United States
Environmental Protection Agency

September 2024
Office of Chemical Safety and
Pollution Prevention

Draft Proposed Approach for Consideration of Chemical Co-exposure in TSCA Risk Evaluations

September 2023

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This report was developed by the United States Environmental Protection Agency (U.S. EPA), Office of Chemical Safety and Pollution Prevention (OCSPP), Office of Pollution Prevention and Toxics (OPPT)

Acknowledgements
The authorship team gratefully acknowledges the participation, input, and review comment from U.S. EPA, OPPT and OCSPP staff, senior managers and science advisors. We also gratefully acknowledge input and review from intra-agency reviewers that included multiple offices within EPA.

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This draft publication was reviewed and cleared for release by OPPT and OCSPP leadership.

Abbreviations and Acronyms

AERMOD	The American Meteorological Society/Environmental Protection Agency Regulatory Model
AERR	Air Emissions Reporting Requirements
ATS	AirToxScreen
ATSDR	Agency for Toxic Substances and Disease Registry
CAP	Criteria Air Pollutant
CMAQ	Community Multiscale Air Quality Model
COU	Condition of Use
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System
HAP	Hazardous Air Pollutant
HAPEM	Hazardous Air Pollutant Exposure Model
IARC	International Agency for Research on Cancer
IRIS	Integrated Risk Information System
IUR	Inhalation Unit Risk
NATA	National Air Toxics Assessment
NEI	National Emissions Inventory
NRC	National Research Council
OAQPS	Office of Air Quality Planning and Standards
OEHHA	Office of Environmental Health Hazard Assessment
OPPT	Office of Pollution Prevention and Toxics
PAH	Polycyclic aromatic hydrocarbon
PESS	Potentially exposed or susceptible subpopulations(s)
PM	Particulate Matter
RSEI	Risk-Screening Environmental Indicators
SAB	Scientific Advisory Board
SACC	Science Advisory Committee on Chemicals
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
WHO	World Health Organization

Executive Summary

The Office of Pollution Prevention and Toxics (OPPT) within the Office of Chemical Safety and Pollution Prevention (OCSPP) is tasked with evaluating and managing chemical risks resulting from exposures to new and existing chemicals. The evaluation of these chemicals is done through implementation of the Toxic Substances Control Act (TSCA) which requires the identification and evaluation of exposures and risks to potentially exposed susceptible subpopulations (PESS). Increasing evidence shows communities, particularly those considered overburdened or subject to environmental justice concerns, may be exposed to multiple co-occurring chemicals. The TSCA risk assessment process for existing chemicals has historically focused on developing and implementing risk assessment methodologies for individual chemicals that consider routes and pathways separately. More recently, EPA OPPT has begun to combine routes and pathways, when appropriate, into aggregate assessments for individual chemicals, and has begun developing methodologies to evaluate cumulative risks from multiple chemicals.

This draft document takes another step in this process to better consider potential multiple chemical exposures. Specifically, this document proposes metrics and methods to identify and evaluate chemical co-exposure or areas where multiple chemical exposures may occur in the same geographic space. The overall purpose of this draft document is to support identification of potential PESS and eventually consider chemical co-exposure as part of individual chemical risk evaluation. The evaluated metrics to inform chemical co-exposure are:

- Number of chemical releasing facilities;
- Number of chemicals released from facilities;
- Number of chemicals meeting chemical risk benchmarks;
- Chemical risk combinations; and
- Bivariate distribution of individual chemical risk with potential chemical co-exposure

AirToxScreen (ATS) is an EPA developed modeling tool for estimation of exposure and risk to airborne toxics across the nation. This draft document proposes to use ATS as the primary screening level tool for evaluating chemical co-exposure to ambient air when conducting TSCA risk assessment. Using ATS, results show that the proposed indicators are useful in providing screening-level information about chemical co-exposure, the chemical species present, and potential risk. While it is important to note that how these metrics and methods may be implemented within OPPT TSCA risk evaluation processes is still under consideration, these approaches can serve as available tools within OPPT to assess chemical co-exposure, better characterize the combined burden communities may face from these exposures, and provide direction for additional and more targeted levels of analysis.

1 Overview

The mission of the U.S. Environmental Protection Agency (EPA or Agency) is to protect human health and the environment. As part of that overall mission, the Office of Pollution Prevention and Toxics (OPPT) within the Office of Chemical Safety and Pollution Prevention (OCSPP) is tasked with evaluating and managing chemical risks arising from exposures to new and existing chemicals. The evaluation of these chemicals is done through the implementation of the Toxic Substances Control Act (TSCA). Originally passed in 1976, it was amended in 2016 with the passage of the Frank R. Lautenberg Chemical Safety for the 21st Century Act (Lautenberg Act).[1]

The Lautenberg Act requires the evaluation of existing chemicals and provides a directive to prioritize the evaluation of those chemicals most likely to cause risks.[2] The evaluation of existing chemicals typically is done through the completion of a chemical risk evaluation that includes risk assessment and risk determination. The Lautenberg Act changed the way EPA evaluates industrial chemicals in many ways. One such way is the requirement to identify and evaluate risks to potentially exposed or susceptible subpopulation(s) (PESS) (89 Fed. Reg. 37028). TSCA also requires the Agency to use reasonably available information consistent with the best available science and to base its decisions on the weight of the scientific evidence. The consideration and evaluation of PESS under TSCA can include, but is not limited to, a wide variety of different individuals or groups, such as children, the elderly, pregnant women, overburdened communities, and Tribal communities. The evaluation of these individuals or groups is intended to ensure that those subject to greater susceptibility and/or greater exposures are considered and evaluated during the risk evaluation and risk management process. The consideration of PESS within the TSCA framework is complementary to and consistent with the increased emphasis on incorporating principles of environmental justice (EJ) and evaluation of overburdened communities as directed by several recent Executive Orders (12898, 13985, 14008, 14094, and 14096) (EOP, 2023a, b, 2021a, b, 1994), research plans by the National Science and Technology Council (EOP, 2024), and direction from Administrator Regan (Regan, 2021). In an acknowledgement of this connection between PESS and EJ, the definition of PESS was recently amended to include the mention of overburdened communities as an example subpopulation to recognize that "there are communities that may experience disproportionate risks from chemicals due to greater exposure or susceptibility to environmental and health harms" (89 Fed. Reg. 37028).

Full consideration of chemical exposure and risk to PESS, including overburdened communities, incorporates a variety of factors. Some of these factors include where chemicals are being released; who is exposed; to what media, pathway, and route of exposure do releases occur; release frequency and magnitude; and the degree to which releases of chemicals may co-occur. EPA OPPT's risk evaluation approaches to address these factors are being developed in a thoughtful, stepwise manner. Initially after the Lautenberg Act was passed, EPA OPPT's risk evaluations considered routes and pathways separately. More recently, EPA OPPT has begun to combine routes and pathways, when appropriate, into aggregate assessment (see discussion in Section 2). Additionally, prior to early 2023, EPA's OPPT focused primarily on developing and implementing risk evaluation methodologies for individual chemicals. In 2023, EPA OPPT took another important step in risk evaluation methodology development to consider multi-chemical exposures by convening a meeting of the Science Advisory Committee on Chemicals (SACC) to review two draft documents related to cumulative risk assessment

[1] Full explanation of the Frank R. Lautenberg Chemical Safety for the 21st Century Act is available at: https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/frank-r-lautenberg-chemical-safety-21st-century-act

[2] Existing chemicals are those that were already in commerce when TSCA was enacted in 1976 or have undergone premanufacture notice review and are listed on the TSCA inventory.

where cumulative risk assessment was defined by EPA as including multiple chemical stressors that share toxicological properties (U.S. EPA, 2023c, d). This draft *Consideration of Chemical Co-exposure in TSCA Risk Evaluations* describes a proposed approach for evaluating another key facet when characterizing chemical exposure, namely the exposure to multiple chemical stressors that may not share toxicological properties. In this draft document, EPA OPPT aims to continue development of potential chemical risk evaluation strategies by describing screening-level approaches and methodologies to evaluate chemical co-exposure. For these purposes, co-exposure is defined as the potential exposure to multiple chemicals in the same geographical area. This proposed evaluation of potential chemical co-exposures informs better understanding and identification of communities facing possible disproportionate impacts from adverse exposures and human health burdens from airborne chemical releases. In doing so it is supportive of OPPT's stated goal of better quantifying and characterizing overburdened communities as part of PESS (89 Fed. Reg. 37028).

Ultimately, EPA OPPT has two key goals for this screening approach methodology:

1. *To support identification of potential PESS* through the evaluation of national and regional trends in airborne industrial releases and chemical co-exposure. These identified potential PESS are intended to be an initial screening-level characterization that can be utilized across the risk evaluation process, and can be further considered in more detailed, refined analysis at a later time. In this draft document, EPA OPPT uses AirToxScreen (ATS) to develop national/regional maps that characterize airborne chemical exposure to multiple chemicals released in or near the same geographic locations. ATS is an EPA-developed screening tool for modeling air toxics exposure and risk. To demonstrate potential uses of ATS for this purpose, EPA OPPT provides a series of national/regional maps (Section 6).
2. *To consider chemical co-exposure as part of an individual chemical risk evaluation* by evaluating chemicals that may co-occur with a specific chemical prioritized for risk evaluation, thereby providing a fuller characterization of exposure. EPA OPPT proposes to use ATS to identify specific locations where the chemical undergoing risk evaluation co-occurs with other airborne chemicals of interest to EPA. EPA OPPT has developed several case studies to show these relationships in tabular and map form (Section 7).

The combined effect of new statutory requirements within the Lautenberg Act, increasing Agency direction to evaluate aggregate and cumulative exposure, and directives to better assess exposure and potential risk to PESS and EJ communities require novel approaches to evaluate chemical co-exposures. This evaluation must also be done in a way that will support the chemical risk evaluation process under the Toxic Substances Control Act (TSCA) and requires statute and program specific interpretation and implementation that may differ from other programs. There is some discussion later in the document as to how the proposed methodologies and approaches described below can be used within the risk evaluation process under TSCA (Section 8), but ultimately their implementation and use is still under consideration. This document represents the first effort within OPPT to characterize and evaluate chemical co-exposures and is submitted here for consultation by the Scientific Advisory Board (SAB) in 2024.

This document is organized as follows:

- Section 2 entitled "Regulatory Context" provides more details on the statutory and regulatory context supporting this evaluation.
- Section 3 entitled "Scope" provides more details on the goals and scope of this screening approach including the support for identifying potential PESS and considering chemical co-exposure as part of a single chemical risk evaluation.

- Section 4 entitled "Proposed Use of AirToxScreen" provides an overview; model description; and assumptions, strengths, limitations and uncertainties associated with the use of ATS.
- Section 5 entitled "Overview of OPPT's Proposed Co-exposure Approach" provides an outline of subsequent analyses, how each approach relates to the overall goals outlined above, and listing of supporting tables and figures.
- Section 6 entitled "National and Regional Scale Chemical Co-exposure" provides the analysis and results related to the identification of potential PESS (Goal 1 above) through the use of ATS
- Section 7 entitled "Chemical Specific Co-exposure" provides the analysis and results related to the consideration of chemical co-exposure as part of a single chemical risk evaluation (Goal 2 above) through the use of ATS.
- Section 8 entitled "Summary, Potential Application and Future Direction" discusses how these approaches may being to be incorporated into the TSCA risk evaluation process and potential future analyses.

2 Regulatory Context

As defined by the Lautenberg Act, a chemical risk evaluation within OPPT requires the consideration of reasonably available information consistent with the best available science and that decisions be based on the weight of the scientific evidence[3,4] [15 U.S.C. § 2625(h), (i), (k)]. Under Section 6(b) of this statute, EPA is required to perform risk evaluations to determine whether a given chemical presents unreasonable risk to health or the environment, including an unreasonable risk to PESS, without consideration of costs or other non-risk factors. PESS are subpopulations "who, due to either greater susceptibility or greater exposure, may be at greater risk than the general population of adverse health effects from exposure to a chemical substance or mixture, such as infants, children, pregnant women, workers, or the elderly." [15 U.S.C. § 2602(12)]. Recent amendments to the TSCA RE rule have included overburdened communities as an example PESS subpopulation due to their potential to "experience disproportionate risks from chemicals due to greater exposure or susceptibility to environmental and health harms" (89 Fed. Reg. 37028).

Direction within EPA, as well as the publication of several Executive Orders in recent years have encouraged better consideration and incorporation of EJ principles and the evaluation of these overburdened communities into Agency work (EOP, 2023b). EJ is defined within Executive Order 14096 as "the just treatment and meaningful involvement of all people, regardless of income, race, color, national origin, Tribal affiliation, or disability, in agency decision-making and other Federal activities that affect human health and the environment." Fair treatment is further defined by EPA as meaning that "no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental and commercial operations or policies"(U.S. EPA, 2016b).[5] Executive Orders 12898, 13985, 14008, 14094 and 14096 all call on the Agency to identify, analyze and address areas that may have disproportionately high adverse effect on human health or the environment (specifically Executive Orders 12898 and 14096) (EOP, 2023a, b, 2021a, b, 1994).

[3] Best available science (40 CFR § 702.33) "means science that is reliable and unbiased. Use of best available science involves the use of supporting studies conducted in accordance with sound and objective science practice, including, when available, peer reviewed science and supporting studies and data collected by accepted methods or best available methods (if the reliability of the method and the nature of the decision justifies use of the data)."

[4] Weight of scientific evidence (40 CFR § 702.33) "means a systematic review method, applied in a manner suited to the nature of the evidence or decision, that uses a pre-established protocol to comprehensively, objectively, transparently, and consistently, identify and evaluate each stream of evidence, including strengths, limitations, and relevance of each study and to integrate evidence as necessary and appropriate based upon strengths, limitations, and relevance."

[5] For more information, see the EPA's Environmental Justice website: http://www.epa.gov/environmentaljustice/.

Most risk assessments/evaluations conducted at EPA, including those for existing chemicals under TSCA, have been conducted on individual chemicals. However, the scientific and regulatory communities acknowledge that human exposure to multiple chemicals released concurrently to air, water, and land are likely in many locations. These exposures are the result of numerous releases to these media. For example, EPA's Toxics Release Inventory (TRI) National Analysis represents a small fraction of all chemicals in commerce as not all chemicals, nor all chemical releases from releasing facilities are required to report. Nevertheless, in 2021 the TRI reported 571 million pounds of toxic chemicals released to air and over 3.2 billion pounds released or disposed of to all environmental media from over 21,000 reporting facilities across 529 chemicals[6] (U.S. EPA, 2023a).

Because an individual may be simultaneously exposed to multiple releases of the same chemical via combined routes (e.g. oral, dermal, and inhalation) and/or pathways (e.g. air, land, and water), EPA's OPPT has begun to perform aggregate assessment. Aggregate exposure is defined as "the combined exposures to an individual from a single chemical substance across multiple routes and across multiple pathways (40 CFR § 702.33)." The draft supplemental risk evaluation for 1,4-dioxane published in 2023 (U.S. EPA, 2023g) and the final risk evaluations for HBCD and NMP in 2020 (U.S. EPA, 2020a, b) represented the first times aggregate exposures had been evaluated by EPA OPPT in a risk evaluation. Following these examples, several recent chemical draft risk evaluations (asbestos; tris(2-chloroethyl) phosphate ; 1,1-dichloroethane; diisodecyl phthalate; and formaldehyde) have evaluated aggregate exposures in a variety of ways depending on the chemical by aggregating across sources of releases, pathways and/or routes (U.S. EPA, 2024a, b, c, 2023e, f).

