laboratory methods in order to compare results. Maine DEP has also collaborated with U.S. EPA to jointly test spiked samples containing known amounts of naphthalene (but unknown to Maine DEP prior to laboratory analysis). Collectively, these efforts continue to raise concerns about the reliability of naphthalene measurements using the TO-15 method. Because naphthalene is officially classified as a SVOC rather than a VOC based on its vapor pressure, it falls at the limit of what U.S. EPA method TO-15 can reliably measure. To investigate the data quality concerns with naphthalene, Maine DEP has collected samples to be analyzed using U.S. EPA method TO-17, a technique specifically for the measurement of SVOCs. These results are pending.

3 Assessment of Short-term Health Hazards

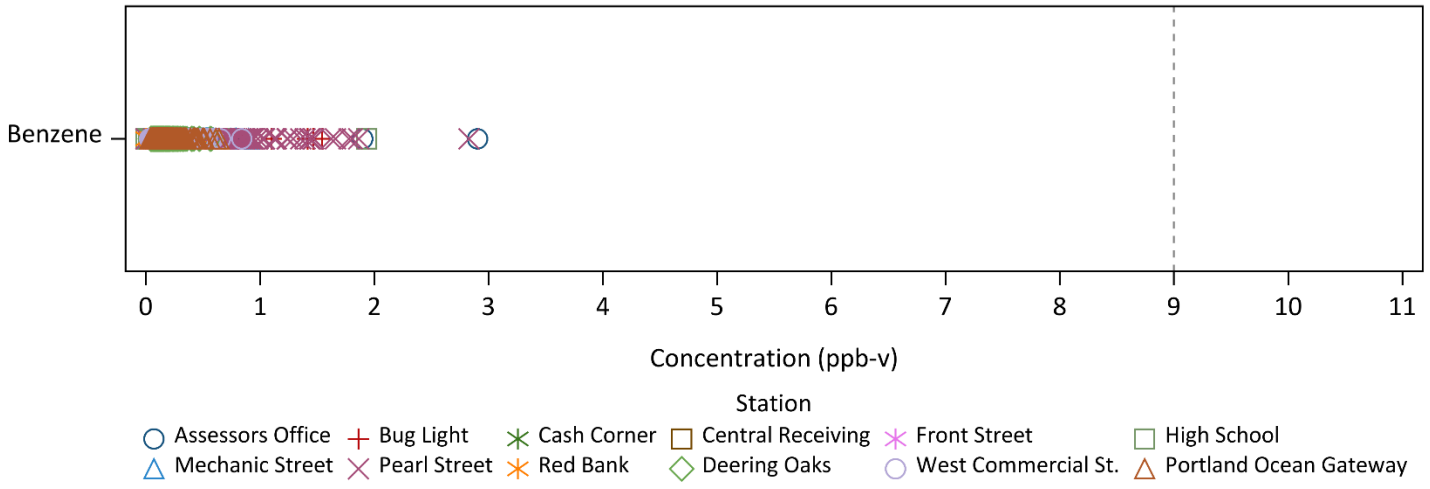
The assessment of short-term health hazards compares each individual 24-hour sample result for each individual VOC to available short-term health guidelines. The U.S. Agency for Toxic Substances and Disease Registry (ATSDR) derives and maintains short-term health guidelines referred to as acute minimal risk levels (MRLs) that are considered suitable for evaluating exposures ranging from 1 to 14 days in duration. The MRLs are considered by ATSDR to be estimates of the amount of a chemical a person can be exposed to for 1 to 14 days without appreciable risk of health effects.[7] Of the 47 chemicals that are measured in each air sample, 18 have a corresponding acute MRL and can be evaluated for short-term health risk.[8]

As an example, Figure 2 illustrates a comparison of all the individual 24-hour sample results for the VOC benzene as compared to the ATSDR acute MRL of 9 parts per billion by volume (ppb-v). This figure shows that

[6] https://www.maine.gov/dep/air/monitoring/docs/archive/2yr%20Summary%20Report%20June%202023.pdf
[7] ATSDR MRLs - https://www.atsdr.cdc.gov/minimalrisklevels/index.html
[8] Available toxicity values for xylenes are only for total xylenes. Thus, for health assessments the measured concentrations of o-xylene and m/p-xylenes are summed together.

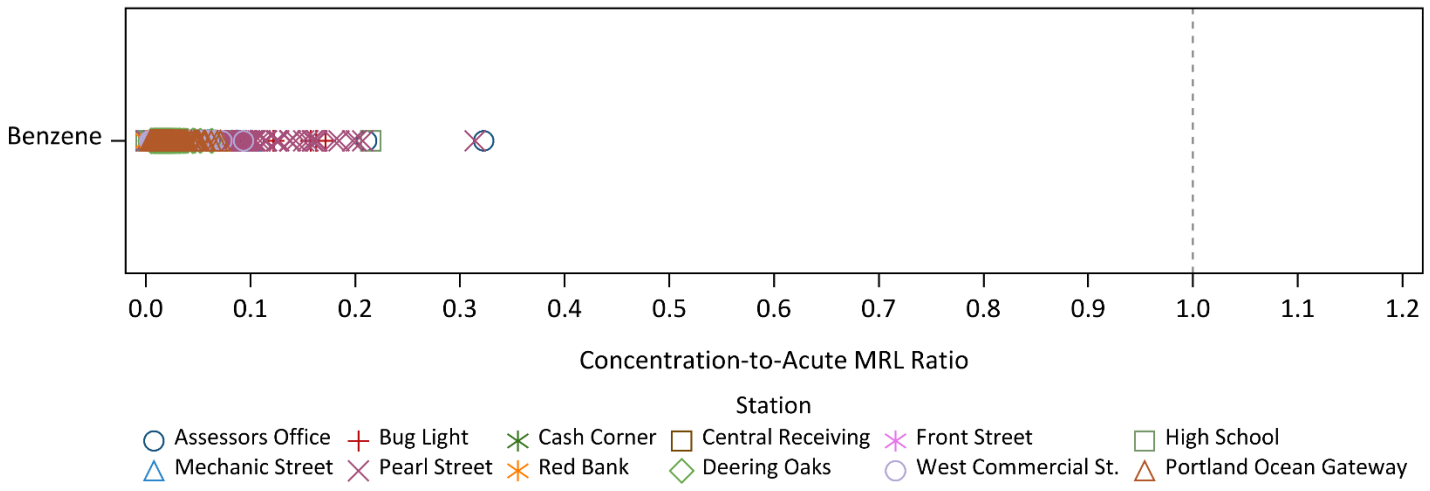
all 2,770 individual 24-hour ambient air samples collected at the 12 locations over the past six years were well below ATSDR's short-term health guideline for benzene.

Figure 2. Individual 24hr Sample Results for Benzene Compared to Acute MRL



Each chemical has a different range of measured ambient air levels, and for chemicals with an ATSDR acute MRL, those MRLs vary by chemical. Rather than presenting 17 additional individual figures for each chemical, Maine CDC has previously described and presented a data transformation method to make it possible to present the results for all 18 chemicals in a single figure. The data transformation method is to divide the individual measured 24-hour concentration for each chemical by its corresponding ATSDR acute MRL. This resulting metric, which is a ratio of the measured concentration to its chemical specific toxicity value, transforms the data for each chemical to a common scale so all chemicals with an acute MRL can be presented on a single figure. A ratio of one indicates the measured VOC concentration for a 24-hour sample is equal to the chemical-specific acute MRL. A ratio greater than one indicates a measured concentration is above the acute MRL, and the more it is above, the greater the concern for potential health impacts. A ratio less than one indicates the measured concentration is less than the acute MRL, and there is minimal risk of any adverse health effect. Figure 3 illustrates this data transformation method applied to benzene.

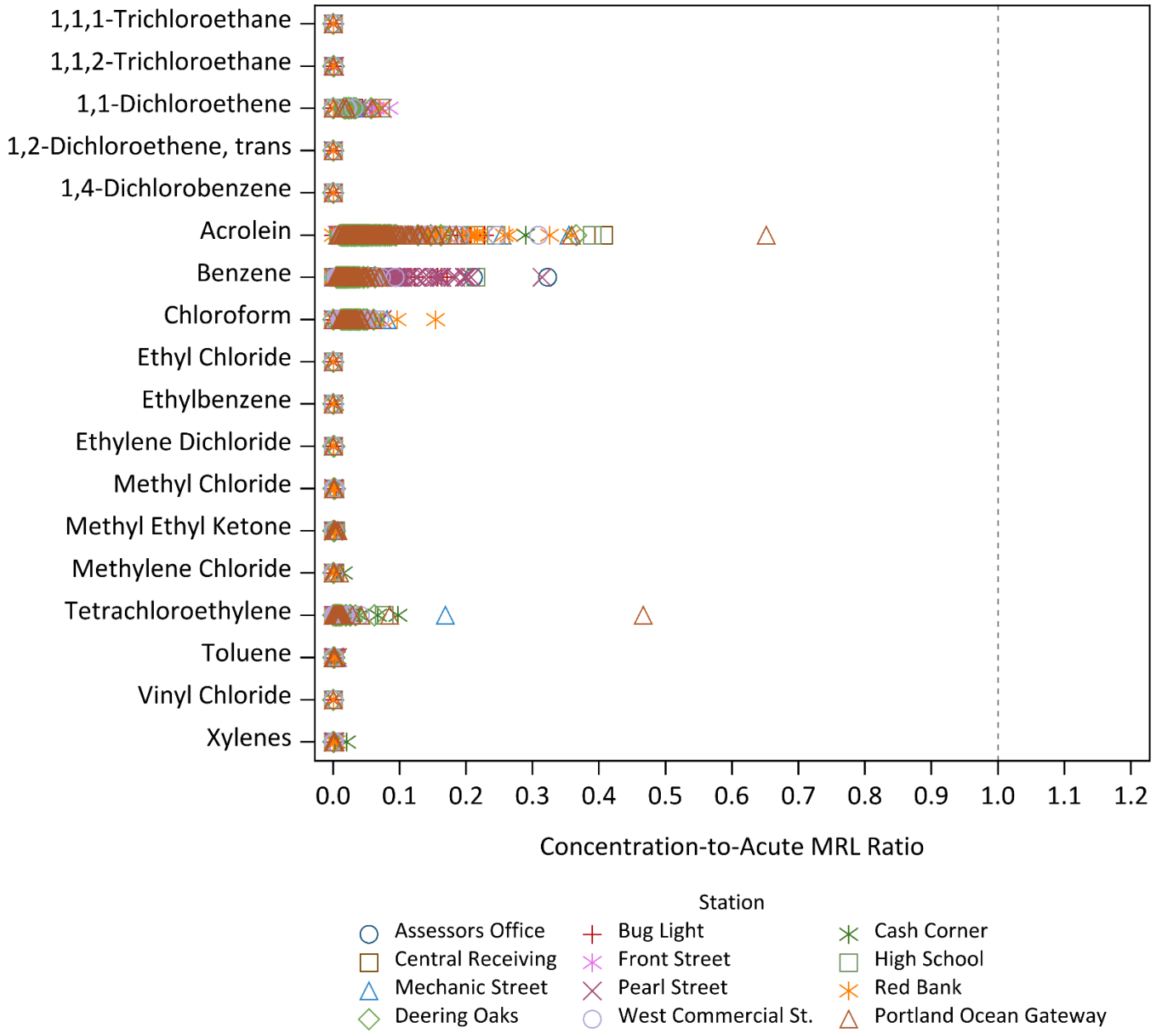
Figure 3. Individual 24hr Sample Results-to-Acute MRL Ratios for Benzene