With regard to multi-chemical exposure, in early 2023 OPPT published proposed methods and processes for conducting cumulative risk assessment under TSCA, relying heavily on several existing approaches. These approaches included approaches both outside and within the Agency such as the 1994 report *Science and Judgment in Risk Assessment,* 2002 *Guidance on Cumulative Risk Assessment of Pesticide Chemicals that have a Common Mechanism of Toxicity,* 2003 *Framework for Cumulative Risk Assessment,* 2008 report *Phthalates and Cumulative Risk Assessment: The Tasks Ahead*, 2009 *Assessment of Combined Exposures to Multiple Chemicals: Report of a WHO/IPCS International Workshop on Aggregate/Cumulative Risk Assessment, 2016 Pesticide Cumulative Risk Assessment: Framework for Screening Analysis,* 2017 *Application of Systematic Review Methods in an Overall Strategy for Evaluated Low-Dose Toxicity from Endocrine Active Chemicals, and 2023 Advances in Dose Addition for Chemical Mixtures: a White Paper* (U.S. EPA, 2023b; NASEM, 2017; U.S. EPA, 2016a; WHO, 2009; NRC, 2008; U.S. EPA, 2003, 2002; NRC, 1994).

This cumulative risk assessment effort resulted in February 2023 of the draft publication of two documents: the *Draft Proposed Principles of Cumulative Risk Assessment under the Toxic Substances Control Act* and its proposed application within a chemical risk evaluation in *Draft Proposed Approach for Cumulative Risk Assessment of High-Priority Phthalates and a Manufacturer-Requested Phthalate under the Toxic Substances Control Act* (U.S. EPA, 2023c, d). The *Draft Principles* document adopts the definition of "cumulative risk assessment" as given in EPA's *Framework for Cumulative Risk Assessment* (U.S. EPA, 2003) where it is defined as: "an analysis, characterization, and possible quantification of the combined risks to health and/or the environment from multiple agents and/or stressors" (U.S. EPA, 2023d). The *Draft Principles* report further describes evaluation of multiple

[6] For more information on TRI, please see: https://www.epa.gov/toxics-release-inventory-tri-program

chemical substances that jointly exert a common toxic effect and those exposures that could be resulting from multiple exposure pathways and/or through multiple routes of exposure. The *Draft Principles* approach, consistent with all those other citations, focuses on the use of dose additive approaches to combine the risks from chemicals that share, to varying degrees, toxicological properties such as target tissue, pharmacokinetics, and/or mode of action.

This document takes another step in this process to better consider multiple chemical exposure by describing here a proposed approach that builds on existing EPA tools and methods. This approach evaluates multi-chemical exposure and risk as screening-level support during the TSCA risk evaluation process ranging from prioritization to risk evaluation and risk management. There are multiple differences between the cumulative risk assessment approach described in the *Draft Proposed Principles of Cumulative Risk Assessment under the Toxic Substances Control Act* (U.S. EPA, 2023d) and this multi-chemical exposure evaluation. One of most important differences is that in this proposed approach, EPA OPPT is evaluating chemicals that may not share toxicological properties (e.g., different target tissues). As such, EPA OPPT is not performing dose additivity to calculate multi-chemical risk or cumulative risk.

3 Scope

The purpose of this proposed approach is to provide a screening level analysis that can be used to better inform chemical co-exposure, highlight geographic areas or population groups that may experience disproportionate impacts, and identify areas that may need more targeted or higher tier exposure and risk characterization. While not being used as a sole basis for health or regulatory action, this approach is intended to aid in EPA identifying chemical co-exposures and make OPPT risk evaluations and rules more health protective. The definition of co-exposure in this draft document represents the potential exposure to multiple chemicals in the same geographic space.

This evaluation of chemical co-exposure is focused on providing screening level analyses and methodologies to support the EPA OPPT risk evaluation process and is subject to the statutory language of TSCA including the aforementioned characterization of PESS. Therefore, specific interpretation and potential use of developed co-exposure approaches within EPA OPPT may not be transferable to, and may differ from, other program's or Agency office's considerations of chemical co-exposure. This document also considers the strengths, limitations, and uncertainties of the data used in this analysis in total, as well as their specific implications within TSCA. For instance, exposure, risk evaluation, and risk determination within TSCA is grounded on evaluation of specific chemicals condition(s) of use (COU(s)) which is beyond the scope of this evaluation. Nevertheless, OPPT views this proposed approach as potentially useful in informing chemical co-exposure within the TSCA risk evaluation process.

EPA OPPT acknowledges that affected populations may be subject to exposures and risks resulting from both chemical and non-chemical stressors that could affect their susceptibility or vulnerability to chemical stressors or have modifying effects on exposure-response function (U.S. EPA, 2003). The consideration of non-chemical stressors including the full consideration of factors that impact susceptibility or vulnerability and may cover an array of biological, social, and behavioral factors more in line with a cumulative impacts analysis is not considered here due to limited availability of quantitative data and vetted methodologies.

Although EPA may expand the scope of this effort in the future, at this time, there are some additional key limits to the scope of this proposed approach:

- As this effort is intended for potential use in TSCA risk evaluations, industrial facility chemical releases are the focus. Other potential point releases (e.g., railyards/airports/etc.) or emission source contributions (e.g., nonpoint/mobile) are not considered except in the evaluation of estimated chemical risk patterning analysis which incorporates estimated risk from all potential source contributions within ATS.
- Exposure for each chemical is treated independently of other chemicals that may be present. OPPT is not calculating a total additive exposure or total additive risk across the chemicals included in the analysis. Thus, this effort does not constitute a complete assessment of multi-chemical risk.
- OPPT is focusing on the human health exposure to ambient air due to the nature of the available datasets that only evaluate the air pathway. OPPT is not considering exposures to other pathways (e.g., water, soil), human exposure scenarios (e.g., occupational, consumer use), or ecological exposures at this time. The evaluation of these other pathways is often considered in OPPT chemical risk evaluations.
- Finally, OPPT is focused on evaluation of chemicals that have existing cancer risk values as described in the datasets used (see Section 4.2). No effort was made at this time to develop or confirm independent chemical specific cancer risk values using OPPT processes, although this effort would typically be undertaken under standard TSCA risk evaluations.

4 Proposed Use of AirToxScreen

Evaluation of chemical co-exposures can occur across a range of spatial scales ranging from the national scale to the scale of individual communities and/or populations. In recent years, improved datasets and modeling techniques as well as data management capabilities have enabled more quantitative consideration of chemical exposures and risks across these spatial scales. With estimates of exposure and risk available nationwide at increasingly finer geographic scales, these more spatially discrete representations of chemical exposure and risk offer the opportunity to better quantify not only cumulative and aggregate exposures, but also consider EJ and potential disproportionate impacts on overburdened communities for air releases. One such tool is AirToxScreen (ATS), an existing EPA modeling tool that estimates chemical exposure and risk at the nationwide level (U.S. EPA, 2022).[7] This tool is proposed for use by OPPT due to the numerous chemicals already modeled within the tool, information and model outputs that are publicly available, and its ability to implement analyses across various geographic scales. In the future, EPA OPPT may consider the development of a tiered framework to incorporate a broader range of spatial scales.

4.1 Overview of ATS

ATS is a peer-reviewed screening level modeling tool developed by EPA to better evaluate air toxics across the United States, inform the collection of air toxics information, and characterize areas of greatest potential concern to the general population. It serves as the successor to the National Air Toxics Assessment (NATA), which originally underwent technical peer review with the EPA's SAB in 2001 for the 1996 NATA Assessment (U.S. EPA, 2001). Following this review, subsequent assessments have been completed in 1999, 2002, 2005, 2011, and 2014. The ATS assessments started in 2017 and use the same basic methods as used in the NATA assessments. ATS models the majority of the 188 current

[7] Full explanation of AirToxScreen is available at: https://www.epa.gov/AirToxScreen

hazardous air pollutants (HAPs) and diesel particulate matter. The modeling tool follows a stepwise process of compiling data from the National Emissions Inventory (NEI), estimating ambient concentrations of air toxics across the United States, estimating population exposures, and then characterizing the inhalation risk to the general public (U.S. EPA, 2022). This process is conducted to produce outputs of ambient air concentrations, exposure concentrations and estimated pollutant risks at the geographic scale of census tracts nationwide for use by state, local, and Tribal air agencies, EPA, and the public.[8]

Data from the NEI serves as the foundation of the modeling efforts done in ATS. These data include emissions from various source categories such as point, nonpoint and mobile sources, biogenic emissions, and fires. This database serves as the primary input along with meteorological data to two air quality models used within ATS to estimate ambient concentrations of air toxics. The first model utilized within ATS is the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) which is an atmospheric dispersion model used to model all air toxics in ATS due to its ability to estimate concentrations with greater spatial granularity and more detailed source attribution. The second model used for exposure estimation within ATS is the Community Multiscale Air Quality (CMAQ) model, which is a photochemical model used to model all sources, but estimation of pollutant concentrations resulting from secondary formation, biogenic releases, and fires is only modeled within this model. It is used on a subset of 52 chemicals. Where a pollutant is estimated by both AERMOD and CMAQ, the annual average concentrations from both models are combined. Using one year of input data, these models output annual ambient air concentration for subsequent development of long-term inhalation exposures. It is important to note that these models do not take into account indoor air toxics information, background air toxics from other media, or other exposures from other media.

Following estimation of ambient concentrations, ATS uses the Hazardous Air Pollutant Exposure Model (HAPEM) to develop exposure concentrations. These exposure concentrations factor in human activity patterns since the ambient air concentrations produced by the AERMOD and CMAQ modeling do not take into account how a person may move through or engage in different activities in the outdoor environment. Required input information for HAPEM include: the ambient concentrations produced by AERMOD and CMAQ, population data, population-activity data, and microenvironmental data.

ATS then estimates census-tract level cancer and non-cancer risk by applying health benchmark data to the exposure concentrations. For the purposes of this evaluation and to support development of the proposed approach, OPPT has chosen to focus on cancer risk which is characterized as the calculation of an upper-bound lifetime individual cancer risk estimate that incorporates both the estimated exposure concentration and inhalation unit risk (IUR) estimate. Data sources for the applied toxicity values for cancer and non-cancer risk estimates can come from a variety of sources including the U.S. EPA Integrated Risk Information System (IRIS), U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry (ATSDR), California Environmental Protection Agency Office of Environmental Health Hazard Assessment (OEHHA), U.S. EPA Health Effects Assessment Summary Tables, and the World Health Organization (WHO) International Agency for Research on Cancer (IARC). Greater weight on selection of the applied toxicity values is given to those which are EPA-derived values.

[8] Note that an updated version of AirToxScreen was released during development of this paper which analyzes air toxics to the spatial scale of census blocks. To see full description of the 2020 AirToxScreen, go to 2020 AirToxScreen | US EPA. All references, description and use of data herein refer to the 2019 version.

With any nation-wide modeling effort such as ATS, there are strengths of the modeling approach, assumptions incorporated into the tool, and resulting uncertainties requiring proper use and interpretation of model outputs. These assumptions, strengths and uncertainties are more fully described below in Section 4.4 and in the ATS Technical Support document, but the modeling tool is intended to provide "general answers to questions about emissions, ambient air concentrations and exposures and risks across broad geographic areas for the year modeled." (U.S. EPA, 2022). As mentioned above, it is intended to inform air toxics information and the cancer health concerns posed for those toxics by identifying those pollutants of greatest concern and prioritize those pollutants and areas needing further investigation and/or data collection. Therefore, it is not intended to pinpoint areas of risk or compare areas of risk at local levels (e.g., census tract to census tract). It also is not intended to be used as the sole basis for risk management or regulations. The analyses and methodologies explored below represent a proposed initial use of this dataset and approaches for evaluating chemical co-exposure. How this information is best incorporated into the risk evaluation process within EPA OPPT remains a work in progress.

Most model outputs from ATS are downloadable from referenced EPA websites above. These ATS outputs are in database or spreadsheet form at various scales from the individual chemical to multi-chemical national syntheses. Location data of NEI releases are given by latitude and longitude. Modeled estimates of ambient air concentration, exposure concentration, and risk are presented at the census tract level nationwide. Together these ATS outputs can be readily incorporated into a geographic information system (GIS) for further manipulation and analysis, as well as subsequent visualization in the form of maps and figures. Many of the analyses performed here are displayed in maps to illustrate nationwide or regional trends and patterns but have supporting tabular information.

4.2 Other Considered Dataset

OPPT also evaluated another potential model for use in this analysis known as the Risk-Screening Environmental Indicators (RSEI) model (U.S. EPA, 2023h).[9] RSEI is a geographically-based, multimedia model and prioritization tool that helps policy makers, researchers, and communities quickly analyze large amounts of data on Toxics Release Inventory (TRI) listed toxic chemicals. RSEI incorporates information from EPA's TRI database, which tracks certain toxic chemical releases and waste management activities at federal facilities and larger industrial facilities across the United States and its territories. RSEI incorporates over 30 years of TRI data, four U.S. censuses, toxicity and physicochemical properties for more than 400 toxic chemicals, and geographical information for more than 100,000 facilities. All of this information is used to model and map the environmental fate and transport of each toxic chemical through the environment and the potential exposure that may result. The RSEI model then calculates numeric results that are designed to be compared to other RSEI model generated results. These RSEI results are designed to help users contextualize, understand, and better communicate the relative hazards and potential for risks posed by certain waste management activities of TRI chemicals (e.g., from releases to the environment). RSEI results and custom analyses can be used for screening-level activities such as trend analyses that compare potential risk-related impacts from year to year, or for ranking and prioritizing toxic chemicals, facilities, industry sectors, or geographic regions for strategic planning. RSEI can also be used in conjunction with other data sources and environmental information, to help policy makers, researchers, and communities establish priorities for further investigation and to look at changes in potential health impacts over time.

[9] Full description of the Risk-Screening Environmental Indicators (RSEI) model is available here: https://www.epa.gov/rsei

While the RSEI model also provides screening-level estimates of chemical exposure and risk-related impacts at a nationwide scale, there are important methodological and computational differences between RSEI and ATS that make direct comparison between the estimated exposure and risk-screening outputs of the two models presented herein using ATS challenging. For instance, the standard outputs from the RSEI model do not provide estimates of risk or benchmark concern level as presented in ATS. RSEI instead incorporates toxicity and population weights to arrive at hazard-based, concentration-based, and risk-related scoring results (U.S. EPA, 2023h). These modeling results are not intended to be quantitative estimates of risk, but rather are intended to be compared to help identify geographic areas, industry sectors, facilities, and chemical releases that may be associated with significant potential human health risks. While RSEI provides a data and modeling foundation worthy of additional analysis and study (see Section 8), OPPT has concluded that ATS is more fit for purpose for TSCA risk evaluation applications and this screening level identification of potential PESS and consideration of chemical co-exposure as part of an individual chemical risk evaluation described below.

4.3 Model Description of ATS

OPPT briefly describes ATS here, but full description of the tool is available in the technical supporting documentation (U.S. EPA, 2022) and Agency website.[10] ATS is described as a screening tool that evaluates air toxics across the U.S. and models air exposure concentration and the health risk from those exposures at the geographic scale of census tracts nationwide. It is important to note that an updated version of ATS was released during development of this paper which analyzes air toxics at a smaller spatial scale of census blocks. All analysis done in this paper used the 2019 ATS version which presents results at the census tract level[11]. Census tracts are relatively permanent subdivisions of a county that generally have a population size of between 1,200 to 8,000 people, with an optimum size of 4,000 people and with boundaries following visible and identifiable features (U.S. Census Bureau, 2022, 1994). 2019 ATS used 2010 Census tract boundaries which has 74,134 identified tracts nationwide. ATS is intended to provide "the best possible national-scale population-level estimates of exposure to and risks associated with air toxics, considering data availability, technical capabilities, and other potentially limiting factors" (U.S. EPA, 2022). It represents one of the only readily available datasets that provides modeled exposure and risk for a sizable number of air toxics nationwide at the census tract level and serves as a good dataset for evaluating chemical co-exposure.

ATS models and integrates emissions of ambient air toxics which consists of hazardous air pollutants (HAPs) and diesel particulate matter (PM). Under the Clean Air Act, HAPs are those pollutants known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects[12]. It is important to note that ATS does not consider possible exposures resulting from indoor air. These emitted chemicals come from a variety of source contributions including:

- point sources such as large waste incinerators and factories;
- nonpoint sources such as residential wood combustion, commercial cooking, and consumer and commercial solvents;

[10] Full explanation of AirToxScreen is available at: https://www.epa.gov/AirToxScreen
[11] To see full description of the 2020 AirToxScreen, go to 2020 AirToxScreen | US EPA. All references, description and use of data herein refer to the 2019 version.
[12] Full explanation of Hazardous Air Pollutants is available at: https://www.epa.gov/haps

- mobile sources such as cars and trucks found on roadways and nonroad equipment including marine vessels, trains, aircraft, lawnmowers or construction equipment;
- biogenics such as those chemicals emitted from vegetation;
- secondary production such as those chemicals formed in the atmosphere; and
- fires which include wildfires, prescribed burning and agricultural-field burning

The geographic domain of these releases includes sources from the contiguous United States, Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands. These sources are integrated to arrive at an aggregated average annual ambient air concentration based on one year of emissions input data primarily from the NEI for 2019. The NEI estimates air emissions of criteria air pollutants (CAPs) and HAPs from all air emission sources in the United States (U.S. EPA, 2022).[13] Emission estimates and emission model inputs are provided by state/local/Tribal air agencies for sources in their jurisdictions, with additional data developed by EPA to establish as complete an NEI as possible. It is noted that these submitted data vary in the level of detail and completeness across state/local/Tribal agencies.

Emissions are modeled to include spatial allocation, temporal allocation, and speciation. Spatial allocation includes both horizontal characterization of the emissions sources as well as vertical allocation through stack parameter information and other model inputs. Temporal allocation produces hourly variation in the emissions based on the source type to account for variability in emission timing throughout the year. These emissions are then modeled to produce estimated ambient air concentrations.

ATS models the majority of the 188 current HAPs and diesel PM. However, only 127 of those 188 chemicals have been assigned dose-response values, with the remaining air toxics not having adequate data to quantitatively assess exposure, hazard and subsequently risk (U.S. EPA, 2022). In sum, a total of 72 chemical toxics or chemical groups were evaluated for cancer risks using their modeled exposure concentrations and cancer health benchmarks within ATS. Ambient air concentrations are modelled using a combination of two EPA air quality models: American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD)[14] and Community Multiscale Air Quality (CMAQ) model[15]. Resulting ambient air concentrations are presented as average annual concentrations ($\mu g/m^3$) for each census tract nationwide.

AERMOD is a steady-state Gaussian plume dispersion model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources and both simple and complex terrain. It is able to incorporate a variety of emission source characteristics, chemical deposition properties, complex terrain and site-specific hourly meteorology at user-defined receptor distances and averaging times and is used to provide more granularity and source attribution.

CMAQ is a photochemical transport model capable of modeling how air toxics disperse and chemically transform. It is used within ATS due to the CMAQ model's strength in its ability to conserve mass from one area to another, model long-range transport, and account for chemical transformations and

[13] More information about the NEI is available at: https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei
[14] More information about AERMOD is available at: https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models#aermod
[15] More information about CMAQ is available at: https://www.epa.gov/cmaq

secondarily formed pollutants. CMAQ is used to model all sources, but estimation of concentrations formed via secondary production, fires and biogenics are only modeled in CMAQ within ATS.

For both models, performance statistics were performed to evaluate the effectiveness of the modeled ambient air concentrations from AERMOD and CMAQ to observed monitoring information. The number of sites with monitored information varied across the evaluated chemicals with mean bias and error differing across chemicals. Full description of these performance statistics is available within Appendix E of U.S. EPA (2022), but CMAQ and hybrid model individual chemical predictions generally resulted in small to moderate biases and errors and AERMOD predictions showed larger biases and errors.

Within ATS, the modeled air concentrations produced by AERMOD and CMAQ are converted to inhalation exposure concentrations since ambient air concentrations do not account for how a person may move through or engage in different activities in the outdoor environment. Exposure concentrations using the Hazardous Air Pollutant Exposure Model (HAPEM)[16] which is a screening-level exposure model that takes into account human activity patterns and commuting-pattern data. Activity patterns include tracking demographic groups as they move between indoor and outdoor environments and take into account actions such as personal activity and commuting. To generate inhalation exposure concentrations, the model needs four types of information including: ambient concentrations of air toxics, U.S. Census Bureau population data, population-activity data, and microenvironmental data. Using this data, HAPEM produces an expected range of exposure concentrations, from which the exposure for a typical individual for each census tract is produced.

For generation of final chemical inhalation exposure concentration estimates within ATS, HAPEM modeling was conducted for seven selected pollutants with the remaining pollutants assigned to one of those modeled chemicals based on whether its chemical phase is gaseous, particulate or variable for typical atmospheric conditions. The categorized phase was related to its available boiling point and literature review of typical physical state. Exposure concentrations were then estimated for the remaining air toxics that were not directly modeled within HAPEM through the use of exposure factors. Final estimated exposure concentrations are output as lifetime average concentrations ($\mu g/m^3$) for each census tract nationwide. Full discussion on the estimation of exposure concentrations within ATS is available in Section 4 of U.S. EPA (2022).

Following estimation of exposure concentrations at each census tract, census-tract risk for each chemical is estimated by applying health benchmark data to these concentrations. While ATS calculates both cancer and non-cancer risk for evaluated chemicals, for the purposes of this evaluation, OPPT focuses on the cancer effects where exposure is assumed to be continuous over a lifetime. For estimation of cancer risks within ATS, results of cancer dose-response assessments for the given chemicals were converted to an inhalation unit risk (IUR) estimate which represents an upper-bound excess lifetime cancer risk. This IUR estimate can then be multiplied by the exposure concentration to obtain a lifetime cancer risk estimate. Underlying data for the toxicity values come from a variety of sources, but with generally greater weight given to those which are EPA values based on risk management guidelines within the Office of Air Quality Planning and Standards (OAQPS) and level of peer review. Data are presented for all states in the United States and include Puerto Rico and the U.S. Virgin Islands.

[16] More information about HAPEM is available at: https://www.epa.gov/fera/human-exposure-modeling-hazardous-air-pollutant-exposure-model-hapem

4.4 Assumptions, Strengths, Limitations and Uncertainties of ATS

Associated with the national-level, screening level nature of ATS, several assumptions are built into the tool leading to strengths and uncertainties as an analysis tool and how results should be interpreted. It is noted that the results associated with this tool should not be used to pinpoint specific risk values or locations, nor be used to compare risks between states or localities (U.S. EPA, 2022). These results are intended to communicate the degree to which air concentrations, exposures, and risk vary across the United States at wider spatial scales based on geography and should not be used to interpret individual chemical exposures and risk. Further, supporting documentation mentions that it should not be used as the sole source of regulatory decision making or enforcement.

A key input dataset used within ATS is the NEI database, which includes both the emission rates and locations of releases (U.S. EPA, 2022). These data, which are primarily submitted by state/local/Tribal agencies, vary in their level of detail and completeness. Additionally, the submitted data use a variety of different methods for reported values including emission factors, material balances, engineering judgement and source testing that can introduce uncertainty in final results. While the data quality of NEI is high and data undergoes rigorous quality assurance processes, current reporting requirements vary by source, which can sometimes lead to lags in data submission of up to two years. Additionally, under the current Air Emissions Reporting Requirements (AERR) hazardous air pollutant (HAP) emissions reporting is voluntary; therefore depth and breadth of coverage for air toxics also varies by state. Despite these uncertainties, the NEI represents the most complete and detailed estimates of air emissions at the national level.

Additional main sources of uncertainty related to the modeled ambient air concentrations and measured results arise from the representativeness of the used meteorological characterization, model formulation and methodology, monitoring, and boundary conditions/background concentrations. The influences of these uncertainty sources are more fully described in the technical supporting documentation (U.S. EPA, 2022).

Temporally, ATS is intended to be a "snapshot" in time as it evaluates a single input year and does not readily allow for comparisons over multiple years. While the modeling does incorporate components of both temporal and spatial allocation for emissions over the evaluated year, the final outputs for ambient air concentrations and exposure concentrations are presented as annual averages. The model does not enable greater temporal granularity or characterization at monthly or seasonal timesteps. Therefore, the estimated number of chemicals and the magnitude of those exposures may differ at smaller temporal timesteps.

The principal geographic unit of evaluation within ATS is at the census tract level[17]. The areal size of a census tract can vary widely across the nation depending on population density (e.g., urban vs. rural). Due to this variable size, caution should be used when evaluating and interpreting some calculations, as they may be influenced by the size of the tract itself. For instance, generated ambient air and exposure concentrations that are reported at the census tract level are based on the population weighted averages of the estimated census block centroid concentrations within a given tract. Census blocks with higher populations within a tract get weighted more than census blocks with lower populations within the same tract. Actual ambient air concentrations for particular locations within a tract may be higher or lower than those predicted for the entire tract. Additionally, while providing

[17] But see recently released 2020 version of ATS which produces modeled results at the census block level (June 2024). Available at: https://www.epa.gov/AirToxScreen/2020-airtoxscreen

spatial resolution nationwide, the results at this scale are more uncertain than at the state or regional level (U.S. EPA, 2022). Given this spatial scale, ATS does not incorporate information that may apply to specific locations and focuses on evaluating exposure concentrations and risk at these broader geographic areas. Therefore, for this proposed approach, OPPT focuses on the utility of the described methodologies for a screening level at broader spatial scales and not for predicting patterns at individual census tracts. To investigate more local patterns of exposure and risk, OPPT recommends additional levels of analysis and interpretation.

Derivation of inhalation exposure concentrations within ATS are described in Section 4.3 of this draft document and described in more detail within Section 4 in U.S. EPA (2022). Principally, the exposure concentrations include modeling within HAPEM to account for human activity patterns, which encompasses a number of spatial, temporal, and population level assumptions that can add degrees of uncertainty to output values. Estimated exposure concentrations may be higher or lower for specific populations or cohorts of interest and values presented in ATS are intended to represent area-wide tract estimates of a "typical" person in that tract. For instance, estimated exposure concentrations to the general population represent the aggregate exposure concentrations across evaluated age cohorts. The six evaluated age cohorts are: 0 – 1, 2 – 4, 5 – 15, 16 – 17, 18 – 64, and ≥65 years. Data supporting activity patterns is based on short term measurement periods (one to two days) that are extrapolated to multi-day patterns through a stochastic process. Activity patterns are intended to capture a representative person and may not capture all demographic groups, including those generally considered for possible EJ concerns such as ethnic minorities and low-income populations (U.S. EPA, 2022).

For most chemicals, final estimated exposure concentrations are based on exposure factors derived from the surrogate chemicals modeled within HAPEM due to time and resource considerations. Coke oven emissions and diesel particulate matter were modeled as themselves and not used as surrogates; while benzene and 1,3- butadiene were used as surrogates for gas-phase pollutants; unspeciated, generic polycyclic aromatic hydrocarbons (PAHs) for mixed-phase pollutants; chromium (VI) for particulate pollutants emitted by point or nonpoint sources; and nickel for particulate pollutants emitted by mobile sources. While caution was taken to assign each chemical to their representative surrogate chemical grouping based on available chemical boiling point and literature review of typical physical state, this process includes additional assumptions that can introduce uncertainty for individual chemicals (see Section 4.3 above and Section 4 of U.S. EPA (2022) for more information).

Nevertheless, the use of HAPEM and the application of exposure factors within ATS have both undergone scientific peer review and been found to be appropriate tools in the estimation of human chemical exposures. The process for characterizing the effects of these chemical releases and associated risk to general population are described in Section 4.3 of this draft document and detailed in Section 5 of U.S. EPA (2022). In this analysis, all hazard values and subsequent calculations of risk are taken as determined by those used in ATS. It is possible that for certain chemicals, OPPT may arrive at different hazard and risk determinations when it undertakes a risk evaluation. The hazard values used with ATS come from a variety of different sources, some of which may be dated and/or needing/undergoing updated analysis. Under TSCA, OPPT would be required to confirm these hazard values comply with the best available science requirement for use in a TSCA risk evaluation. Additionally, OPPT chose not to use the total cancer risk calculated as an output for ATS since adding potential cancer risks across different tissue types and different modes of action introduces additional uncertainty and methodological considerations that are beyond the scope of this document.

The implications of these assumptions and uncertainties on particular analyses are further discussed in Section 5 – Section 7. Nevertheless, ATS represents one of the few nationwide modeling tools available for the evaluation of air toxics in such a comprehensive manner. It is intended to identify geographic patterns of risk and ranges of risks posed by a suite of air pollutants. Additionally, one of its strengths is its ability and intention to improve understanding of the health risks posed by air toxics and identify those pollutants and industrial categories of greatest concern. For a complete discussion on the strengths, limitations and assumptions associated with the use of ATS, the reader is referred to the technical supporting documentation (U.S. EPA, 2022).

5 Overview of OPPT's Proposed Co-exposure Analyses

Here OPPT evaluates chemical co-exposure with the aim of generating a screening level identification of geographic areas with multiple chemical and/or facility releases. Such information about potential chemical co-exposure is useful for identifying potential PESS at national to regional scales and for considering chemical co-exposure as part of individual chemical risk evaluations. The evaluation of these two potential scales of analysis can better inform chemical exposure, risk, and support efforts to incorporate principles of EJ and evaluation of overburdened communities.