The pattern of the data display remains the same for Figures 2 and 3, because the transformation is dividing all 24-hour results by a constant, chemical specific value.

Figure 4 presents the results for the 18 chemicals with ATSDR acute MRLs on a single figure using the ratio metric described above. All individual 24-hour sample results at all sampling locations for all 18 chemicals with an acute MRL were well below their associated short-term health guideline (i.e., a ratio of less than one). Collectively, these results indicate a lack of evidence for potential health hazards from occasional events where the 24-hour average ambient air concentrations of VOCs are unusually high at any of the monitoring stations throughout South Portland and Portland.

Figure 4. Individual 24hr Sample Results-to-Acute MRL Ratios for Chemicals with Acute MRLs



4 Assessment of Long-term Health Hazards

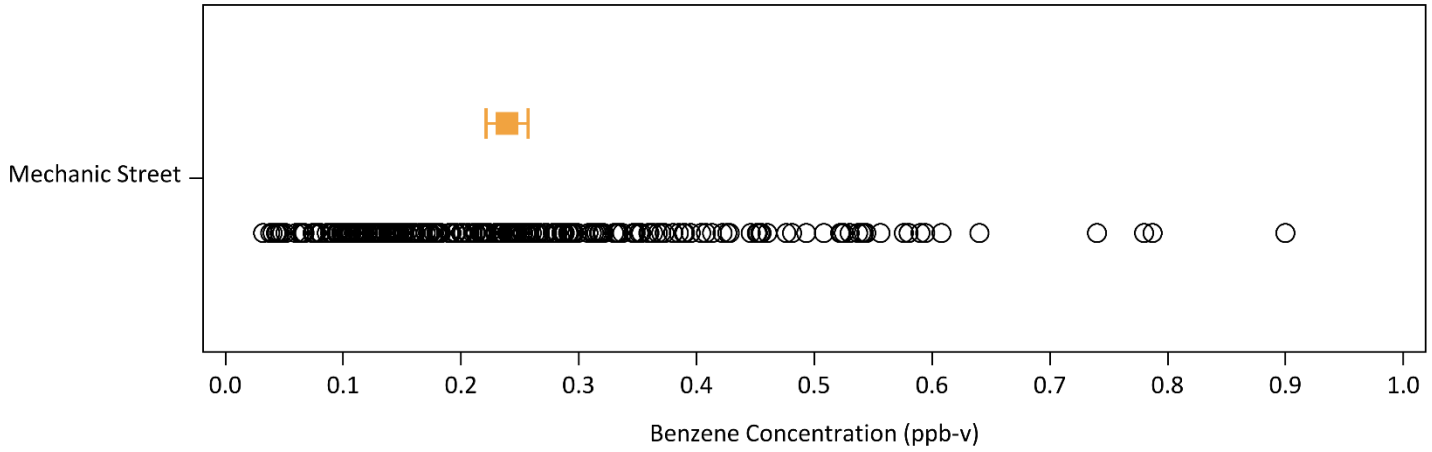
A similar approach is used for assessing long-term health hazards, with two key differences. First, to estimate long-term exposures, there is a need to compute a long-term average concentration of each VOC in ambient air from the individual 24-hr sample results. These long-term average[9] concentrations are then compared to a chemical-specific long-term (chronic) health guideline. The AAGs are used as the chronic health guidelines. The AAGs are derived using the U.S. EPA Regional Screening Level (RSL) calculator[10] with the health-protective assumptions that exposure to chemicals in ambient air is continuous for 24 hours per day, 7 days per week, and for 70 years.[11] The U.S. EPA RSL calculator considers the available information on both cancer and noncancer long-term health outcomes and computes risk-based screening levels for both outcomes. The AAGs are based on whichever (cancer or noncancer) screening level is more health protective (i.e., the lower value). For chemicals where it is possible to calculate cancer risk, the RSL calculator presents health guidelines for incremental lifetime cancer risks of 1-in-10,000, 1-in-100,000, or 1-in-1,000,000. The AAGs, by policy, are based on an incremental cancer risk level of 1-in-100,000. An incremental cancer risk level of 1-in-100,000 means that if a population of 100,000 was continually exposed to a chemical at the AAG, it would be expected to result in one additional case of cancer over a 70-year period.

4.1 Computation of the Long-term Average VOC Concentration

The long-term average ambient air concentration of a VOC is calculated as the arithmetic mean of all the individual 24-hour samples at each station over the entire monitoring period. All monitoring locations have at least a full year of measurements resulting in over 60 individual 24-hour samples, and most have two or more years of monitoring results. For some locations, there are over 300 individual results from six years of monitoring. As an example, Figure 5 illustrates the calculated long-term average concentration for the VOC benzene at the Mechanic Street monitoring location. The individual circles represent each individual 24-hour sample result, and the yellow square is the long-term average concentration derived from 265 individual sample results. The lines on either side of the square are 95th percentile confidence intervals on the arithmetic mean. Figure 5 shows how the individual 24-hour sample concentrations can vary above and below the long-term average. The more variable the individual 24-hour sample results (i.e., the more results that are not close to the long-term average), the larger the uncertainty in the estimated long-term average and the longer the lines on each side of the mean. This same method is used to compute the long-term average ambient air concentration for each measured VOC at each sampling location.

[9] In previous reports, this has also been referred to as a cumulative average.
[10] U.S. EPA RSL Calculator: https://www.epa.gov/risk/regional-screening-levels-rsls
[11] Maine Chronic Ambient Air Guidelines (2026): https://www.maine.gov/dep/air/monitoring/docs/ME_DEP_AAG_LIST_2026_FINAL_with%20notes%20(002).pdf

Figure 5. Individual 24hr Benzene Concentrations and Long-term Average Concentration

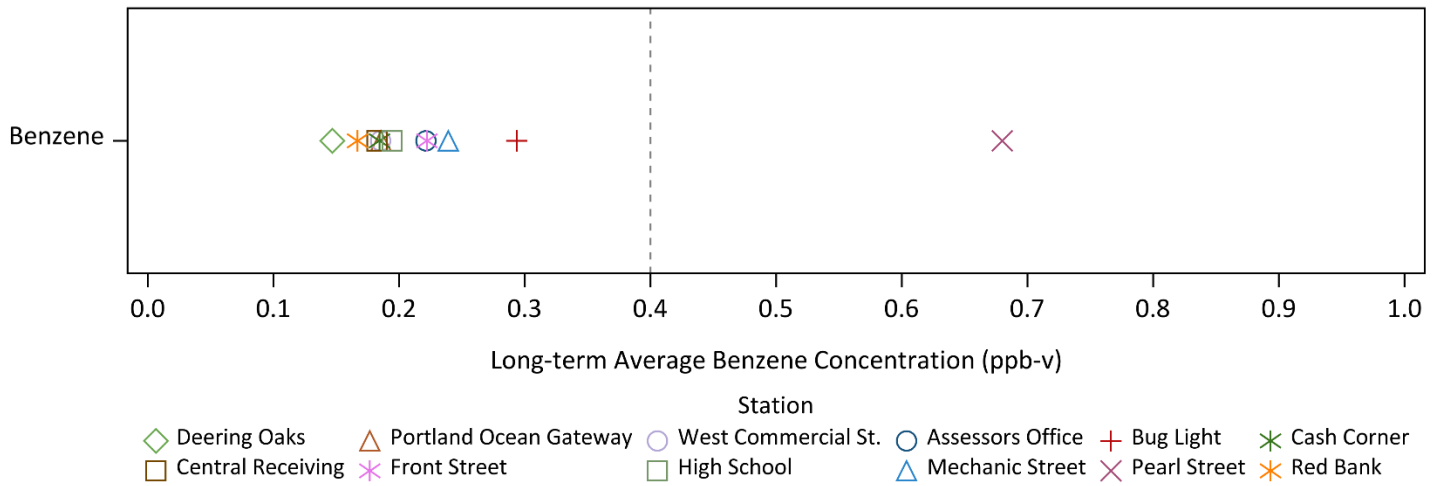


4.2 Comparisons of Long-term Averages to Maine's Ambient Air Guidelines

The resulting estimates of the long-term average ambient air concentration at each monitoring location can be compared to the AAGs in a manner similar to that used in the assessment of short-term health hazards. Of the 47 chemicals that are measured in each air sample, 33 have a corresponding AAG and can be evaluated for long-term health risk.

Figure 6 illustrates the long-term health assessment for benzene comparing the average benzene concentration for each monitoring location to the AAG of 0.4 ppb-v. This figure shows that only the Pearl Street location had a long-term average benzene concentration that was above the AAG, with all other stations having average benzene levels less than the AAG.

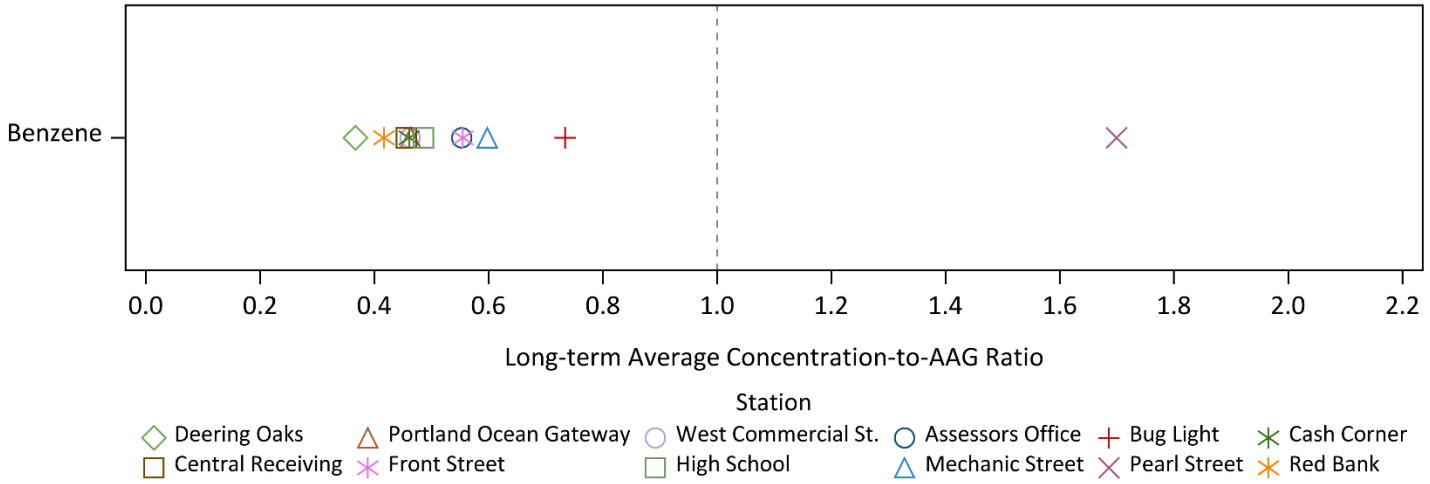
Figure 6. Long-term Average Benzene Concentrations Compared to the AAG



As with the short-term health assessment, a data transformation method was performed to convert the average concentration to a ratio of the average concentration to the AAG so that all the measured VOCs with a corresponding AAG can be put on a common scale and collectively displayed in a single figure. A ratio of one indicates the calculated average VOC concentration is equal to the chemical-specific AAG. A ratio greater than one indicates an average concentration above the AAG, and the more it is above, the greater the concern for

potential health impacts. A ratio less than one indicates the average concentration is less than the AAG, and there is minimal risk of any adverse health effect. Figure 7 illustrates this data transformation method applied to the station averages for benzene. It shows that the Pearl Street location average benzene levels were about 1.7-fold higher than the AAG.

Figure 7. Long-term Average Concentration-to-AAG Ratios for Benzene



Similar to the short-term health assessment, Figure 8 shows the ratios between the long-term average concentration and the AAG for 31 of the 32 VOCs with an AAG. Acrolein is not included in Figure 8 because it would need a very different scale that would obscure the results for the other VOCs and is instead presented separately in Figure 9. Any VOCs that have both a cancer and non-cancer health endpoint are indicated by an asterisk in the below figures. Figure 8 shows that, other than acrolein, benzene is the only measured VOC with a long-term average concentration above an AAG, and, as noted above, this occurred only at the Pearl Street location.

Figure 8. Long-term Average Concentration-to-AAG Ratios for Individual Chemicals with AAGs

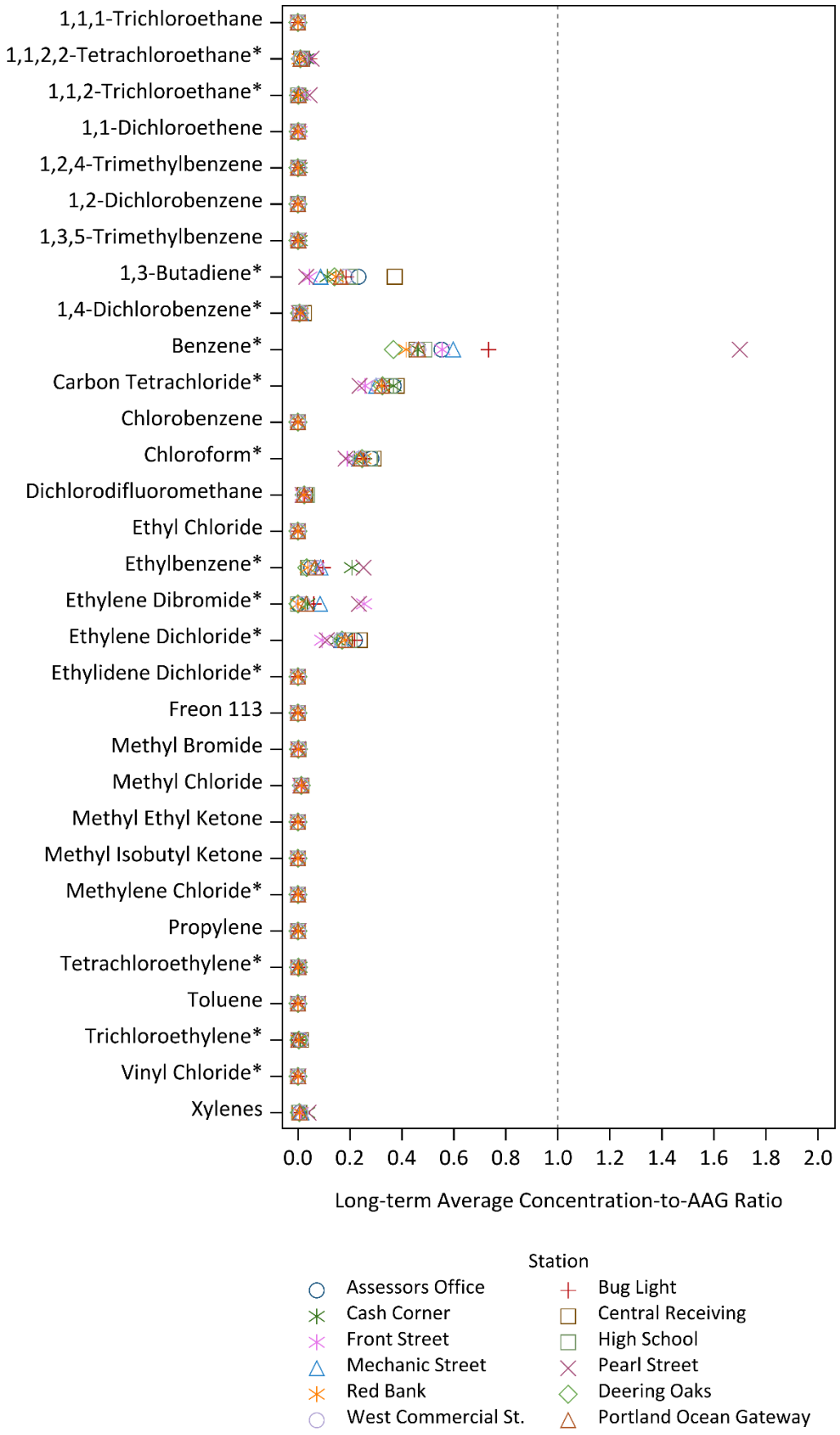
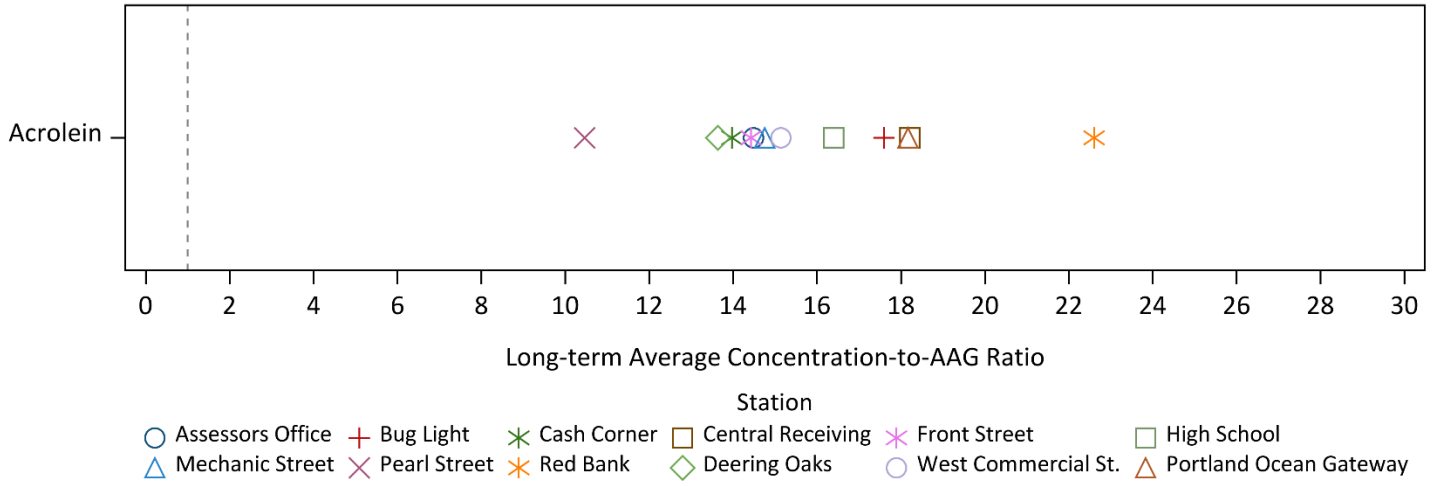


Figure 9 shows that ambient air levels of acrolein at all monitoring stations exceeded the AAG by more than 10-fold (i.e., a ratio greater than 10). Red Bank is the location with the highest acrolein levels as indicated by the highest ratio of close to 23-fold higher than the AAG. From a concentration perspective, most stations had long-term average concentrations of acrolein in the 0.12 to 0.16 ppb-v range, relative to the AAG of 0.009 ppb-v.