1) ***National and regional scale analysis (Section 6)***: In this scale of analysis, the evaluation is focused on identifying potential PESS by calculating the number of facilities releasing chemicals, the number of chemicals released, and the number of chemicals reaching estimated cancer risk benchmarks. All analyses at this scale are aggregated to the census tract level, with an emphasis on the numbers of facilities or chemicals meeting these benchmarks independent of the individual chemical identities represented in each census tract. Data is analyzed and shown at the regional to national spatial scale to show spatial trends or potential areas of chemical co-exposure. Several metrics are evaluated to inform chemical co-exposure and are briefly explained below, with full explanation in their referenced sections.
    a. **Analysis Steps (6.1.2)**: Explanation of steps undertaken in analysis.
        - Figure 6-1. Example of number of NEI releases by census tract.
    b. **Facility Releases (Section 6.1.3)**: This metric captures the number of facility releases from the evaluated NEI database within a census tract or within 5 km of a census tract. Supporting figures and tables explained herein include:
        - Figure 6-2. Number of NEI releases within a census tract.
        - Figure 6-3. Number of NEI releases within 5 km of a census tract.
        - Table 6-1. Number of NEI releases within a census tract or within 5 km of a census tract
    c. **Chemical Released (Section 6.1.4)**: This metric analyses the number of chemicals released from the NEI releases database nationwide within each census tract or within 5 km of a census tract. Supporting figures and tables explained herein include:
        - Figure 6-4. Number of chemicals released within each census tract.
        - Figure 6-5. Number of chemicals released within 5 kilometers of each census tract.
        - Table 6-2. Number of released chemicals within a census tract and within 5 km of a census tract.
    d. **Regional Example (Section 6.1.5)**

- Figure 6-6. NEI releases and number of chemicals released from those facilities within 5 km of census tracts in a) Houston, Texas metropolitan area and b) Baton Rouge - New Orleans, Louisiana corridor.

e. **Chemical Risk Co-exposure (Section 6.2)**: This metric analyzed the number of chemicals per census tract exceeding investigated risk benchmarks as predicted by AirToxScreen. Supporting figures and tables explained herein include:
   - Figure 6-7. Number of chemicals per census tract exceeding the one-in-ten-million (10^{-7}) cancer risk benchmark within AirToxScreen.
   - Figure 6-8. Number of chemicals per census tract exceeding the one-in-a-million (10^{-6}) cancer risk benchmark within AirToxScreen
   - Table 6-3. Number of chemicals per census tract with greater than $1x10^{-7}$ cancer risk.
   - Table 6-4. Number of chemicals per census tract with greater than $1x10^{-6}$ cancer risk.

f. **Chemical Combinations Analysis (Section 6.3).** This metric analyzed the prevalence of chemical combinations exceeding risk thresholds as estimated by ATS. An example is given for all census tracts that had 12 chemicals greater than a $1x10^{-7}$ cancer benchmark in the following figure:
   - Figure 6-9. Distribution of chemical combinations for tracts with 12 chemicals greater than $1x10^{-7}$ cancer benchmark (n = 15,696 tracts nationwide with 148 unique combinations).

2) ***Chemical Risk Evaluations (Section 7).*** This scale of analysis is focused on evaluating chemical co-exposure as part of an individual chemical of interest by displaying and analyzing the individual chemical release locations, the nationwide individual estimated chemical risk, and then relating those patterns to the co-exposure of other chemicals. Two case studies have been developed with the chemicals selected based on the primary source of their exposures. These different sources of exposure result in different distributions of exposure and risk nationwide. Chemical A exposure and risk are primarily from secondary production, while Chemical B exposure and risk are primarily from stationary point and nonpoint releases. The chemicals evaluated represent actual chemicals within the ATS dataset, but actual identities are not provided here since this document describes a proposed approach and is not a risk evaluation. For Chemical A and Chemical B the following figures and tables are provided:

a. **Case Study for Chemical A (Section 7.2)**
   - Figure 7-1. NEI releases and estimated cancer risk within the AirToxScreen dataset for Chemical A. Data are shown by census tract. Data not shown for AK, HI, PR, and USVI.
   - Figure 7-2. Bivariate distribution of Chemical A cancer risk (in pink) with number of other chemicals with estimated risks greater than 1 in 10 million within AirToxScreen (in blue).
   - Table 7-1. Estimated risk of chemical A for census tracts within 5 km of a release with average and maximum number of co-occurring chemicals at the one in ten million and one in a million risk thresholds in those tracts.

b. **Case Study for Chemical B (Section 7.3)**
   - Figure 7-3. Estimated Cancer risk of Chemical B in AirToxScreen dataset.
   - Figure 7-4. Percent of total cancer risk for Chemical B from stationary point sources.

- Figure 7-5. Bivariate distribution of Chemical B cancer risk (in pink) with number of other chemicals with estimated risks greater than 1 in 10 million within AirToxScreen (in blue).
- Table 7-2. Estimated cancer risk of chemical B in census tracts within 5 km of a release with average and maximum number of co-occurring chemicals at the 1×10^{-7} and 1×10^{-6} risk thresholds in those tracts.

6 National and Regional Scale Chemical Co-exposure

The purpose of this investigation is to look at patterns of co-exposure ranging from the regional to national scale in support of identification of potential PESS. The first level of co-exposure analysis evaluates per census tract the number of releases and number of chemicals released at these locations. The focus of these analyses is on the documented number of facility releases and the associated chemicals released at these locations and not on the magnitude or potential risk associated with those releases or the identities of the chemicals that co-occur (Section 6.1). OPPT then investigates the number of chemicals per census tract reaching defined risk thresholds to identify screening level patterning of chemical co-exposure at these risk levels ranging from the regional to national scale (Section 6.2). Finally, OPPT analyzes the specific chemical combinations of tracts with the same number of co-occurring chemicals to determine whether some chemical combinations are more prevalent than others (Section 6.3).

Summary of Analysis Steps:

1. ***Evaluation of Facility Releases and Number of Chemical Releases (Section 6.1)***
    a. *NEI Download* **–** Provides the foundational and initial input data of release locations in latitude and longitude for the analyses performed in later steps (Section 6.1.1)
    b. *Analysis Steps* – The NEI spreadsheet tabular data was incorporated into a geographic information system (GIS) to aid in geospatial analysis (Section 6.1.2)
    c. *Facility Releases*– This step calculates the number of NEI release locations per census tract nationwide and the number of release locations within 5 km of a census tract nationwide (Section 6.1.3)
    d. *Chemicals Released* – This step calculates the number of chemicals released within a census tract nationwide and within 5 km of a census tract nationwide (Section 6.1.4)
    e. *Regional Example* – This step provides two more localized examples of the analyses performed in 1c and 1d to show how these analyses are useful across spatial scales (Section 6.1.5).
2. ***Evaluation of Chemical Risk Co-exposure (Section 6.2)***
    a. *AirToxScreen Download* – Provides the foundational and initial input data for the analyses performed in later steps (Section 6.2.1)
    b. *Analysis Steps* – This step calculates the number of chemicals per tract nationwide that have chemical with an estimated risk greater than either a $1x10^{-6}$ or $1x10^{-7}$ cancer risk benchmark (Section 6.2.2)
    c. *Cancer Risk Benchmark Analysis* – Description of findings and interpretation for the cancer risk benchmark analysis (Section 6.2.3)
3. ***Evaluation of Chemical Risk Chemical Combinations (Section 6.3)***
    a. *Analysis Steps* – This step describes the calculation of the modeled chemical co-exposure combinations to determine whether certain combinations co-occur with great frequency nationwide (Section 6.3.1)

b. *Chemical Co-exposure Combination Analysis* – Description of findings and interpretation for the chemical combination co-exposure analysis for tracts represented by 12 chemicals with greater than a $1x10^{-7}$ risk benchmark and 4 chemicals with greater than a $1x10^{-6}$ risk benchmark within a census tract nationwide. Twelve chemicals and four chemicals were chosen as example combinations as they represented the numerical combination having the most identified tracts nationwide at their respective risk benchmarks. (Section 6.3.2)

6.1 Evaluation of Facility Releases and Number of Chemicals Released

6.1.1 NEI Download

To begin characterizing chemical co-exposure, data for 2019 NEI facility releases was downloaded and extracted by EPA OPPT. This dataset documents point releases with a given latitude and longitude for each recorded release and the individual chemicals released at that location. These documented releases serve as an initial input into the ATS tool that is subsequently used to model total chemical exposure and risk for each of the evaluated chemicals. Please note that facility releases or stationary point sources are just one category of emissions included in ATS as described in Section 4.3. These data of facility releases are available at the ATS website and represents nearly 49,000 annual releases nationwide[18]. State, local, and Tribal agencies may vary in the degree of detail and completeness in the submitted data, but effort is taken to review the data to ensure the input data are as complete and accurate as possible prior to inclusion into ATS (U.S. EPA, 2022). It is important to note that documented releases within this dataset represent individual stack releases at the process level at a given location and that multiple releases of multiple chemicals may be occurring at a single facility location across the year. Therefore, it represents a more granular reporting dataset than other reporting databases such as TRI which combines releases to the facility level. For the purposes of this analysis, no effort was made to combine releases from individual process level releases that may occur at a single facility. Additionally, since emissions reporting protocols may vary across reporting agencies, some may choose to aggregate emissions points together while others may not. Finally, for this analysis the magnitude of a chemical release was not considered with the focus being on the location of release and the reported chemicals released at that location. For example, given two facilities with known releases within a census tract, a facility releasing a single kg per year was counted the same as a facility that may be releasing thousands of kg per year. While estimation of exposure relies on the amount of an emitted chemical, the evaluation of the number of releasing facilities as well as the chemicals released give a useful initial screening indicator of potential chemical exposure and risk. Identification of areas with more releases or more chemicals released may offer insight into areas needing particular focus or greater levels of evaluation.

6.1.2 Analysis Steps

Following download and extraction, the NEI dataset was incorporated into a geospatial information system (GIS) to allow for spatial analysis and tabulation (ArcGIS Pro Version 3.1, ESRI). Next, the number of NEI releases and number of chemicals released from those facilities within a census tract across the nation was summed by OPPT (Figure 6-1). Figure 6-1 shows a local scale example of number of facility releases within 5 km of a census tract boundary to highlight the methodology employed nationwide. It is important to note that the evaluation of number of releases and number of chemicals released should be considered separate from each other but give relevant information for

[18] Available at: https://www.epa.gov/AirToxScreen/2019-airtoxscreen-assessment-results under "2019 AirToxScreen emissions by facility (xlsx)" with downloadable file "point_fac_2019_emissions.xlsx" (accessed June 15, 2023)

characterizing chemical co-exposure. For instance, the evaluation of the number of facilities releasing per census tract does not consider what is released at these locations or how many chemicals are released, only that it has a documented release within the NEI. So given an example census tract with five documented releasing facilities, this analysis does not inform whether those five facilities are all releasing the same chemical or multiple. Similarly, the analysis of number of chemicals released per census tract does not consider the potential number of release locations. While caution was taken to not double count numbers of chemicals released within a census tract given that multiple facilities could be releasing the same chemical, this analysis does not inform whether all the chemicals released within a census tract occur at a single facility or many.

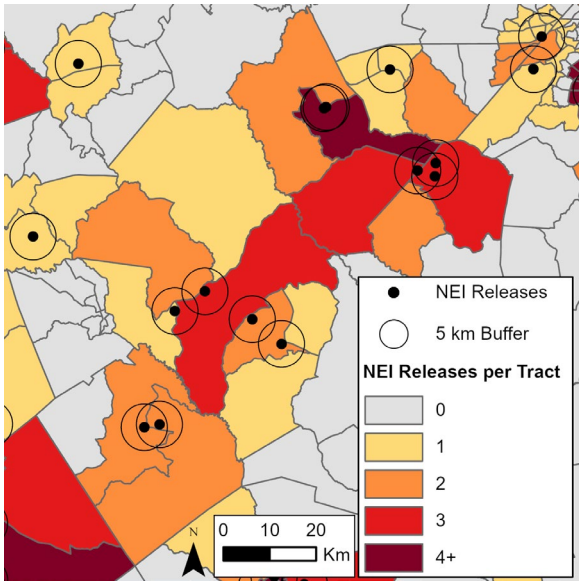

Figure 6-1. Example of number of NEI facility releases by census tract. Each NEI release is shown with its 5 km buffer and census tracts are shaded based on the number of facility releases within 5 km of each tract. Scale: 1:1,400,000

As described above, census tracts are a non-uniform measure of geographic area with urban locations tending to have multiple small area tracts, while more rural locations are characterized by larger area tracts. Chemical releases are known to transport in some cases tens of kilometers from their release location, so limiting the evaluation to the census tract where a chemical is initially released may give an incomplete picture of possible chemical co-exposure to surrounding communities. To better evaluate neighboring locations that could be considered PESS and may be exposed due to releases outside their immediate census tract, a second analysis was conducted where release locations were buffered at a 5 km radius. For each census tract, the total number of facility releases and the chemicals released by that facility whose 5 km buffer intersected the census tract boundary were summed. For this analysis, the primary direction of transport (e.g., downwind vs. upwind) and resultant variation in exposure concentrations around a releasing facility were not considered. All tracts within the 5 km buffer were considered equally impacted as an initial screen of potentially affected areas. It is understood that within ATS that chemical releases and their resultant exposure concentrations are modeled up to 50 km away from its emitting source, but the 5 km radius is intended to identify those facilities contributing closer to a geographic area where potential exposures and risk would generally be expected to be higher with identification of potential overburdened communities more likely.

6.1.3 Facility Releases

EPA OPPT started by evaluating the number of facility point releases. A total of 48,690 release locations were evaluated with those releases occupying 18,189 census tracts out of 73,426 nationwide (Table 6-1). The number of releases per tract ranged from one to 210 with a median of one release and mean of 2.6 releases for all tracts having at least one release. Higher number of releases are shown in Wyoming, Colorado, and California (Figure 6-2).

Buffering of release locations by a radius of five kilometers increased the number of tracts potentially influenced by a reported release to 63,496 tracts out of 73,426 nationwide having at least one release

intersecting its perimeter and a five-fold decrease in number of tracts with no releases (Table 6-1). With the five km buffer around releasing facilities, the median number of releases per tract increased to five releases per tract, with a mean of 16.8 releases and a maximum of up to 846 releases within a tract. Tracts within Wyoming, Colorado, and California continue to show the highest numbers of releases per tract (Figure 6-3).

It is important to note that some of the higher frequency of releases observed in the tracts in these locations is influenced by the size of the census tracts in these areas. Census tracts have no defined shape or areal extent but attempt to encompass areas of comparable population (See Section 4). Therefore, census tracts in rural locations tend to be larger in area, while those in urban locations tend to be smaller. The larger, more rural tracts in many instances have more releases within or adjacent to their boundaries by their areal size and perimeter alone, as in some cases the tracts themselves are tens of kilometers on a side or thousands of square kilometers in area. Additionally, with the larger areas it makes it more likely that potential exposures and risks from these releases do not overlap in a true sense. Further, in the larger tracts, the proximity of releases to actual population centers or locations where people reside may be less. No effort was made in these analyses to look at the proximity of the general population to actual releases or quantify the number of potential people exposed. The smaller, more granular boundaries associated with more urban census tracts are likely to give more representative measures of potential exposure and risk, particularly at smaller distances.