Figure 9. Long-term Average Concentration-to-AAG Ratios for Acrolein



As described and shown above the long-term health assessment based on comparison to the AAGs identified two VOCs of possible public health concern: acrolein and benzene. Acrolein is likely the chemical of greatest potential public health concern because it is present in ambient air at concentrations more than 10-fold higher than its AAG at all monitoring locations. Benzene is more of a localized concern as average concentrations were only found to be above the AAG at the Pearl Street location, which is on the fenceline of a petroleum storage facility but also close to nearby homes. These two chemicals will be further discussed in the next two sections as to their potential health concerns, as well as how these measured concentrations compare to those measured at other monitoring locations in the state.

4.2.1 Acrolein

Acrolein is produced and released into ambient air from burning fossil fuels and can also be found in woodsmoke and cigarette smoke. In the indoor environment, acrolein can be formed when cooking fats and oils are heated to very high temperatures, and is responsible for the acrid, burning smell in those situations. In outside ambient air, acrolein breaks down fairly rapidly by reacting with other chemicals and sunlight, which means levels in ambient air typically reflect ongoing, local releases. Acrolein can be perceived as having a strong, burned, sweet, and intensely pungent odor. The odor threshold (i.e., the level at which people can detect an odor) for acrolein is approximately 160 ppb-v, which is higher than ambient air levels measured in South Portland and Portland (generally less than 2 ppb-v). Indoor air levels for acrolein have been reported to range from < 0.02 to as high as 18 ppb-v.[12]

[12] Toxicological Profile for Acrolein. April 2025. U.S. Agency for Toxic Substances and Disease Registry. https://wwwn.cdc.gov/TSP/ToxProfiles/ToxProfiles.aspx?id=557&tid=102

Health Effects of Acrolein Exposure

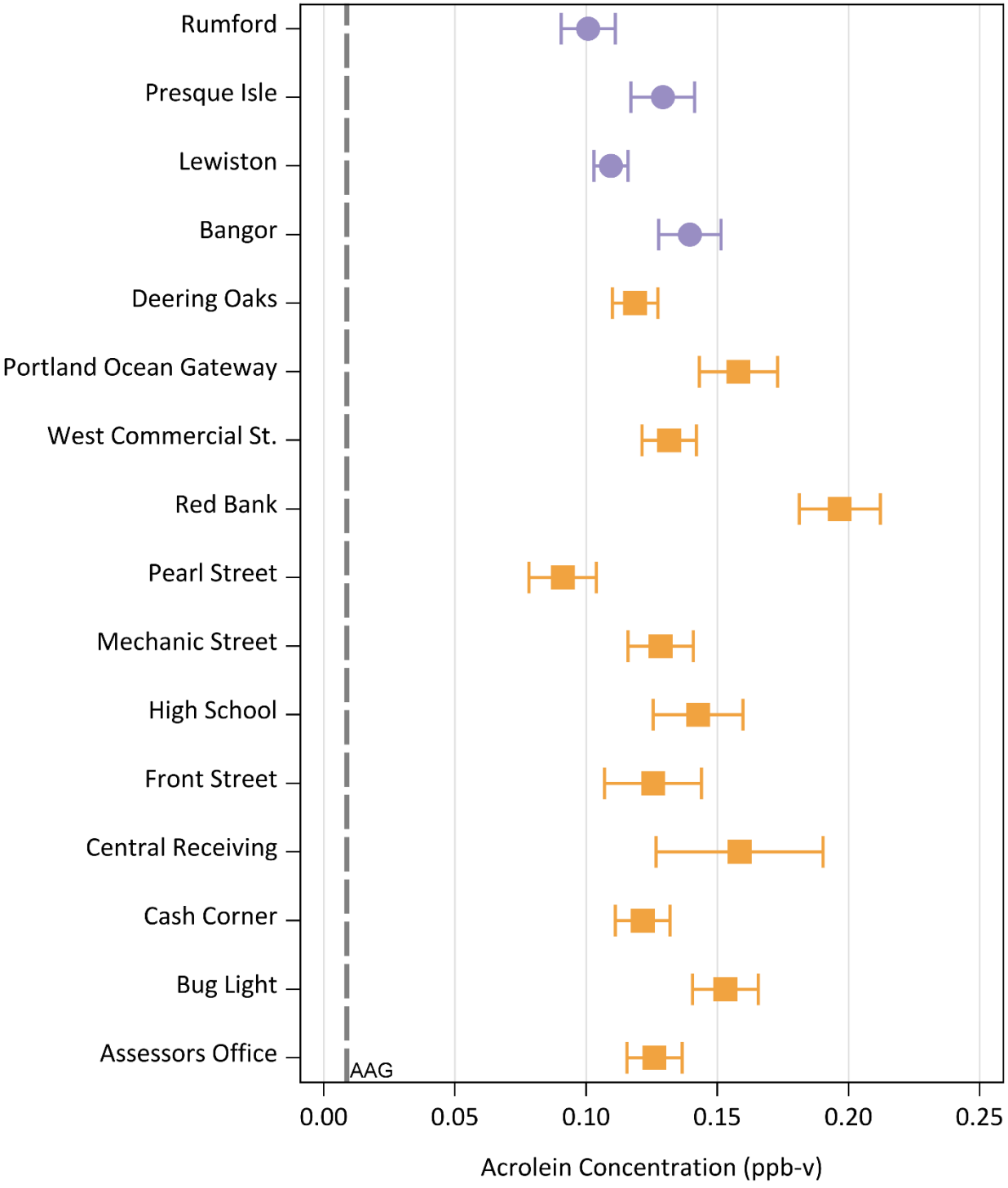
Long-term exposure to elevated levels of acrolein in ambient air can harm the respiratory system, leading to problems such as congestion, shortness of breath, worsened asthma, and ongoing respiratory irritation. The AAG of 0.009 ppb-v is based on a U.S. EPA health assessment of acrolein and is intended to be an ambient air level that poses minimal risk for any adverse health effect from lifetime exposure even for sensitive individuals. The underlying toxicity value is based on the lowest concentration of acrolein that caused damage to nasal tissue in a controlled rodent study. This air concentration of acrolein was then divided by a cumulative uncertainty factor of 1,000 to provide added public health protection.[13] These safety factors are used in deriving toxicity values to account for uncertainty in extrapolating animal studies to the most sensitive humans. A cumulative uncertainty factor of 1,000 indicates considerable uncertainty in the derived toxicity value.

Comparison to Statewide Concentrations

Given that all South Portland and Portland monitoring stations had long-term average air concentrations of acrolein above the AAG, and all at fairly similar levels, Maine CDC compared these ambient air levels to those measured at other locations in Maine as part of DEP's HAPs Network. DEP monitors many of the same VOCs using the same methods at Bangor, Lewiston, Presque Isle, and Rumford stations. Maine CDC compiled these data for the same six-year period and computed long-term average ambient air concentrations for acrolein for comparison to the South Portland and Portland stations. These data are summarized in Figure 10 and show that, with the exception of Red Bank, the ambient concentrations of acrolein in South Portland and Portland are fairly similar to concentrations across the State of Maine.

[13] Toxicological Review of Acrolein. May 2003. U.S. Environmental Protection Agency. https://iris.epa.gov/static/pdfs/0364tr.pdf

Figure 10. Long-term Average 24-Hour Acrolein Sampling Results With 95% Confidence Interval by Station



4.2.2 Benzene

Benzene can be present in gasoline in amounts up to one percent by volume and can be released through evaporative losses at petroleum storage facilities, such as those along the South Portland waterfront. This has been an ongoing concern for the community. Benzene is also released into the air from vehicle exhaust, other gasoline-powered equipment and combustion sources, and gas station operations, and it can be released from the use of products like paint thinners and certain solvents. Once in ambient air, benzene breaks down within a few days, and thus its presence in the ambient air is mostly representative of ongoing releases. In the indoor home environment, benzene is present in tobacco smoke and can be released from gas stoves and ovens as well as wood burning fireplaces. Multiple studies have reported typical indoor air levels of benzene of around 1 ppb-v. The odor threshold for benzene, approximately 97,000 ppb-v, is much higher than typical ambient air or indoor air concentrations.[14]

Health Effects of Benzene Exposure

Benzene has been designated by several federal and international authoritative organizations (U.S. DHHS, U.S. EPA, IARC) as known to cause cancer in humans. Occupational studies have shown a significantly increased risk of leukemia among benzene-exposed workers. The AAG of 0.4 ppb-v is based on a U.S. EPA cancer health assessment of benzene and is intended to be an ambient air level that poses minimal risk of cancer assuming an exposure of 24 hours per day, 7 days per week, for 70 years.[15] The AAGs use a minimal risk threshold for cancer-causing chemicals of an incremental cancer risk of 1-in-100,000. This risk threshold can also be interpreted as resulting in one additional cancer per 100,000 people exposed to benzene at the AAG over their lifetime. As a matter of policy, guidelines and regulations typically use cancer risk thresholds ranging from 1-in-10,000 to 1-in-1,000,000.[16]

Comparison to Statewide Concentrations

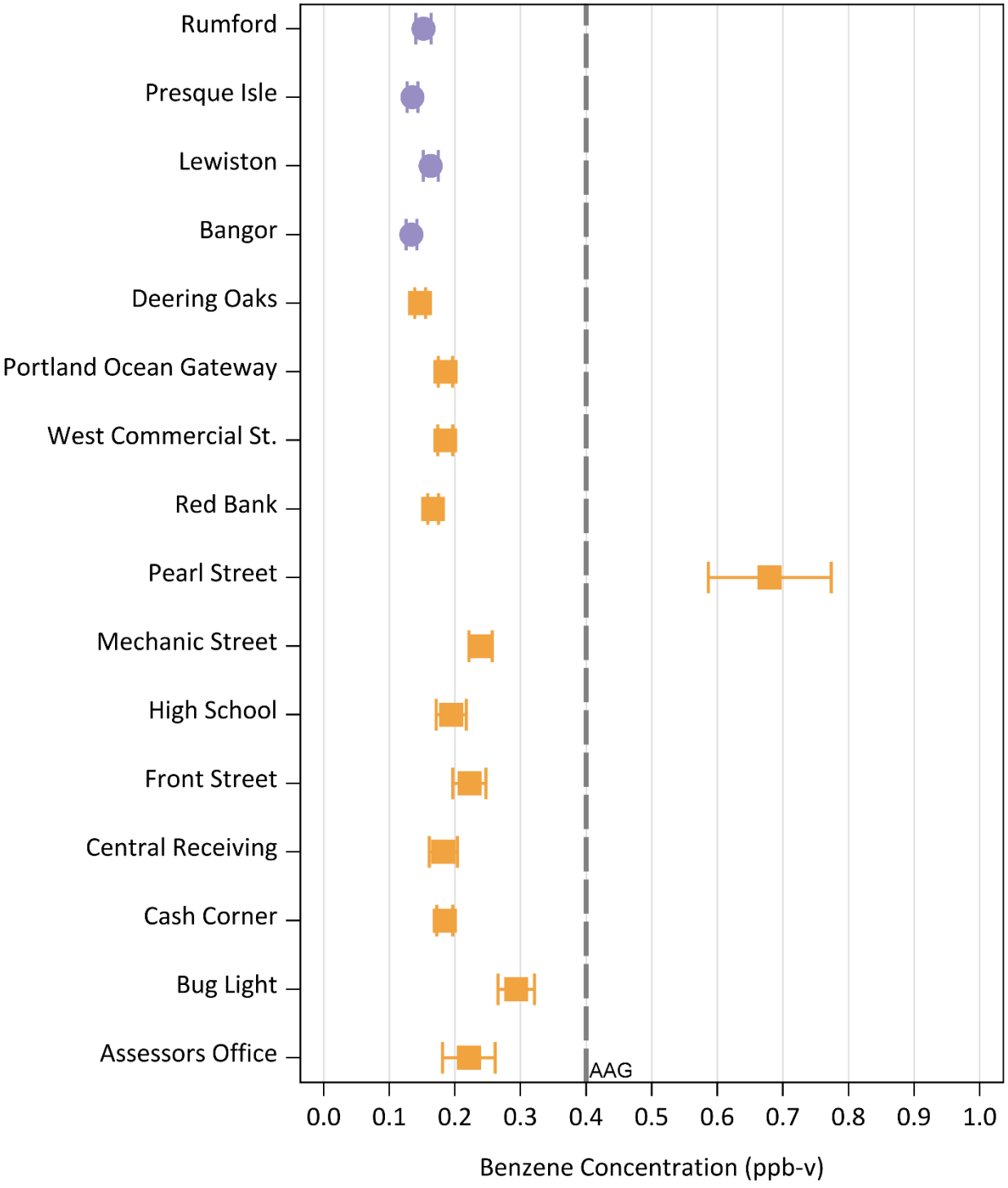
In a manner similar to acrolein, Maine CDC compiled the data from DEP's HAPs Network sites in Bangor, Lewiston, Presque Isle, and Rumford for the same six-year period, computed long-term average ambient air concentrations for benzene, and compared these statewide monitoring results to the South Portland and Portland stations. These data are summarized in Figure 11 and show that average ambient air benzene levels for the South Portland and Portland communities are between 0.15 and 0.3 ppb-v and appear slightly higher than other locations in the state, which are typically between 0.1 and 0.2 ppb-v. As noted above, the average benzene level at the Pearl Street location of 0.7 ppb-v is notably higher than all other monitoring locations in South Portland and Portland, as well as statewide. This location is on the fence line adjacent to a petroleum storage facility, but it is also in close proximity to homes.

[14] Toxicological Profile for Benzene (Draft for Public Comment). October 2024. U.S. Agency for Toxic Substances and Disease Registry. https://wwwn.cdc.gov/TSP/ToxProfiles/ToxProfiles.aspx?id=40&tid=14

[15] https://iris.epa.gov/ChemicalLanding/&substance_nmbr=276

[16] https://www.epa.gov/sites/default/files/2013-09/documents/cancer_guidelines_final_3-25-05.pdf; https://oehha.ca.gov/sites/default/files/media/downloads/risk-assessment/fact-sheet-california-human-health-screening-levels-chhsls/riskfactsheet.pdf

Figure 11. Long-term Average 24-Hour Benzene Sampling Results With 95% Confidence Interval by Station



4.3 Cumulative Cancer Risk Assessment

The South Portland Clean Air Advisory Committee expressed an interest in assessing cumulative potential health impacts from the combined exposure to certain hazardous air pollutants.[17] Fifteen of the measured VOCs (excluding naphthalene) have cancer toxicity values in the U.S. EPA RSL calculator and contribute to the overall cancer risk. Computation of the cumulative cancer risk from the combined exposure to multiple carcinogenic chemicals is a standard type of risk analysis for hazardous air pollutants. For example, the U.S. EPA uses a cumulative cancer risk as part of its assessment of HAPs, accessible using online tools like AirToxScreen (formerly called National Air Toxics Assessment or NATA).[18] In these types of analyses, the cancer risk for each chemical is assumed to act in an independent and additive manner, and thus the individual chemical risk estimates assuming 70 years of continuous exposure can be summed to provide a cumulative cancer risk from the combined VOC exposure. Maine CDC presented a cumulative cancer risk assessment in a previous report using data from the first two years of the VOC monitoring.[19] In this report, this assessment is updated using the additional years of data and additional locations.

Figure 12 shows the estimated cumulative cancer risk at each South Portland and Portland monitoring station and the contributions of the individual VOCs to the total. The figure is presented on a per 100,000 basis for consistency with the cancer risk units used in the AAGs, as described previously, and to avoid potential confusion by switching between different risk units (e.g., cases per 100,000 vs. cases per 1,000,000). Any VOC contributing fewer than 0.1 cancer case per 100,000 was grouped into the "other" category to facilitate presentation. The exact values for cumulative cancer risk for each VOC shown in Figure 12 can be found in Appendix Table A-2a. Previous reports have presented cumulative cancer risk on a per million basis. For comparison to previous analyses, Appendix Table A-2b presents the exact values for cumulative cancer risk for each VOC on a per million basis.