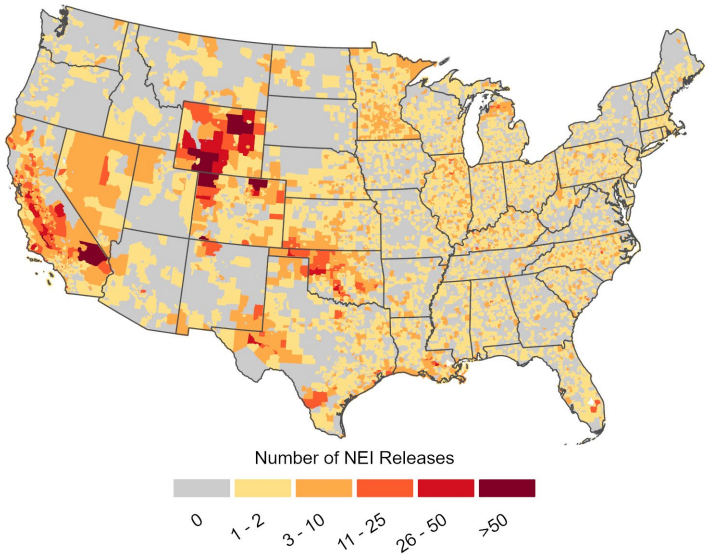

Figure 6-2. Number of NEI releases within a census tract.
Category breaks are based on natural breaks in the overall distribution. Scale 1:50,000,000. Data not shown for AK, HI, PR, or USVI.

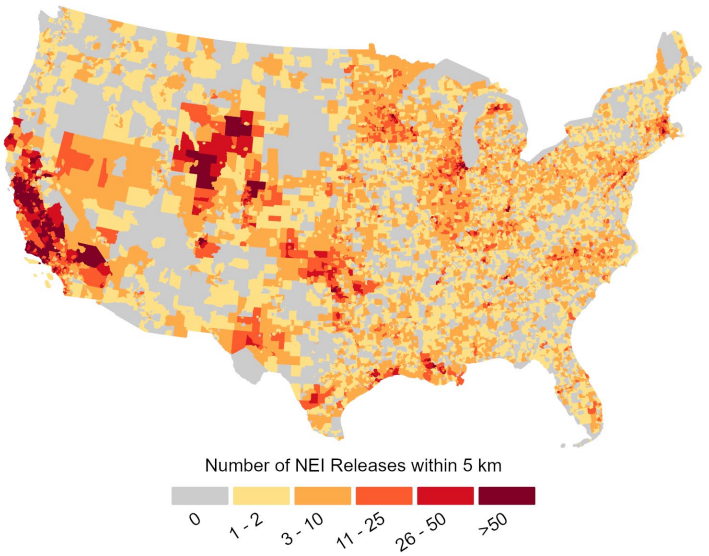

Figure 6-3. Number of NEI releases within 5 km of a census tract.
Category breaks are based on natural breaks in the overall distribution. Scale 1:50,000,000. Data not shown for AK, HI, PR, or USVI.

Another consideration is that this metric measures the presence of release locations over an annual scale and does not inform the

magnitude or frequency of those releases or the released air toxics. Therefore, this metric cannot reliably inform whether these releases are simultaneous or overlapping in nature. Additionally, the different reporting protocols and decisions on whether to aggregate emissions across different reporting agencies likely plays a role in the observed patterns and influences the interpretation of this metric, particularly when comparing between locations with different reporting agencies. While expert judgement should be used when interpreting this metric in terms of potential impact on actual exposure and risk, it does provide insight into where releases of air toxics are clustered and shows that even with a relatively modest buffer size of 5 km around each release location, the number of releases intersecting a census tract increases markedly and the number of census tracts subject to no facility releases decreases markedly. With the potential for impacts from facility releases to extend tens of kilometers beyond their release location, actual influences on a census tract may be higher. While EPA OPPT suggests this metric be used in conjunction with other measures of exposure (like release magnitudes), this analysis suggests that many locations are subject to the co-exposure of multiple release locations and this metric is useful when conducting a screening level evaluation of chemical co-exposure and identification of possible overburdened communities and identification of areas best served by additional analysis and higher tier evaluation.

Table 6-1. Number of NEI releases within a census tract or within 5 km of a census tract

Number of NEI Releases	Within a Tract		Within 5 km of a tract	
	Number of tracts[1]	Percent of all	Number of tracts	Percent of all
0	55,237	75.2	9,930	13.5
1 – 2	13,326	18.1	16,929	23.1
3 – 10	4,286	5.8	26,819	65.5
11 – 25	481	0.7	11,463	15.6
26 – 50	78	0.1	4,198	5.7
>50	18	< 0.1	4,087	5.6
Non-zero	18,189		63,496	
Mean/median of non-zero release tracts	2.6/1		16.8/5	
Maximum	210		846	

[1]Nationwide there are 73,426 evaluated tracts

6.1.4 Chemicals Released

Given the previous metric is not intended to inform the air toxics being released at a particular location, a similar exercise was done to evaluate the number of chemicals released from these reported facilities both within the tract (Figure 6-4) and within 5 km of a tract (Figure 6-5). When looking at the number of chemicals released within a tract alone, 16,645 tracts have at least one chemical released (23%), while 56,781 have no chemicals released (77%) (Table 6-2). Due to the large number of tracts with zero releases, the mean and median number of released chemicals for all tracts nationwide is 2.1 and 0

respectively. When only the non-zero tracts are considered, the mean and median number of chemicals released per tract are 9.4 and 9 indicating that tracts often have multiple chemical releases without consideration of any transport from the source. Spatially, the tracts with the highest chemical counts appear in Minnesota, Wyoming, and California, but several other states have numerous tracts with at least 20 chemicals released per tract.

Given that chemicals can often be transported tens of kilometers from their source location and across census tract boundaries (particularly in urban areas where tracts are smaller in size), OPPT also evaluated the number of chemicals released within 5 kilometers of a census tract as a proxy for nearer-source exposure. Nationwide, over 83% of all census tracts have at least 1 chemical released within 5 kilometers of their boundary.

Number of chemicals released to census tracts nationwide ranged from 1 – 62 chemicals with the mean and median number of chemicals released within 5 km of all census tracts being 11.8 and 12 respectively (Table 6-2). Evaluating just the tracts with at least one released chemical resulted in increased means and medians of 14.2 and 13 chemicals per tract respectively. Nationwide, there is observed spatial patterning of locations with higher numbers of chemical releases such as in Minnesota, Wyoming, California, Illinois, and portions of the southeastern U.S. (Figure 6-5).

Many of the uncertainties with this metric are similar to those discussed for the Facilities Released metric discussed in Section 6.1.3. Both the lack of spatial, temporal, and chemical magnitude considerations along with the lack of uniformity in reporting to the NEI discussed in the previous section are relevant for this metric. Larger area tracts that may have more chemical releases due to

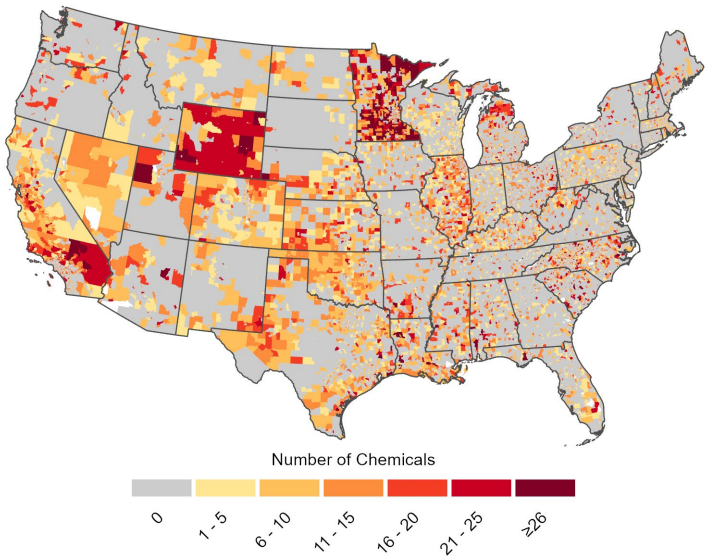

Figure 6-4. Number of chemicals within each census tract.
Scale = 1:50,000,000. Data not shown for AK, HI, PR, or USVI.

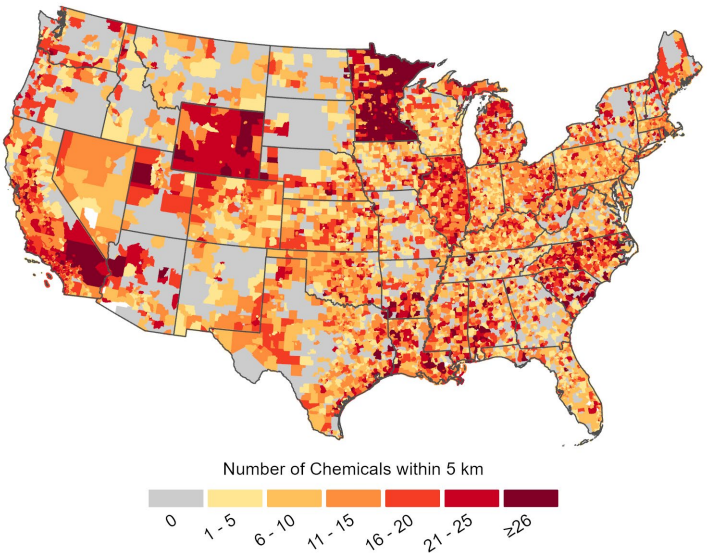

Figure 6-5. Number of chemicals within 5 km of each census tract.
Scale = 1:50,000,000. Data not shown for AK, HI, PR, or USVI.

their size subsequently may have a wider range of chemicals released from those locations. Additionally, this metric is unable to inform the nature of when these chemicals are released from their releasing locations at less than an annual timescale. Therefore, it is unknown whether an individual is exposed to all these potential chemicals simultaneously and/or continuously over the course of a year. This metric is also unable to determine the magnitude of exposure or risk to an individual within a census tract or the exact proximity of that person to an actual release. Greater granularity in these components and/or consistency in reporting nationwide would offer an improved estimation of chemical co-exposure. Finally, many release locations may release multiple chemicals over the course of a year and many locations in geographic proximity release the same chemical. Therefore, OPPT suggests this metric be used in combination with other metrics discussed in this paper to get a fuller accounting and explanation of chemical co-exposure.

EPA OPPT shows that this metric is a useful screening tool towards assessing chemical co-exposure at regional to national scales and aids in the identification of potential PESS. This analysis shows that greater than half of all tracts have 11 or more chemicals released within 5 km of their tract boundary (Table 6-2). Keeping in mind the uncertainties described above, the presence and release of multiple chemicals to a census tract is oftentimes common. While the magnitude of the exposures and potential risk arising from those chemical releases should be considered in a full risk evaluation, this metric can serve to quickly identify locations subject to multiple chemical releases and highlight those areas needing greater evaluation of chemical co-exposure.

Table 6-2. Number of released chemicals within a census tract and within 5 km of a census tract.

Number of Chemicals Released	Within a tract[1,2]		Within 5 km of a tract[1]	
	Number of Tracts	Percent of all	Number of Tracts	Percent of all
0	56,781	77.3	12,441	16.9
1 – 5	5,246	7.1	7,578	10.3
6 – 10	4,867	6.6	12,146	16.5
11 – 15	4,341	5.9	17,734	24.2
16 – 20	1,231	1.7	10,808	14.7
21 – 25	634	0.9	9,263	12.6
≥26	326	0.4	3,456	4.7
Mean/Median w/ zero tracts	2.1/0		11.8/12	
Mean/median of non-zero tracts	9.4/9		14.2/13	
Maximum	62		62	

[1]Census tracts with either no land area or no population are omitted from analysis.
[2]Nationwide there are 73,426 evaluated tracts

6.1.5 Regional Example

The investigation in Sections 6.1.3 and 6.1.4 show the number of NEI releases per tract and the number of chemicals released per tract is potentially more informative and illustrative in identifying prospective overburdened communities as PESS at more granular spatial scales (e.g., regional). Figure 6-6 shows two example locations within the Houston, Texas and Baton Rouge-New Orleans, Louisiana regions. For each location, this analysis shows geographic differentiation with the eastern side of Houston and the western sides of Baton Rouge and New Orleans showing tracts with higher numbers of released chemicals and greater densities of NEI releases. Visualizing these indicators in this manner can aid in identifying areas of potentially greater chemical co-exposure and highlight areas of potential PESS for focused consideration in a chemical risk evaluation.

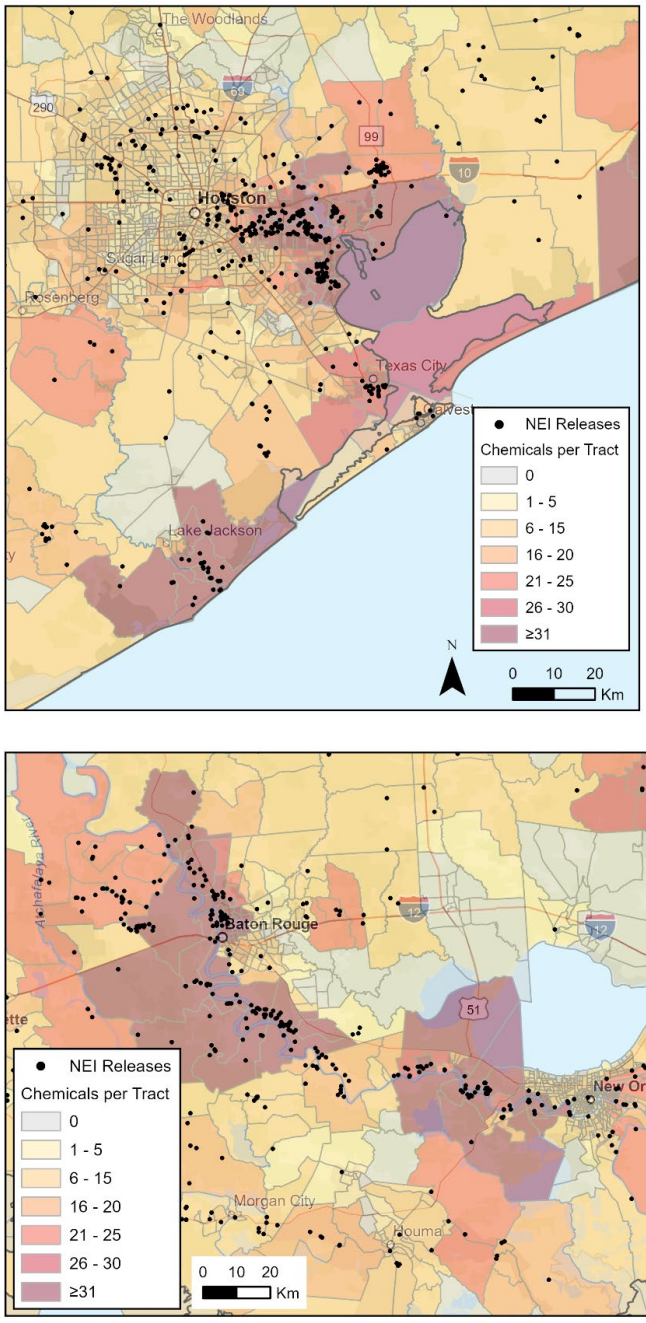

Figure 6-6. NEI releases and number of chemicals released from those facilities within 5 km of census tracts in a) Houston, Texas metropolitan area and b) Baton Rouge - New Orleans, Louisiana corridor. Basemap credits are via World Street Map in ArcGIS Pro.