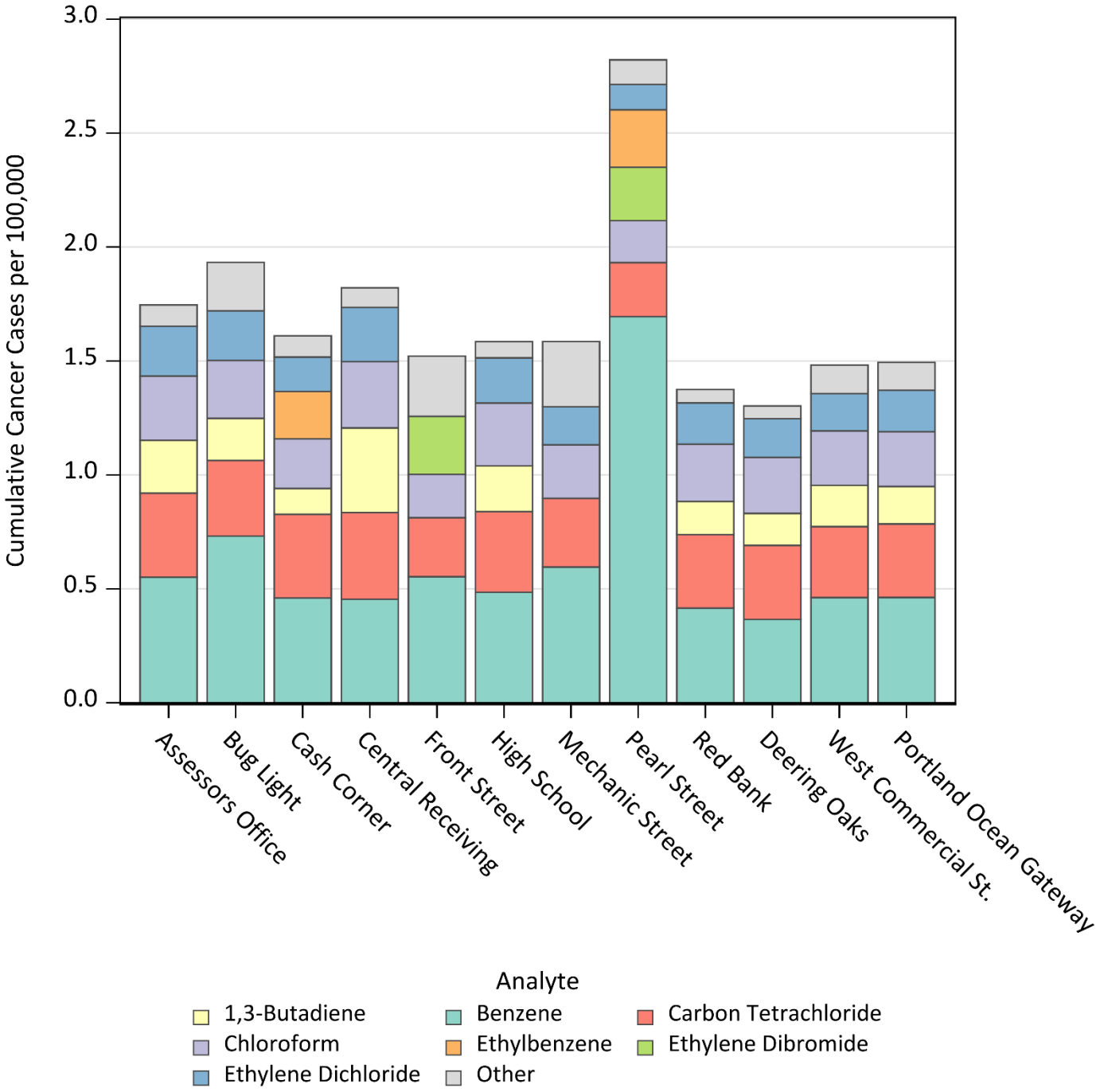
The cumulative cancer risk was relatively consistent across stations, ranging from a combined incremental cancer risk of between 1.3 and 1.9 per 100,000 for most locations. Pearl Street was higher, with a cumulative cancer risk of 2.8 per 100,000. For all stations, benzene was the single largest contributor to the cumulative cancer risk (the teal green bar segments in Figure 12). Pearl Street had a higher cumulative cancer risk, primarily due to the higher ambient air concentrations of benzene. Carbon tetrachloride, a legacy VOC with a long residence time in ambient air, was typically the second largest contributor to cancer risk at most locations. Other carcinogenic VOCs significantly contributing to the cumulative risk varied by location. For most locations, the third largest contributing chemical was chloroform (a known byproduct of water and wastewater chlorination). Other lesser contributing VOCs include 1,3-butadiene, ethylene dichloride, ethylbenzene, and ethylene dibromide.

These cumulative cancer risk estimates on a per 100,000 basis are lower than the Maine CDC reported in its 2022 report. This is largely due to the decision to exclude ambient air levels of naphthalene due to uncertainty about the reliability of measured concentrations. Were the unconfirmed naphthalene results from the TO-15 method to be included in this analysis, the cumulative cancer risk estimates in Figure 12 could be increased

[17] https://www.southportland.gov/DocumentCenter/View/2035/CAAC-2022-Report-to-City-Council---Final_Feb-2023
[18] https://www.epa.gov/AirToxScreen/airtoxscreen-mapping-tool
[19] https://www.maine.gov/dep/air/monitoring/docs/archive/2yr%20Summary%20Report%20June%202023.pdf

more than 2-fold at some locations (e.g., Cash Corner, West Commercial Street), whereas at other locations the contribution is likely to be considerably less.

Figure 12. Cumulative Cancer Risk per 100,000 by Station



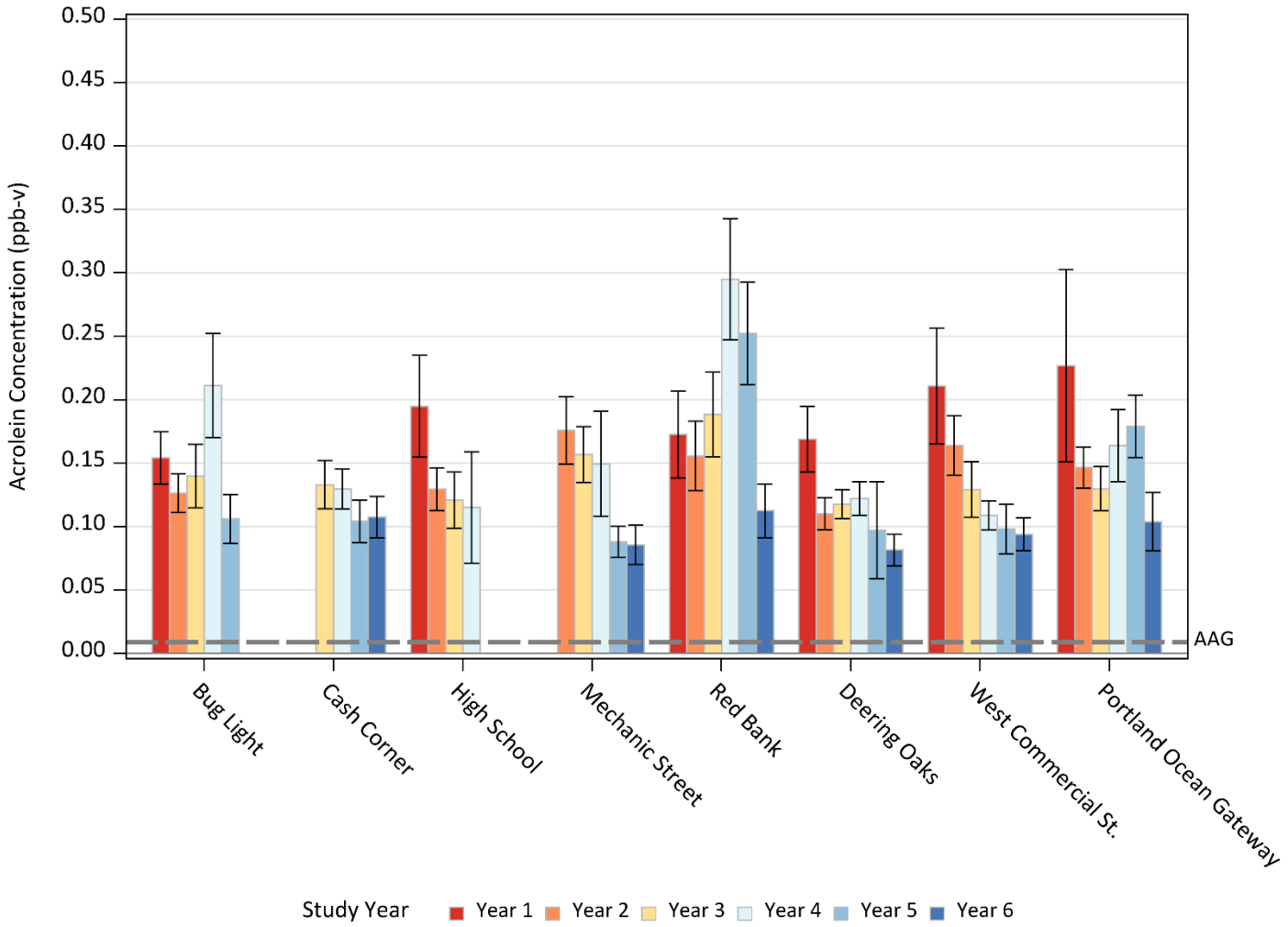
5 Yearly Trends in VOC Levels

The long-term health assessment assumes the average ambient air concentrations of VOCs will remain relatively constant over many years. There are now multiple years of measurements at most monitoring locations. It is therefore of interest to evaluate the data from locations where we have multiple years of measurements to see if there are any apparent trends of increasing or decreasing concentrations of VOCs. One location in South Portland (Red Bank) and three locations in Portland (Deering Oaks Park, West Commercial Street, and Portland Ocean Gateway) have six years of monitoring data. The Bug Light, Cash Corner, High School, and Mechanic Street stations in South Portland have at least four years of monitoring data. These are the locations best suited for evaluating the presence of trends. The presence of trends was first examined by inspection of individual annual averages over the monitoring period and then evaluated using standard statistical regression methods. This evaluation focused on acrolein and benzene, the two VOCs discussed in this report that have annual and long-term average concentrations that exceed the AAGs.

5.1 Acrolein

The annual average acrolein levels for individual years varied between roughly 0.1 and 0.3 ppb-v over the six study years, with the highest annual average concentration typically occurring in the first year of the study and the lowest in the final year of the study (Figure 13). Red Bank and Bug Light were exceptions, with the highest annual average occurring in the fourth year of the study. Several of the monitoring locations show evidence of decreasing trends in annual average acrolein concentrations (Deering Oaks, West Commercial Street, Portland Ocean Gateway, Mechanic Street, Cash Corner, and High School). Red Bank and Bug Light did not appear to exhibit either decreasing or increasing trends. Linear regression analyses were performed using the individual 24-hour sample results over the multiple years of measurements for each location to assess whether the apparent trends were statistically significant. Decreasing trends were highly significant for all monitoring locations except Bug Light and Red Bank. Most decreases were less than a 50% change in the average concentrations of their monitoring period (Appendix Table A-3). Whether this decrease will continue long-term (i.e., over decades) is unknown, but if these decreasing trends were to continue risk levels would also decline over time. It is worth noting that this downward trend in ambient air concentrations of acrolein was also apparent at the other HAPs monitoring locations in the State of Maine (Appendix Table A-4).

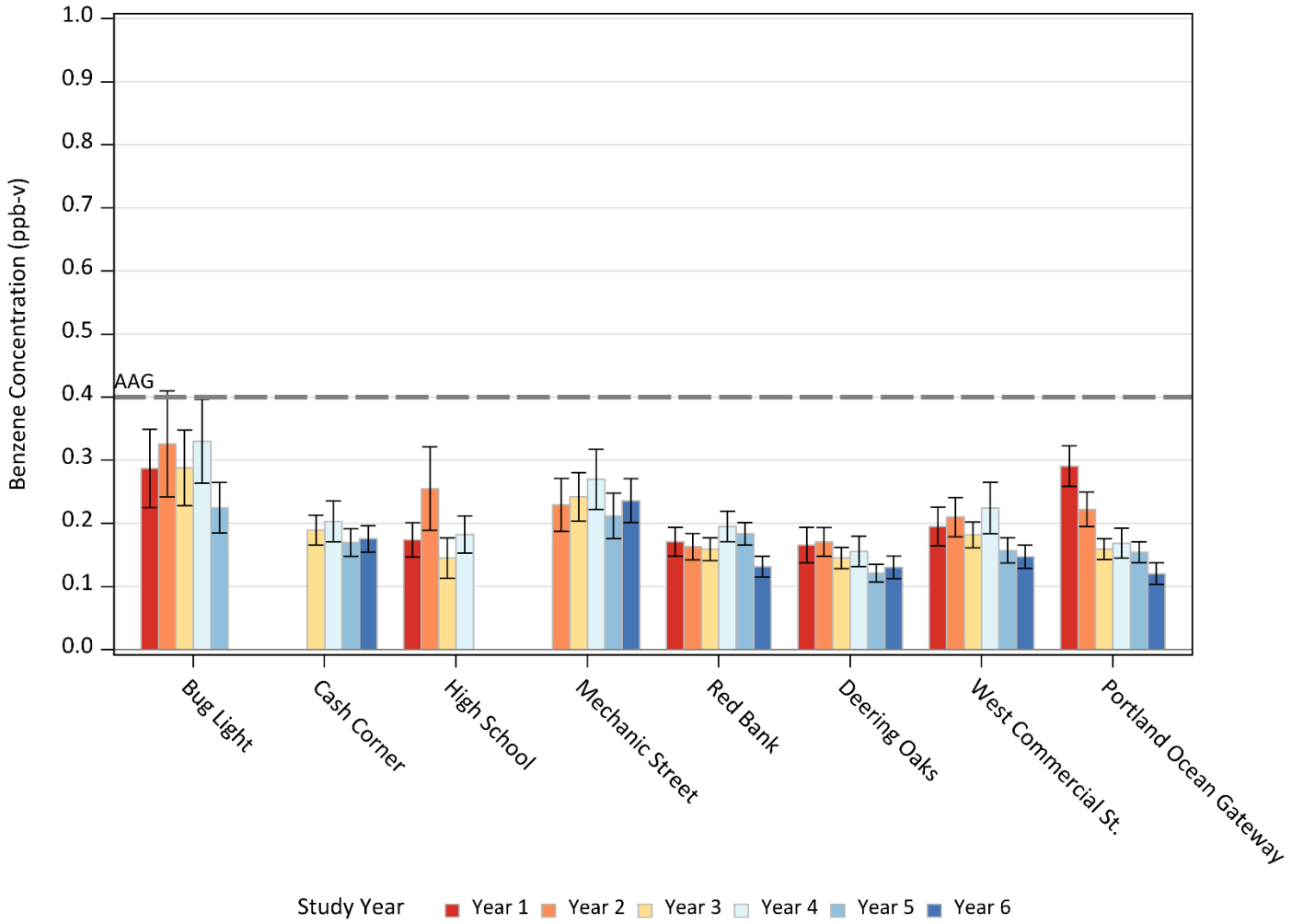
Figure 13. Annual Average 24-hour Acrolein Sampling Results with 95% Confidence Interval by Station



5.2 Benzene

Annual average benzene levels varied between roughly 0.1 and 0.3 ppb-v for locations with four or more years of monitoring results (Figure 14). Decreasing trends in annual average benzene levels were apparent at all the Portland monitoring locations. Linear regression analyses found that all the Portland monitoring locations as well as the South Portland Cash Corner and Red Bank stations had statistically significant decreasing trends in benzene ambient air concentrations (Appendix Table A-5). The magnitudes of these decreases were relatively modest, with the exception of Portland Ocean Gateway where the decrease in average concentration over time approached 60%. Whether this decrease will continue long-term (i.e., over decades) is unknown, but if these decreasing trends were to continue, risk levels would also decline over time. Notably, locations in South Portland in closer proximity to petroleum storage facilities (Bug Light and Mechanic Street) did not exhibit trends in decreasing benzene concentrations. For these locations, the observed average concentration over the study period is likely to be a reasonable estimate of long-term exposure absent any changes in local emissions. Similar to acrolein, there was also evidence of decreasing trends in benzene concentrations at the other HAPs monitoring locations in the State of Maine over this same time period (Appendix Table A-6).

Figure 14. Annual Average 24-hour Benzene Sampling Results with 95% Confidence Interval by Station



6 Discussion

Maine DEP has been conducting an ambient air monitoring study of VOCs in the South Portland and Portland communities for six years. Over this entire period, there has been no evidence that any of the over 2,770 individual air samples that represent 24-hour average ambient air VOC concentrations exceeded ATSDR short-term health guidelines. This includes monitoring at four locations near petroleum storage facilities (Pearl Street, Mechanic Street, Front Street, Bug Light). The long-term health assessment identified two VOCs that exceed the AAGs, acrolein and benzene, and thus are of potential public health concern.

Acrolein was found to be more than 10 times above the AAG at all monitoring locations. The ambient air levels of acrolein in the South Portland and Portland communities are not significantly different than ambient air levels elsewhere in Maine and are also in the range of concentrations reported from national air monitoring programs. The long-term average ambient air concentrations of acrolein for South Portland and Portland were found to range from 0.1 to 0.2 ppb-v. Average acrolein concentrations for Bangor, Lewiston, Presque Isle, and Rumford ranged from 0.1 to 0.15 ppb-v. ATSDR reports that data from the U.S. EPA National Air Quality

System (AQS) show the most recent mean acrolein concentrations in ambient air in the United States ranging between 0.06 and 0.59 ppb-v, with lower concentrations found in more rural areas and higher levels in more urban areas.[20]

The public health significance of the ambient air levels of acrolein is unclear, as the long-term health guidelines for acrolein are evolving in response to new research. The ATSDR recently published a new long-term health guideline (called a chronic MRL) for acrolein in ambient air of 0.4 ppb-v that is based on a more recent and higher quality rodent study than the old rodent study on which U.S. EPA's toxicity value is based.[21] An AAG based on ATSDR's guideline of 0.4 ppb-v would result in a much higher AAG than Maine's current AAG of 0.009-v ppb. In fact, none of the monitoring locations in South Portland or Portland had long-term average ambient air levels of acrolein above the new ATSDR guideline. However, in the same rodent study that ATSDR used for developing their new chronic MRL for acrolein, there was also evidence of cancer in the rodents. ATSDR does not develop guidelines for cancer risk. In May 2026, the California Office of Environmental Health Hazard Assessment (CA OEHHA) released a draft cancer risk assessment for acrolein based on this rodent study, providing the first estimates of cancer risk for this chemical since it was classified as "probably cancer-causing to humans" in 2020 by the International Agency for Research on Cancer.[22] While California's cancer toxicity value is not finalized, an AAG based on the draft CA OEHHA cancer risk assessment would be very similar to Maine's current AAG. Thus, despite the recent and much higher ATSDR guideline for noncancer-related health hazards of acrolein, Maine CDC believes it is premature to revise Maine's current AAG for acrolein until California finalizes its cancer risk assessment.

Benzene ambient air levels were only found to be above an AAG at the Pearl Street monitoring location. This location is on the fenceline of a petroleum storage facility. There are several homes located close to this monitoring location, and thus residents in these homes are likely exposed to elevated ambient air levels of benzene. There are even more homes located near the fencelines of petroleum storage facilities throughout South Portland. How quickly the ambient air concentration of benzene declines with distance from a fenceline is currently unknown. Prevailing wind direction may be an important factor in how benzene levels decrease with distance from petroleum storage facilities. The Mechanic Street, Front Street, and Bug Light monitoring locations are all within 500 feet of the fencelines of petroleum storage facilities, and all three had long-term average benzene levels below the AAG. The AAG for benzene is an ambient air concentration that is estimated to be associated with an increased cancer risk of 1-in-100,000 assuming 70 years of exposure, 7 days per week, 24 hours per day. The cancer risk would be lower if exposure were less than the assumed 70 years of continuous exposure; higher if longer.

The cumulative cancer risk estimates from the combined exposure to co-occurring carcinogenic VOCs ranged from 1.5 to 2.8 per 100,000. These cumulative cancer risk estimates based on monitoring data are likely underestimates, because they do not include the contribution of the chemical naphthalene due to data quality concerns and uncertainty about the reliability of measured values. Because of the inability to include naphthalene, Maine CDC investigated the output from U.S. EPA's AirToxScreen Mapping Tool for the South Portland and Portland area. U.S. EPA's AirToxScreen Mapping Tool produces cumulative cancer risk estimates

[20] Toxicological Profile for Acrolein. April 2025. U.S. Agency for Toxic Substances and Disease Registry. https://wwwn.cdc.gov/TSP/ToxProfiles/ToxProfiles.aspx?id=557&tid=102

[21] Toxicological Profile for Acrolein. April 2025. U.S. Agency for Toxic Substances and Disease Registry.