It is noted that these evaluations are a measure of exposure to different chemicals based purely on the presence of a release location or presence of a released chemical but does not incorporate the magnitude of those releases or the potential risk associated with those releases. For instance, a release of a single kg of a given chemical is treated the same as a potential release of 100 kg. Similarly, while all the chemicals evaluated as part of this evaluation are considered HAPs, releases associated with different chemicals are treated equally, independent of the hazard associated with a particular chemical. As noted above, this analysis is also partially dependent on the size of the census tracts as they are not uniform in size. As discussed previously, tracts with larger areal extent (e.g., in rural locations) may capture more potential releases and numbers of released chemicals due to their size. Despite these limitations, in both example

regions areas of higher NEI releases and chemicals released (e.g., higher point density for NEI releases and darker red colors representing more chemicals released in Figure 6-6) span a spectrum of tract sizes. Along with the observed geographic differentiation, this process highlights the utility of these indicators for identifying locations prone to chemical co-exposures from the regional to national scale. Using these indictors to identify locations more prone to these co-exposures allows for better identification of potential overburdened communities. It also aids in identifying locations needing higher tier modeling or analysis to determine exposure informing risk in a risk evaluation.

6.2 Evaluation of ATS Estimated Chemical Risk Patterning

6.2.1 ATS Download

To assess patterns of national-scale chemical co-occurrence associated with ATS derived cancer risk estimates, data from the modeled ATS results for national cancer risk summaries were downloaded and extracted by OPPT[19]. For this dataset, ATS derived cancer estimates characterizes the potential lifetime cancer risks greater than levels of concern (e.g., 1 x 10^{-7}) in each census tract nationwide. Within this dataset, ATS sums the risk contribution from each individual chemical modeled within the tract to calculate a total cancer risk. EPA OPPT is not using the combined total cancer risk values across chemicals that are calculated by ATS since EPA OPPT has not confirmed the hazard cancer values used in ATS as would be necessary to comply with the best available science requirement under TSCA. Moreover, adding potential cancer risks across different tissue types and different modes of action brings in additional uncertainty and methodological considerations that are outside the scope in this co-exposure methods development draft document.

6.2.2 Analysis Steps

Rather than sum all the potential lifetime cancer risks associated with chemicals occurring within a census tract, EPA OPPT elected to look at the estimated cancer risk associated with each chemical independent of the other chemicals co-occurring within the census tract and to characterize co-exposure as the number of chemicals meeting specific cancer risk thresholds. The modeled data may be filtered to look at various thresholds of interest, but EPA OPPT has focused this analysis by separately characterizing the number of chemicals in each tract meeting a 10^{-7} and a 10^{-6} cancer benchmark. All chemicals with estimated risks meeting these benchmarks within each census tract were identified and summed. For instance, consider the analysis exploring the co-exposure of chemicals within census tracts with a 10^{-6} cancer benchmark or greater. Given an example census tract with three different chemicals having estimated risks of 5 x 10^{-6}, 4 x 10^{-6}, and 2 x 10^{-7} respectively, the methodology would identify 2 chemicals co-occurring in that census tract at the explored benchmark. This process was repeated for all census tracts nationwide and following filtering and synthesis of the tabular data, these data were incorporated into a GIS to aid in mapping of trends nationwide and further geospatial analysis. For this analysis, the focus is on the number of chemicals above an investigated benchmark within a census tract and not their individual chemical identities (but see Section 6.3). For instance, separate tracts each with 5 chemicals above a benchmark may be composed of the same five chemicals in each or exhibit different combinations of five chemicals.

[19] Available at: https://www.epa.gov/AirToxScreen/2019-airtoxscreen-assessment-results under "2019 AirToxScreen National Cancer Risk by pollutant" with downloadable file "2019_National_CancerRisk_by_tract_poll.xlsx. (accessed June 15, 2023)

Within EPA OPPT, a 1×10^{-6} cancer benchmark is oftentimes used as an indicator of risk to the surrounding general population. Meanwhile, a 1×10^{-7} benchmark was also explored as an indicator of chemicals that may warrant additional scrutiny in locations where multiple chemicals may be present. No effort is made in this analysis to add those risks together and no policy implications should be inferred from these selected cancer benchmarks, but these thresholds are chosen to illustrate the proposed methodology and identify locations where chemicals with potential risk may be clustered and warrant additional evaluation.

6.2.3 Cancer Risk Benchmark Analysis

Section 6.1 evaluates the number of facility releases and the number of chemicals emitted by those facilities, and while informative as indicators of chemical co-exposure, those analyses do not explicitly inform the potential risk associated from those chemicals. While all the chemicals within ATS are considered HAPs, they can vary in their hazard and potency. To get a better characterization of chemical co-occurrence that may need additional evaluation by EPA OPPT, the modeled risk values for each chemical in each census tract nationwide was extracted from the ATS dataset. Within each tract, the number of chemicals reaching estimated cancer benchmarks of greater than 1×10^{-6} or 1×10^{-7} was summed. Figure 6-7 and Figure 6-8 illustrate the geographic distribution of number of chemicals per tract greater than the 1×10^{-7} and 1×10^{-6} benchmarks respectively within the ATS dataset. For tracts with chemicals greater than the 1×10^{-7} benchmark, the number of chemicals per tract ranged from 3 to 22 per tract with a mean of 10.9 and a median of 11 chemicals (Table 6-3). Areas of higher number of chemicals per tract include the upper Midwest and various major population centers throughout the nation (Figure 6-7). When the evaluated cancer benchmark is raised to greater than 1×10^{-6}, the number of chemicals per tract necessarily decreases with number of chemicals ranging from two to eleven chemicals per tract with a mean of 4.5 and median of 4 chemicals per tract (Table 6-4). Observed areas of potentially higher number of chemicals per tract include the western part of Oregon and major population centers nationwide (Figure 6-8).

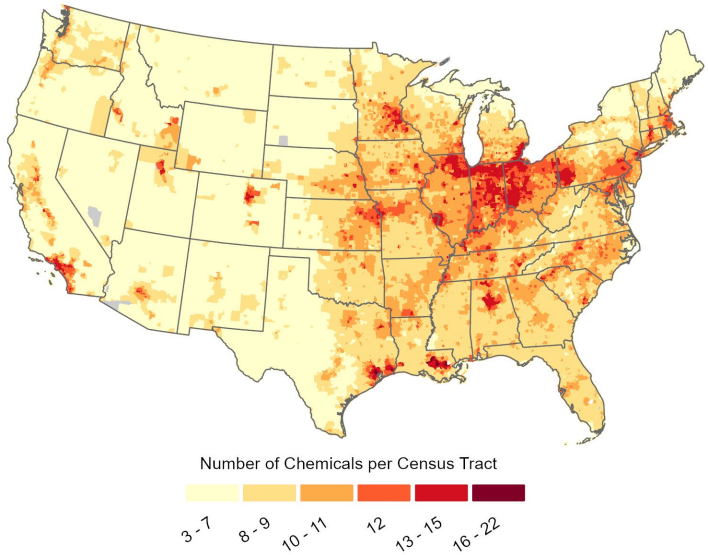

Figure 6-7. Number of chemicals per census tract exceeding the one-in-ten-million (1×10^{-7}) cancer risk benchmark within AirToxScreen.
Note areas in grey represent those tracts having no land area, population, or match within the ATS dataset. Scale 1:50,000,000. Data not shown for AK, HI, PR, and USVI.

Additionally, this methodology allows for the evaluation of chemical co-exposure across various potential estimated cancer risk benchmarks and the calculation of the change in number of co-occurring chemicals across those evaluated benchmarks. As observed here, a change in just one order of magnitude in estimated risk can change the number of co-occurring chemicals markedly (Figure 6-7 vs. Figure 6-8). For instance, nationwide the change from a 1×10^{-6} estimated cancer risk benchmark to a

1×10^{-7} benchmark resulted in 6.4 additional co-occurring chemicals per tract on average (max of 15) and an average increase in number of co-occurring chemicals at that benchmark by 152% (max of 500%). Identifying these areas of marked change may be useful in identifying areas where chemical co-exposure could have differential influence(s) with relatively small changes in estimated risk.

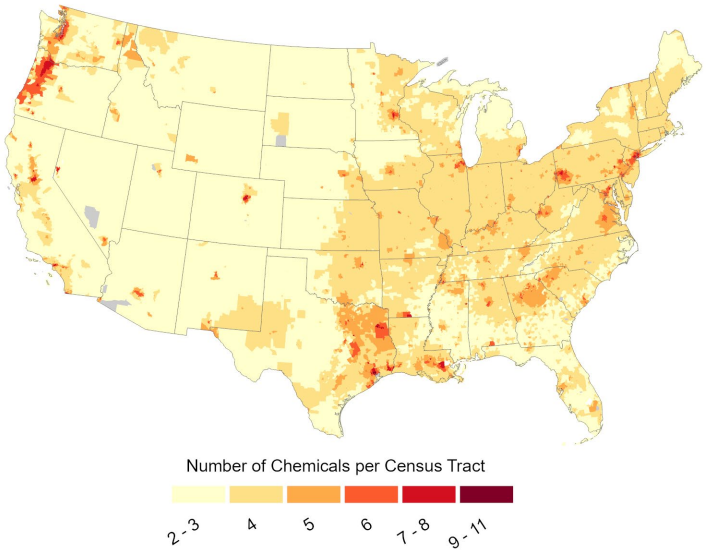

Figure 6-8. Number of chemicals per census tract exceeding the one-in-a-million (10^{-6}) cancer risk benchmark within AirToxScreen
Note areas in grey represent those tracts having no land area, population, or match within the ATS dataset. Scale 1:50,000,000. Data not shown for AK, HI, PR, and USVI.

These proposed analyses may be useful for identifying areas of possible PESS and in prioritizing target areas that may need additional modeling and analysis to determine risks to the general population. As mentioned previously, EPA OPPT is not taking a combined measure of these risk thresholds or using the total cancer risk metric within ATS since EPA OPPT has not confirmed the hazard cancer values used in ATS as would be necessary to comply with the best available science requirement under TSCA. Further, the additional uncertainty and methodological considerations associated with adding cancer risks across different tissue types and different modes of action are outside the scope of this draft document. Nevertheless, this methodology does highlight and aid in identifying areas subject to multiple co-occurring chemicals, how those patterns change with evaluated cancer risk benchmarks, and where further investigation using a combined chemical approach may be appropriate for addressing potential risk.

Table 6-3. Number of chemicals per census tract with greater than $1x10^{-7}$ cancer risk.

Number of Chemicals	Number of Tracts[1]	Percentage
3 – 7	4,307	5.9%
8 - 9	14,313	19.5%
10 - 11	22,806	31.1%
12	15,696	21.4%
13 – 15	15,963	21.7%
16 – 22	330	0.5%
Sum	73,415	
Mean/Median number of chemicals	10.89/11	

[1]Census tracts with either no land area or no population are omitted from analysis

Table 6-4. Number of chemicals per census tract with greater than $1x10^{-6}$ cancer risk.

Number of Chemicals	Number of Tracts[1]	Percentage
2 – 3	9,494	12.9%
4	34,805	47.4%
5	16,962	23.1%
6	7,947	10.8%
7 – 8	4,136	5.6%
9 – 11	71	0.1%
Sum	73,415	
Mean/Median number of chemicals	4.47/4	
[1]Census tracts with either no land area or no population are omitted from analysis		

6.3 Evaluation of Chemical Risk Combinations

6.3.1 Analysis Steps

The analysis in Section 6.2 evaluates the number of chemicals per census tract nationwide reaching relevant estimated risk thresholds of either 1×10^{-6} or 1×10^{-7} but does not inform the chemicals occurring within those chemical combinations. For instance, when comparing two separate tracts each with 5 chemicals above a benchmark, those two tracts may be composed of the same five chemicals in each or exhibit different combinations of five chemicals. In this section, EPA OPPT explores the combinations of co-occurring chemicals making up that potential mixture to discern whether certain chemical combinations may co-occur with more frequency over other chemical combinations. Understanding the extent to which certain chemical combinations co-occur with greater frequency on the landscape or in particular geographic locations may be useful information for determining which potential chemical mixtures could be impacting potential PESS and/or identifying which chemicals may warrant evaluating in combination.

Using the ATS dataset described and analyzed in Section 6.2 the data were filtered to bin all tracts of the same number of potentially co-occurring chemicals above the evaluated risk thresholds. Once binned, the chemical identities of the different combinations were filtered and summed. As numbers of co-occurring chemicals within a tract increase, the numbers of possible combinations of those chemicals also increase, with potentially hundreds of different chemical combinations. This analysis focuses on those chemical combinations that make up more than 1% of the total number of tracts for that chemical co-exposure class number. Similar to the analysis in Section 6.1.4, this analysis is limited by the annual scale of the ATS dataset, and it is not possible to discern whether all these potential chemical combinations would occur at smaller or overlapping time scales. While the combinations of chemicals found within these classes represent real identifiable chemicals within the ATS dataset, the identities of those individual chemicals have been anonymized as the focus here is on methodology and utility of this approach and not for risk evaluation at this time.

6.3.2 Chemical Co-exposure Combination Analysis

Here EPA OPPT shows an example using the dataset compiled for chemicals greater than a 1×10^{-7} risk benchmark. Within this dataset, nationwide the number of co-occurring chemicals with greater than a 1×10^{-7} risk benchmark ranged from three to 22 chemicals per tract, with 12 chemicals per tract having the highest number of tracts overall representing 15,696 tracts or 23% of all tracts nationwide (Table 6-3). Within the tracts composed of 12 chemicals above a 1×10^{-7} cancer risk benchmark there were a total of 148 different 12-chemical combinations. Of those 148 different 12-chemical combinations, only four of those combinations were found at a frequency greater than 1% of all census tracts with 12 co-occurring chemicals (Figure 6-9). In fact, over half of all the tracts with 12 chemicals greater than a 1×10^{-7} estimated cancer risk benchmark are represented by a single combination (e.g., Combo I in Figure 6-9). The highlighted four 12-chemical combinations represent nearly 75% of all tracts in this chemical number class.

This pattern of a few chemical combinations making up the majority of a chemical number class holds if looking at tracts with the numbers of co-occurring chemicals in a tract greater than a 1×10^{-6} cancer benchmark as well (Figure 6-8). In this case, at the 1×10^{-6} cancer benchmark, 47% of all tracts nationwide (34,806 tracts) have four co-occurring chemicals greater than this benchmark (Table 6-4). Within those tracts with four co-occurring chemicals greater than a 1×10^{-6} cancer benchmark, those tracts are represented by 23 unique four-chemical combinations. For instance, a tract with Chemicals A, B, C, and D greater than a 1×10^{-6} cancer benchmark would be unique from a tract with Chemicals A, B, C, and E. However, only two of those 23 combinations are found in >1% of tracts in this chemical class and 97% of all tracts in this four-chemical class are identified by the same chemical combination of four chemicals.