[22] https://oehha.ca.gov/air/press-release/press-release-air/california-releases-draft-cancer-risk-assessments-two-air-toxics

based on available chemical emission inventories provided by the mapping tool, air dispersion models to estimate ambient air levels of chemicals from the emission inventories and long-range transport, and human exposure modeling using U.S. EPA models to estimate cumulative cancer risk. AirToxScreen provides estimates for naphthalene as well as a broader suite of chemicals than were measured in the South Portland and Portland ambient air study. AirToxScreen predicts cumulative risk estimates of 3 per 100,000 (which is the same as 30 per 1,000,000 and the risk units AirToxScreen presents) for the South Portland and Portland areas. These modeled estimates are higher than the average estimates of 1.5 to 2.0 per 100,000 that Maine CDC computed based on measured ambient air levels. AirToxScreen predicted that the chemical contributing the most to cumulative cancer risk was formaldehyde (about 50% of the total) – a chemical that is not measured using U.S. EPA method TO-15. The second biggest contributor was carbon tetrachloride (about 10-12% of the total), with naphthalene and benzene typically the third and fourth contributors to cumulative cancer risk.

There is some evidence that acrolein concentrations at most South Portland and Portland locations have declined over the six-year study period, and there is similar evidence of declining concentrations for benzene at all the Portland monitoring locations as well as Red Bank and Cash Corner. It is unknown whether these trends will continue over a longer period of time. While the magnitude of these declines was relatively small over the six-year monitoring study, if these trends were to continue for the decades of exposure considered in the long-term health assessment, risk and hazard levels could be lower in the future. In contrast, there was no evidence of declining concentrations of benzene for the South Portland monitoring locations in close proximity to petroleum storage facilities.

7 Appendix

Table A-1. List of Target Analytes and Corresponding Method Detection Limits (MDLs) (ppb-v).

Analyte	CASRN	MDL (ppb-v)
1,1,1-Trichloroethane	71-55-6	0.014
1,1,2,2-Tetrachloroethane	79-34-5	0.012
1,1,2-Trichloroethane	79-00-5	0.013
1,1-Dichloroethene	75-35-4	0.011
1,2,4-Trimethylbenzene	95-63-6	0.018
1,2-Dichlorobenzene	95-50-1	0.032
1,3,5-Trimethylbenzene	108-67-8	0.014
1,3-Butadiene	106-99-0	0.014
1,3-Dichlorobenzene	541-73-1	0.027
1,4-Dichlorobenzene	106-46-7	0.027
1-Pentene	109-67-1	0.05
2,3-Dimethylbutane	79-29-8	0.05
2,3-Dimethylpentane	565-59-3	0.05
Acrolein	107-02-8	0.014
Benzene	71-43-2	0.013
Carbon Tetrachloride	56-23-5	0.016
Chlorobenzene	108-90-7	0.013
Chloroform	67-66-3	0.013
cis-1,2-Dichloroethene	156-59-2	0.012
cis-1,3-Dichloropropene	10061-01-5	0.013
Dichlorodifluoromethane	75-71-8	0.016
Ethyl Chloride	75-00-3	0.013
Ethylbenzene	100-41-4	0.011
Ethylene Dibromide	106-93-4	0.013
Ethylene Dichloride	107-06-2	0.015
Ethylidene Dichloride	75-34-3	0.011
Freon 113	76-13-1	0.018
Freon 114	76-14-2	0.018
Isopentane	78-78-4	0.05
m,p-Xylenes*	1330-20-7	0.023
Methyl Bromide	74-83-9	0.016
Methyl Chloride	74-87-3	0.016
Methyl Ethyl Ketone	78-93-3	0.012
Methyl Isobutyl Ketone	108-10-1	0.011
Methylene Chloride	75-09-2	0.012
Naphthalene	91-20-3	0.041
n-Butane	106-97-8	0.05

Analyte	CASRN	MDL (ppb-v)
n-Pentane	109-66-0	0.05
o-Xylene*	95-47-6	0.011
Propane	74-98-6	0.05
Propylene	115-07-1	0.05
Tetrachloroethylene	127-18-4	0.012
Toluene	108-88-3	0.015
trans-1,2-Dichloroethene	156-60-5	0.01
Trichloroethylene	79-01-6	0.013
Trichlorofluoromethane	75-69-4	0.013
Vinyl Chloride	75-01-4	0.018

* For evaluating health risks, m,p-xylenes and o-xylene are summed together as total xylenes.

Table A-2a. Cumulative Cancer Risk per 100,000.

	1,3-Butadiene	Benzene	Carbon Tetrachloride	Chloroform	Ethylbenzene	Ethylene Dibromide	Ethylene Dichloride	Other	**Total**
Assessor's Office	0.2	0.6	0.4	0.3	<0.1	<0.1	0.2	0.1	**1.7**
Bug Light	0.2	0.7	0.3	0.3	0.1	<0.1	0.2	0.2	**1.9**
Cash Corner	0.1	0.5	0.4	0.2	0.2	<0.1	0.2	0.1	**1.6**
Central Receiving	0.4	0.5	0.4	0.3	<0.1	<0.1	0.2	0.1	**1.8**
Front Street	<0.1	0.6	0.3	0.2	<0.1	0.3	<0.1	0.3	**1.5**
High School	0.2	0.5	0.4	0.3	<0.1	0	0.2	0.1	**1.6**
Mechanic Street	<0.1	0.6	0.3	0.2	<0.1	<0.1	0.2	0.3	**1.6**
Pearl Street	<0.1	1.7	0.2	0.2	0.3	0.2	0.1	0.1	**2.8**
Red Bank	0.2	0.4	0.3	0.3	<0.1	<0.1	0.2	0.1	**1.4**
Deering Oaks	0.1	0.4	0.3	0.3	<0.1	<0.1	0.2	0.1	**1.3**
West Commercial St.	0.2	0.5	0.3	0.2	<0.1	<0.1	0.2	0.1	**1.5**
Portland Ocean Gateway	0.2	0.5	0.3	0.2	<0.1	<0.1	0.2	0.1	**1.5**

Table A-2b. Cumulative Cancer Risk per 1,000,000.

	1,3-Butadiene	Benzene	Carbon Tetrachloride	Chloroform	Ethylbenzene	Ethylene Dibromide	Ethylene Dichloride	Other	**Total**
Assessor's Office	2.3	5.5	3.7	2.8	<1	<1	2.2	0.9	**17**
Bug Light	1.8	7.3	3.3	2.5	1.0	<1	2.2	2.1	**19**
Cash Corner	1.1	4.6	3.7	2.2	2.1	<1	1.5	0.9	**16**
Central Receiving	3.7	4.5	3.8	2.9	<1	<1	2.4	0.9	**18**
Front Street	<1	5.5	2.6	1.9	<1	2.5	<1	2.6	**15**
High School	2.0	4.8	3.5	2.8	0.4	0	2.0	0.7	**16**
Mechanic Street	<1	6.0	3.0	2.3	<1	<1	1.7	2.9	**16**
Pearl Street	<1	16.9	2.4	1.8	2.5	2.3	1.1	1.1	**28**
Red Bank	1.5	4.2	3.2	2.5	<1	<1	1.8	0.6	**14**
Deering Oaks	1.4	3.7	3.2	2.5	<1	<1	1.7	0.6	**13**
West Commercial St.	1.8	4.6	3.1	2.4	<1	<1	1.6	1.3	**15**
Portland Ocean Gateway	1.6	4.6	3.2	2.4	<1	<1	1.8	1.2	**15**

Table A-3. Regression Results for Acrolein – South Portland/Portland.

Location	N	Adjusted R^2	p-value*	Percent Change
Bug Light	251	-0.003	0.63	-6%
Cash Corner	228	0.024	0.011	-26%
High School	199	0.074	<0.0001	-43%
Mechanic Street	265	0.203	<0.0001	-61%
Red Bank	333	-0.002	0.625	6%
Portland Ocean Gateway	344	0.034	0.0003	-32%
Deering Oaks	332	0.138	<0.0001	-49%
West Commercial Street	335	0.183	<0.0001	-65%

* A p-value less than 0.05 is considered statistically significant, meaning it is unlikely to have occurred by chance.

Table A-4. Regression Results for Acrolein – Statewide.

Location	N	Adjusted R^2	p-value*	Percent Change
Bangor	351	0.195	<0.0001	-65%
Lewiston	355	0.136	<0.0001	-47%
Presque Isle	349	0.148	<0.0001	-53%
Rumford	341	0.270	<0.0001	-68%

* A p-value less than 0.05 is considered statistically significant, meaning it is unlikely to have occurred by chance.

Table A-5. Regression Results for Benzene – South Portland/Portland.

Location	N	Adjusted R^2	p-value*	Percent Change
Bug Light	251	-0.003	0.704	-6%
Cash Corner	228	0.024	0.011	-26%
High School	199	0.013	0.06	-24%
Mechanic Street	265	-0.002	0.54	-8%
Red Bank	333	0.013	0.023	-18%
Deering Oaks	332	0.065	<0.0001	-35%
Portland Ocean Gateway	344	0.284	<0.0001	-64%
West Commercial Street	335	0.047	<0.0001	-33%

* A p-value less than 0.05 is considered statistically significant, meaning it is unlikely to have occurred by chance.

Table A-6. Regression Results for Benzene – Statewide.

Location	N	Adjusted R^2	p-value*	Percent Change
Bangor	351	0.049	<0.0001	-36%
Lewiston	355	0.073	<0.0001	-44%
Presque Isle	349	0.071	<0.0001	-41%
Rumford	341	0.045	<0.0001	-40%

* A p-value less than 0.05 is considered statistically significant, meaning it is unlikely to have occurred by chance.