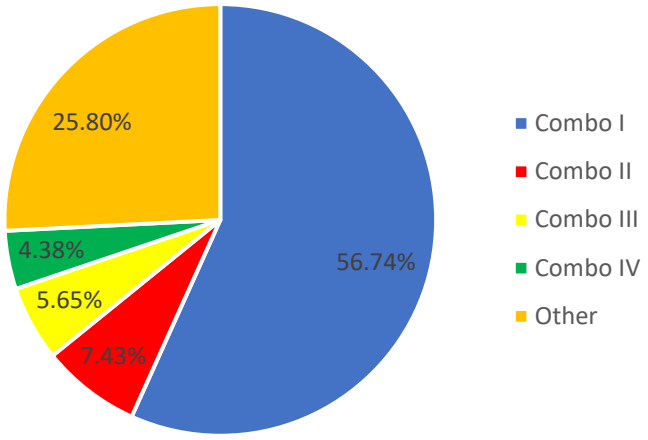

Figure 6-9. Distribution of chemical combinations for tracts with 12 chemicals greater than $1x10^{-7}$ cancer benchmark (n = 15,696 tracts nationwide with 148 unique combinations).
Combos I, II, III, and IV are those chemical combinations making up greater than 1% of all tracts with 12 chemicals. "Other" category represents the combined total of 144 other 12 chemical combinations in this class.

While shown here for the number of co-occuring chemicals most prevalent at the census-tract level nationwide for each of the investigated cancer benchmarks, this pattern largely remains consistent across tracts with different numbers of co-occurring chemicals present regardless of the evaluated cancer benchmark. Namely, the combinations of chemicals making up tracts of different numbers of co-occurring chemicals tends to be dominated by just a few unique chemical combinations and many other combinations being much less than 1% of the chemical number class. This relative consistency in identified chemicals contributing to estimated exposure and potential risk within census tracts offers the opportunity for better targeting of these combinations and investigations into their possible interactions. Given that the interactions of chemical mixtures are often poorly understood, the

identification of chemical combinations that may co-occur with greater frequencies is useful in development of research into the effects of these chemical combinations.

While the focus here has been at the nationwide scale, it is possible that more unique combinations of co-occurring chemicals may drive exposure at localized scales. For example, if an evaluation is occurring at a regional or even individual site scale, a unique chemical combination at that scale may have a disproportionate representation as compared to national trends or patterns. Knowing which chemical combinations are co-occurring could likely be useful in better determining exposure and risk in a targeted risk evaluation. Similarly, if a particular chemical co-exposure combination is known to be of interest for evaluating combined chemical risk, the location and frequency of that combination is easily identified using this approach. This methodology is adaptable across research scales to aid in identifying these more unique examples for targeted evaluation depending on the geographic scope of the assessment.

7 Chemical Specific Co-exposure

The largely chemical independent analyses explored in Section 6 are informative in characterizing chemical co-exposure patterns at the regional and national levels and work is in progress about how best to incorporate these types of information into risk assessments and risk evaluations. However, most risk assessments and risk evaluations are conducted based on an individual chemical of interest. To evaluate how information about chemical co-exposure could be combined with information about exposure and risk of an individual chemical, this section evaluates two chemical specific case studies from available ATS modeling results. In these case studies, information about the distribution of modeled exposure, risk and source characterization from an individual chemical is combined with the analysis investigating number of chemicals reaching a 1×10^{-7} risk benchmark in census tracts nationwide as described in Section 6.2. The choice of this evaluated risk benchmark is again selected to illustrate this methodological approach and is not intended to imply any policy or risk characterization implications.

Summary of Steps

1) ***Analysis steps (Section 7.1)***
    a. *NEI data preparation* – NEI release location data described in Section 6.1.1 is filtered for release locations of case study chemicals with given latitude and longitude.
    b. *Incorporation of data into GIS for geospatial analysis* – The spreadsheet tabular data is incorporated into a GIS for use in geospatial analysis.
    c. *Calculation of census tracts containing specific chemical releases and census tracts within 5 km of a chemical specific release* – This step identifies census tracts containing a case study chemical release or a chemical release within 5 km at the nationwide scale.
    d. *ATS download* – ATS data product that characterizes chemical specific risk attributed to various source categories.
    e. *Calculation of source categorization percent risk* – Using the downloaded ATS dataset, calculate the percent of overall risk attributed to source categories. For purposes of this analysis, OPPT chose two chemicals: one whose overall risk was primarily due to secondary production and another whose risk is due to point and nonpoint source contributions. Resulting tabular data incorporated into GIS for further analysis and visualization.

f. *Characterize bivariate distribution of chemical risk with prevalence of chemical co-exposure* – Using GIS, map and analyze the distribution of individual chemical risk and prevalence of chemical co-exposure.

2) ***Case Study for Chemical A (Section 7.2)*** – Description and interpretation of bivariate analysis of individual chemical risk for Chemical A combined with other chemical co-exposure. Chemical A risk is characterized by contributions from secondary production.

3) ***Case Study for Chemical B (Section 7.3) –*** Description and interpretation of bivariate analysis of individual chemical risk for Chemical B combined with other chemical co-exposure. Chemical B risk is characterized by contributions from point and nonpoint sources.

7.1 Analysis Steps

First, the NEI facility dataset described in Section 6.1.1 was filtered for the case study pollutant of interest and NEI release locations incorporated into a GIS based on a given latitude and longitude. For this characterization, the selected case study chemicals represent real chemicals within the NEI dataset, but they have been anonymized to focus on the methods employed. Following incorporation of known chemical-specific facility locations into a GIS, census tracts containing releases as well as census tracts within 5 km of a release were identified.

Next, ATS data offering pollutant specific results with estimated exposure concentrations, cancer risk, and source characterization at the census tract level was downloaded from the ATS website and incorporated into the GIS.[20] For each modeled chemical, ATS estimates per census tract the total cancer risk due to various chemical releases sources including: major stationary, nonpoint, mobile, fires, biogenic, secondary and background (U.S. EPA, 2022). The source characterization information estimates the risk from each of the evaluated source pathways per census tract and then sums those pathways for a total estimated risk for that chemical in a census tract. Using this information, OPPT calculated a percentage of the total risk resulting from each source pathway for each individual census tract as well as a chemical nationwide average. For instance, in a hypothetical census tract for the evaluated chemical, there are modeled cancer risks of 3×10^{-6} from point sources, 1×10^{-6} from mobile sources, and 1×10^{-6} from secondary production, resulting in a total estimated cancer risk of 5×10^{-6}. In this example, 60% of the estimated total risk (e.g., $3\times10^{-6}/5\times10^{-6}$) would be coming from point sources and 20% each from mobile and secondary sources (e.g., $1\times10^{-6}/5\times10^{-6}$). For the two chemicals case studies, OPPT chose a chemical whose overall risk was predominantly through point and nonpoint source contributions and another whose risk was predominantly via secondary production.

With modeled ATS information of the individual chemical cancer risk at each census tract nationwide, OPPT next overlaid the chemical co-exposure information described in Section 6.2.3 in the developed GIS. Together these two data layers are used to characterize the numbers of co-occurring chemicals across the individual chemical risk distribution. For instance, given bins of modeled risk for the individual chemical, are there observed differences in the number of other co-occurring chemicals in these identified tracts? Additionally, a bivariate analysis using these combined datasets was developed geospatially to identify patterns of where these variables are low to high by themselves as well as together. For instance, this analysis allows for a screening level evaluation nationwide that is able to identify where both of these components are high (e.g., both high individual chemical risk with high

[20] Available at: https://www.epa.gov/AirToxScreen/2019-airtoxscreen-assessment-results under "Pollutant Specific Results"

numbers of other chemicals) as well as the prevalence of other chemicals co-occurring in tracts where the individual chemical is released.

OPPT uses a case study approach using two example chemicals to evaluate how individual chemical information on exposure and risk can be joined with co-exposure information about other chemicals in the ATS dataset. The results from both evaluated chemicals are described and interpreted from the regional to the national scale. OPPT shows how relating individual chemical risk with possible risk from other chemical co-exposures can be used to better inform possible general population risk and identify areas potentially needing higher tiers of evaluation in an individual chemical risk evaluation.

7.2 Case Study for Chemical A

Figure 7-1 shows the ATS modeled cancer risk per census tract nationwide for Chemical A. Chemical A has over 22,000 unique NEI releases, leading to modeled cancer risks between 0.23 – 4.46×10^{-6} within the ATS dataset. The majority of the risk associated with this chemical is due to secondary production as, on average nationwide, 74% of modeled total Chemical A risk within a census tract is attributable to secondary production. Geospatially, modeled risk is highest in the southeastern United States, but with large portions of the United States showing an estimated risk of greater than 1×10^{-6} (Figure 7-1).

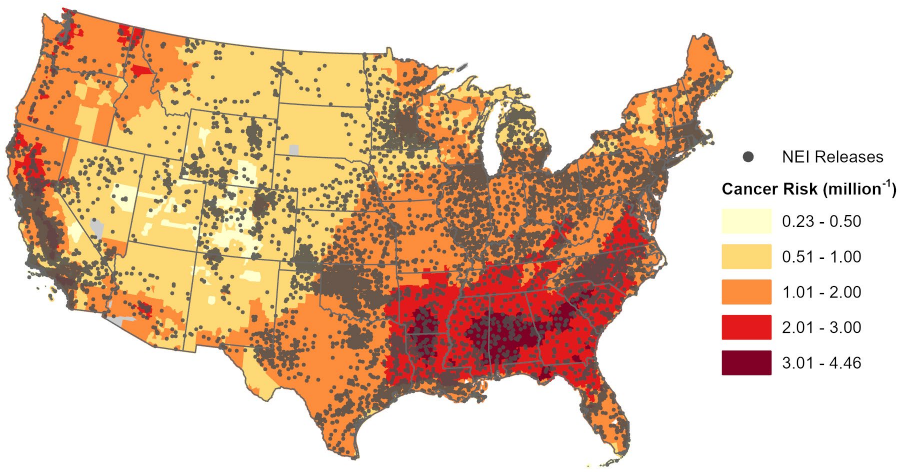

Figure 7-1. NEI releases and estimated cancer risk within the AirToxScreen dataset for Chemical A.
Data are shown by census tract. Data not shown for AK, HI, PR, and USVI.

While this evaluation of Chemical A risk and its releases from the ATS dataset is informative, it does not give information about the potential co-exposure due to other chemicals and potential risks from those chemicals where Chemical A is released. Using the data compiled nationally in Sections 6.1 and 6.2, tracts where Chemical A has a documented release is compared to all tracts within 5 km of a documented Chemical A release (Table 7-1). Focusing on results for those tracts within 5 km of a release, over 49,000 census tracts have a NEI release of Chemical A within 5 km. The estimated cancer risk for Chemical A in those tracts range from 0.23 – 4.40×10^{-6}, with the majority of identified tracts having estimated risks from Chemical A between 1 – 2×10^{-6} (Table 7-1).

Using the national co-exposure data developed in Section 6.2 for evaluation of chemical risk, for census tracts with an estimated Chemical A risk greater than 1×10^{-6}, on average 10.0 – 10.6 co-occurring chemicals have estimated cancer risks greater than 1×10^{-7} cancer risk and as many as 21 other

Table 7-1. Estimated cancer risk of chemical A for census tracts within 5 km of a release with average and maximum number of co-occurring chemicals at the 1×10^{-7} and 1×10^{-6} risk thresholds in those tracts.

Chemical A Risk ($\times10^{-6}$)	Tracts[1]	Number of other Co-occurring Chemicals			
		Avg>1×10^{-7}	Max>1×10^{-7}	Avg>1×10^{-6}	Max>1×10^{-6}
0 - 0.5	144	5.1	9	2.0	2
0.5 - 1	3,000	7.8	14	2.8	6
1 - 2	35,029	10.5	21	3.7	10
2 - 3	10,228	10.6	18	3.9	9
>3	875	10.0	14	4.0	9
Grand Total	49,276	10.3	21	3.7	10

[1]Nationwide there are 73,426 evaluated tracts

chemicals (Table 7-1). Even if that threshold for identifying co-occurrence is raised to a 1×10^{-6} cancer risk threshold for co-occurring chemicals, there are on average 3.7 – 4.0 other chemicals with estimated risks of 1×10^{-6} or greater and as many as 10 other chemicals co-occurring in these tracts. Together, this suggests that across evaluated cancer risk benchmarks, there are likely to be multiple other chemicals co-occurring in tracts where the risk from Chemical A is greater than 1×10^{-6} alone. Additionally, for those census tracts where the risk from Chemical A was modeled to be less than 1×10^{-6}, on average 5.1 – 7.8 other chemicals have identified risks of greater than 1×10^{-7} in those same tracts. While the focus here is on the number of other potential co-occurring chemicals above evaluated benchmarks to Chemical A, it is also possible to evaluate the co-occurring chemical identities as described in Section 6.3. Doing so would enable us to determine the distribution of chemicals that co-occur with Chemical A across its estimated risk distribution. Identifying potential patterns of chemical co-exposure across the distribution of individual chemical risk as shown here is useful in identifying PESS and provides a screening level identification of locations where exposure and potential risk from other co-occurring chemicals may be contributing additional burden and could be further investigated with more targeted analysis.

EPA OPPTs described approach potentially aids in identifying areas nationwide where the risk from a particular chemical is co-located with risk from other chemicals as well as areas where those potential risks do not co-occur. Using a bivariate analysis, Figure 7-2 shows areas where risk from Chemical A ranges from low to high (in pink) and where the

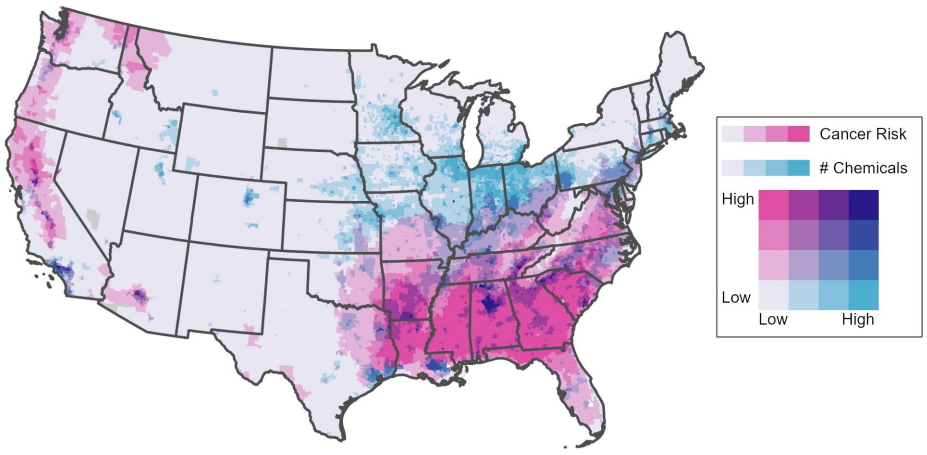

Figure 7-2. Bivariate distribution of Chemical A cancer risk (in pink) with number of other chemicals with estimated risks greater than 1×10^{-7} within AirToxScreen (in blue).

number of chemicals greater than a 1×10^{-7} estimated cancer risk threshold ranges from low to high (in blue), with combined high influences of both in purple. While Figure 7-2 shows higher risk from Chemical A across most of the southeastern United States (in pink) as previously shown in Figure 7-1, it also highlights areas within this region subject to higher number of a chemicals greater than a 1×10^{-7} risk threshold (in purple). In particular, clusters of census tracts in central Alabama, Louisiana, and southern California show the joint influence of higher risk from Chemical A with greater number of chemicals above a 1×10^{-7} risk threshold. While OPPT does not evaluate the interaction of Chemical A with the co-occurring chemicals here, the ability to highlight these areas of joint individual chemical risk and areas with higher chemical co-exposure is useful for screening areas that may benefit from greater levels of analysis for exposure and possible risk to the general population within a individual chemical risk evaluation.

7.3 Case Study for Chemical B

A complementary analysis is shown here for a chemical with different exposure characteristics. Chemical B has over 3,000 unique NEI releases leading to modeled cancer risk between 0 to 3.48×10^{-6} nationwide within the ATS dataset. In contrast to Chemical A, Chemical B is characterized by chemical risk being attributed to stationary/point releases and nonpoint releases. Nationally, on average total cancer risk for Chemical B is characterized by 85% of the estimated risk due to nonpoint sources and 15% due to point releases. Potential risk from Chemical B also shows different spatial patterning, with most of the nation exhibiting uniformly low risk with estimated risks well below 1×10^{-6} (Figure 7-3). There are however some observed localities with estimated risk greater than 1×10^{-6} in Louisiana, Kentucky, Wisconsin, and South Carolina. In those areas, much of that risk is due to stationary point releases with tracts attributing 75% or more of the total estimated chemical risk to point releases (Figure 7-4).

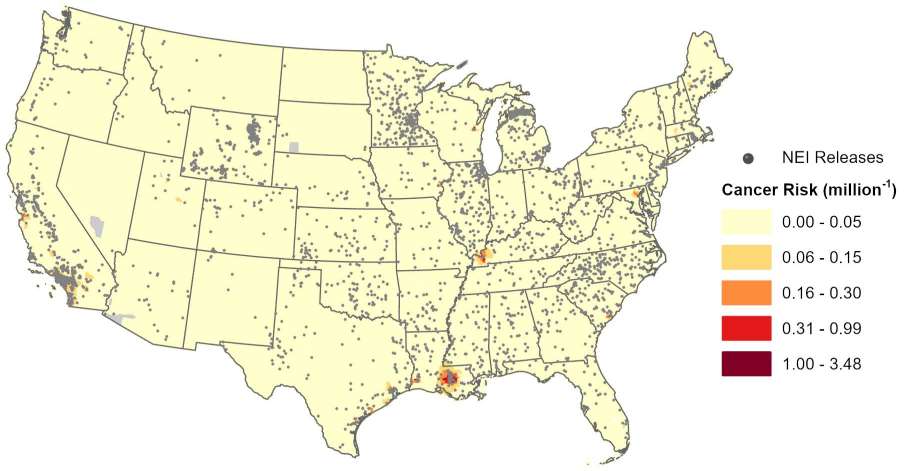

Figure 7-3. Estimated Cancer risk of Chemical B in AirToxScreen dataset.
Risks are shown per census tract. Scale 1:50,000,000. Data not shown for AK, HI, PR, and USVI.

When evaluating the co-exposure of other chemicals in tracts within 5 km of a Chemical B release, the results are similar to those of Chemical A. Chemical B tends to be collocated with several other chemicals. On average, in tracts where Chemical B has an estimated risk less than 1×10^{-6}, there are on average between 11.1 – 12.5 other chemicals co-occurring in those tracts with estimated risks greater than 1×10^{-7} with a maximum of 21 (Table 7-2). When the cancer risk threshold is raised to chemicals estimated to have cancer risks greater than 1×10^{-6}, on average 4.5 – 5.1 other chemicals are found with a maximum of 11. Interestingly, in the few tracts where Chemical B has estimated risks greater than 1×10^{-6} those averages are even higher with on average 15.8 chemicals greater than 1×10^{-7} and 5.8 greater than 1×10^{-6}.

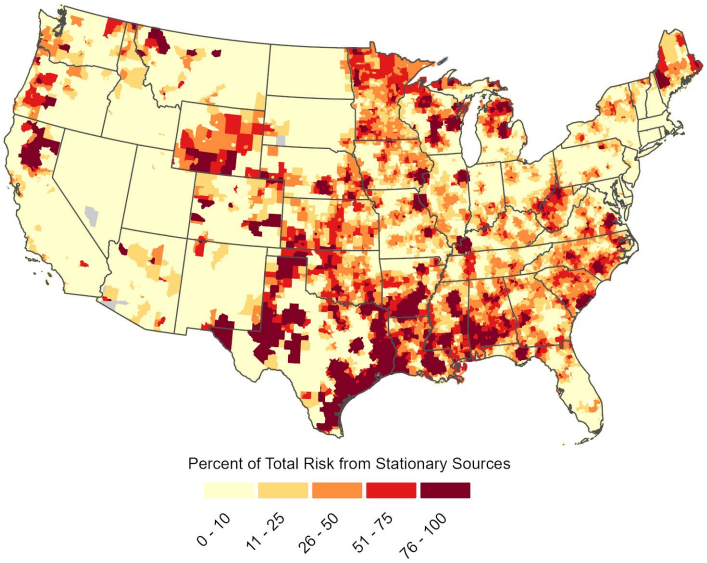

Figure 7-4. Percent of total cancer risk for Chemical B from stationary point sources.
Percent is shown by census tract. Scale 1:50,000,000. Data not shown for AK, HI, PR, and USVI.

While the risks associated with Chemical B are estimated to be uniformly low across most of the nation with only a few areas with estimated risks greater than 1×10^{-6} (Figure 7-3), the bivariate combination of Chemical B cancer risk with number of chemicals with cancer risk greater than 1×10^{-7} is useful in highlighting these combined exposures (Figure 7-5). As shown in Figure 7-5, the areas of higher relative risk for Chemical B (in pink) are mostly geospatially separate from those areas subject to multiple chemicals above a 1×10^{-7} risk threshold (in blue). However, these localized areas subject to elevated cancer risks combined with risks from other chemicals (in purple) provides a screening level identification of areas where more targeted or localized monitoring and evaluation of combined chemical risk may be appropriate.

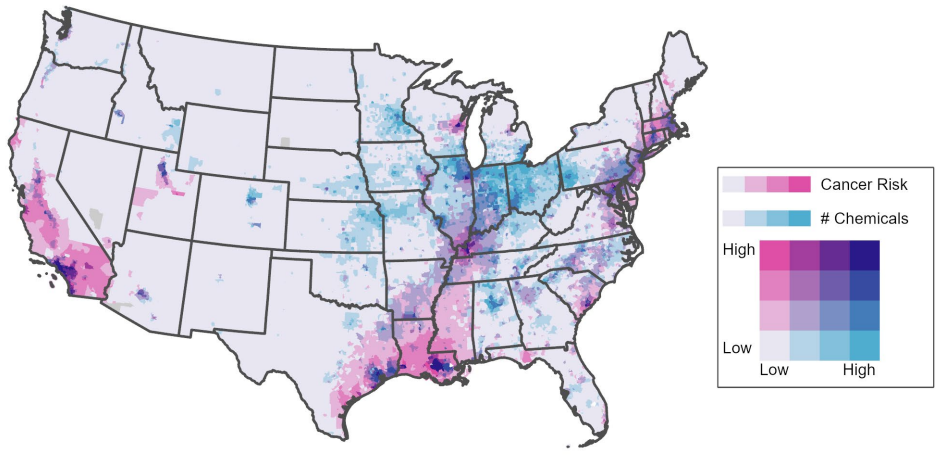

Figure 7-5. Bivariate distribution of Chemical B cancer risk (in pink) with number of other chemicals with estimated risks greater than 1×10^{-7} within AirToxScreen (in blue).
Data are shown by census tract. Scale 1:50,000,000. Data not shown for AK, HI, PR, and USVI.

Table 7-2. Estimated cancer risk of chemical B in census tracts within 5 km of a release with average and maximum number of co-occurring chemicals at the 1×10^{-7} and 1×10^{-6} risk thresholds in those tracts.

Chemical B Risk ($\times10^{-6}$)	Tracts[1]	Number of other Co-occurring Chemicals			
		Avg>1×10^{-7}	Max>1×10^{-7}	Avg >1×10^{-6}	Max>1×10^{-6}
0 - 0.05	15,373	11.1	18	4.5	10
0.05 - 0.15	2,912	12.5	19	5.1	11
0.15 - 0.3	1,667	12.0	21	4.6	11
0.3 -1	276	12.5	21	4.7	8
>1	34	15.8	18	5.8	8
Grand Total	20,262	11.4	21	4.6	11

[1]Nationwide there are 73,426 evaluated tracts

8 Summary, Potential Application and Future Direction

Summary and Potential Application

A goal of this effort is aimed at developing prospective methodologies to better identify PESS and characterize the potential exposure(s) and risk(s) due to chemical co-exposures within these communities. How specifically these processes will be incorporated and considered in OPPT's existing chemical review process was not the focus of this effort. Nevertheless, this effort is informative for characterizing potentially overburdened communities and could be actionable across various stages of the existing chemical review process ranging from pre-prioritization, through prioritization, scoping and problem formulation, as well as risk evaluation and risk management. However, the incorporation of these methodologies and processes requires incremental adoption within OPPT due to several programmatic and regulatory considerations. For instance, the risk evaluation process for chemical substances under TSCA is grounded on evaluation of individual chemicals and their specific chemical COU(s). In contrast, the processes investigated in the methodologies here did not take a COU specific approach and could require some translation for use in a TSCA existing chemical review.

The proposed methodologies described above provide screening level information not only on the number of facilities and potential chemicals a given geographic area is exposed to on an annual basis, but also the number of chemicals above investigated cancer risk thresholds. These screening level methodologies are a useful first-level set of tools that enables better characterization of total chemical burden at particular locations or regions with potential eventual incorporation into a tiered approach within the TSCA regulatory framework. Section 6.3 describes how the ATS dataset and described methodologies can be used to identify the locations and frequency of chemicals that tend to co-occur. The ability to rapidly identify potential commonly occurring combinations of chemicals due to facility releases and the geographic locations where they occur may aid in prioritizing which chemicals may be best evaluated in combination as well as focus analysis on those chemicals most likely to co-occur at initial stages of the risk evaluation process. By doing so, the risk evaluation process may be able to be streamlined and maximize limited OPPT resources.

Consideration and evaluation of cumulative chemical exposure and risk within OPPT, as well as across the Agency, is of renewed focus (EOP, 2023b). To better characterize the total potential overall exposure and risk(s) communities may encounter from chemical releases, OPPT has begun to provide approaches and, where appropriate, actively consider these cumulative chemical pathways (See Section 2). While this paper does not look at cumulative risk to the general population in a quantitative fashion, these methodologies are intended to aid in the identification of PESS and assist in better characterizing the potential total chemical burden a given community may face across various stages of the risk evaluation process. These efforts are also responsive of suggested research direction by EOP (2024) for federal agencies to inform and fill data gaps relevant to EJ, develop methods that "more accurately reflect risks, harms and benefits of complex environments", and incorporate the consideration of multi-stressor indicators like multiple co-occurring chemicals.

These approaches can serve as available tools within the toolbox of approaches currently being developed within OPPT to better evaluate and consider potential cumulative exposure and risk. They offer a starting point in assessing chemical co-exposure and provide direction for more targeted and higher tiers of modeling and monitoring. Used as initial indicators, these methods begin to describe and provide a fuller accounting of total general population exposure and potential risk at various spatial scales. Additionally, the methodologies described in this draft document are easily conducted in a GIS for visualization and analysis purposes and are readily adaptable as new or more granular levels of information on chemical exposure and risk and principles of EJ become available. Together these methods and approaches aid in better identifying areas of chemical co-exposure, the chemical species present, and the combined burden communities may face from these exposures.

Potential Future Direction

While this effort represents an initial contribution on methods and approaches to identify and characterize areas of chemical co-exposure at a nationwide scale, the development of a more formalized tiered framework or implementation plan is needed. It is anticipated that this framework would better describe when, where, and under what conditions evaluation of co-exposure is best undertaken and useful. Such an exercise would be anticipated to better describe the degree of analysis needed ranging from screening to higher tier evaluations and how they might differ across different stages of the TSCA chemical risk evaluation process. Development of such a framework that better clarifies these considerations is a useful next step and potential future direction toward formal incorporation of these approaches.

The ATS dataset is one framed around its spatial foundation of data reported at the census tract level. As discussed in Section 4, this spatial hierarchy affects the results presented here, particularly in locations where census tracts are large. Simply due to their areal extent, it may misrepresent true exposure and risk, particularly in a tract-by-tract nature. Recent updates to the ATS data estimate exposure and risk at a more granular spatial scale of census blocks and offers additional spatial resolution to estimated exposure and risk[21]. Comparing the results here with the just released census block level data would offer additional insight in characterizing chemical co-occurrence at smaller, more community specific spatial scales. The ability to compare these datasets across differential spatial scales also provides useful insight into appropriate potential tiering when considering chemical co-exposure.

Regardless of the spatial scale, the choice to report results based on census designated hierarchies offers the ability to pursue multiple lines of additional inquiry. The interest in and Agency focus on better

[21] To see full description of the 2020 Air Tox Screen, go to 2020 AirToxScreen | US EPA

characterizing chemical exposures on overburdened communities is aided by the organization of these data in census designated geographies. These census designated geographies offer a readily available way to compare the estimates found within ATS and the methods shown here to various census tabulated factors such as race, gender, age, and economic indicators amongst others typically used to characterize overburdened communities. For example, the Environmental Justice Screening and Mapping tool (EJScreen) is an existing Agency developed tool that includes several environmental and demographic socioeconomic indicators to inform the consideration of environmental justice organized around census designated hierarchies. Using the information and indicators found within the Census and EJScreen to relate to results in this evaluation would be straightforward and offers additional information about the communities in areas of chemical co-occurrence that may be useful to the OPPT risk evaluation process. For instance, is the patterning of elevated chemical co-occurrence related to or coincident with areas of elevated environmental justice indicators?

This work shows the power and utility of large chemical databases and models such as ATS, but other Agency datasets would offer a useful point of comparison and contrast. The Risk Screening Environmental Indicators (RSEI) model incorporates information from the Toxics Release Inventory (TRI) including information on over 400 chemicals and 30 years of reporting. As mentioned in Section 4.2, there are important methodological and computational differences between the RSEI and ATS models that made RSEI less appropriate for the analyses investigated here, but it similarly estimates chemical exposure and risk-related scoring results and could serve as another useful tool in the toolbox of approaches for evaluating chemical co-exposure. Additionally, there may be opportunities to compare the results here with RSEI following some methods and data translation. Comparing and contrasting chemical co-exposures across two complementary models could offer the ability to validate the initial results shown here.

As outlined in Section 3, the approaches evaluated here were focused on addressing co-exposure in ambient air from facility releases and human health cancer risk and that scope could be expanded in the future. For example, ATS also offers modeled information on chronic non-cancer health risks that could be incorporated in subsequent evaluations of chemical co-exposure as appropriate. Additionally, other pathways or routes of exposure may also be able to be considered and inform the full spectrum of co-exposures to which a population is exposed. For example, RSEI offers modeled estimates of exposure and risk within the surface water pathway, offering the potential for investigation of co-exposure in that pathway.

Evaluation of chemical co-exposure under TSCA is an exposure pathway challenged by scientific, programmatic, and regulatory considerations. Arriving at co-exposure approaches that better inform the risk evaluation process and can be reliably incorporated will require incremental progress that is informed by the best reasonably available science and new, novel approaches. Nevertheless, the methods investigated here provide a useful first step and start the process of evaluating chemical co-exposure and provide initial thoughts on possible incorporation into the TSCA risk evaluation process, while accepting that full incorporation of these approaches will require additional consultation and investigation.

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