Public Health Assessment

Public Comment Release

UROBOROS GLASS MANUFACTURING SITE

2139 N KERBY AVENUE

PORTLAND, OR 97227

Prepared by
Oregon Health Authority

SEPTEMBER 20, 2018

COMMENT PERIOD ENDS: NOVEMBER 5, 2018

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR's Cooperative Agreement Partner has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR's Cooperative Agreement Partner will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i) (6) (H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR's Cooperative Agreement Partner. This revised document has now been released for a 45-day public comment period. Subsequent to the public comment period, ATSDR's Cooperative Agreement Partner will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR's Cooperative Agreement Partner which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

Use of trade names is for identification only and does not constitute endorsement by the U.S. Department of Health and Human Services.

Please address comments regarding this report to:

Agency for Toxic Substances and Disease Registry
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PUBLIC HEALTH ASSESSMENT

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2139 N KERBY AVEUNUE

PORTLAND, OREGON 97227

Prepared by:
Oregon Health Authority, Public Health Division
Environmental Health Assessment Program
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

Foreword

This report was supported by funding through a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services. It was completed in accordance with approved methodologies and procedures existing at the time the Public Health Assessment was initiated. Editorial review was completed by the cooperative agreement partner.

The Oregon Health Authority (OHA), in cooperation with state and federal partners, prepared this Public Health Assessment (PHA). The Agency for Toxic Substances and Disease Registry (ATSDR) and its Oregon cooperative agreement partner, OHA's Environmental Health Assessment Program (EHAP), conduct Public Health Assessments to evaluate environmental data and community concerns. A PHA reviews available information about hazardous substances at a site and evaluates whether exposure to them might cause harm to people. A Public Health Assessment is not the same as a medical exam or a community health study.

ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and disease related to exposures to toxic substances.

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List of Abbreviations and Acronyms

Abbreviations

ADHD	attention deficit hyperactivity disorder
AT*	averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
BW	body weight
CA-EPA	California Environmental Protection Agency
CAC	community advisory committee
CDC	Centers for Disease Control and Prevention
COC	contaminant of concern
CREG*	cancer risk evaluation guide
CV*	comparison value
DEQ	(Oregon) Department of Environmental Quality
ED*	exposure duration
EHAP	(Oregon) Environmental Health Assessment Program
EJ*	environmental justice
EMEG*	environmental media evaluation guide
EPA	(U.S.) Environmental Protection Agency
HC*	health consultation
HQ*	hazard quotient
IARC	International Agency for Research on Cancer
IUR	inhalation unit risk
mg/kg	milligrams per kilogram
MRL	minimal risk level
N	north
NAAQS	National Air Quality Ambient Standards
NCEH	National Center for Environmental Health
ND	not detected
NESHAP	National Emission Standards for Hazardous Air Pollutant
ng/m^3	nanograms per cubic meter
NHANES	National Health and Nutrition Examination Survey
OHA	Oregon Health Authority
OHA-PHD	Oregon Health Authority, Public Health Division
OSCaR	Oregon State Cancer Registry
PATS	Portland Air Toxics Solutions
PEHSU	Pediatric Environmental Health Specialty Unit
PHA	public health assessment
PHD	Public Health Division
PPS	Portland Public Schools
REL	recommended exposure level
RSL*	regional screening level
SIR*	standardized incidence ratio

SoilSHOP	soil screening, health, outreach, and partnership
St.	street
UCL*	upper confidence limit
U.S.	United States of America
USFS	United States Forest Service
XRF	X-ray fluorescence

*Abbreviations with an asterisk are defined in the glossary (Appendix H).

Summary

Introduction

Through a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), Oregon's Environmental Health Assessment Program (EHAP) priority is to ensure that the community around the site has the best information possible to protect its health.

In 2015, the United States Forest Service (USFS) analyzed moss samples collected around the city of Portland for concentrations of heavy metals. USFS found cadmium, a top concern of the Oregon Department of Environmental Quality (DEQ), at the highest concentrations near two glass manufacturing facilities: Uroboros Glass and Bullseye Glass.

Uroboros Glass is located in the Eliot neighborhood of north Portland, Oregon near residential areas, child care facilities, schools, public parks, and areas where people grow fruits and vegetables. It used heavy metals to make colored glass from 1974 until it permanently stopped operating in 2017. To better understand concentrations of metals emitted from Uroboros Glass, in February 2016, DEQ placed four air monitoring stations around the facility and collected soil samples from the area. Community groups, DEQ, Public Health Division (PHD) leadership, and the governor of Oregon requested that EHAP evaluate the air, soil, human biomarkers of cadmium exposure, and cancer surveillance data. Limitations of this Public Health Assessment (PHA) evaluation include historic air sampling that did not specify the types of chromium, the inability to differentiate between Uroboros Glass emissions and emissions from other sources, uncertainties about how meteorology and times of year affect air concentrations of metals, limited information about bioavailability of contaminants in the soil around the facility, and assumptions made about calculating realistic dose. Urine samples were not collected in a systematic way, and the cancer surveillance data could not be used to attribute causation.

Conclusions

EHAP reached *four* conclusions about the Uroboros Glass site:

Conclusion 1

EHAP concludes exposure to metals in areas around Uroboros Glass are not expected to harm the health of adults or children in the area, based on current data. This includes past, present, and future ingestion of metals in soil and inhalation of metals in air in areas around the facility. This applies to our evaluation of long-term resident, short-term resident, and non-resident exposure scenarios such as children at daycare centers, schools and parks.

Basis for decision	Exposure to the levels of metals measured in the soil in 2016 and air in 2009/2011 and 2016 were too low to result in harmful health effects.
Next steps	EHAP will continue to work with Oregon DEQ on the statewide Cleaner Air Oregon effort, which aims to implement regulations that ensure all industrial operations have pollution controls that are fully protective of public health. EHAP will continue to collaborate and provide input with other government agencies regarding air toxics issues. As requested, EHAP will provide environmental health resources to Tubman School, the site of the original 2009/2011 monitoring and 2016 monitoring. Examples include EPA's Tools for Schools resources.
Conclusion 2	*Methods used to collect urine samples for cadmium analysis have too many uncertainties and too many scientific limitations to draw a health conclusion in this assessment.*
Basis for decision	The 865 urine cadmium samples, collected statewide, were voluntarily obtained by individuals and not collected in a systematic manner. While the testing results were reported to OHA, the results did not contain enough site-specific information on location or risk factors to evaluate. The laboratories used for testing could not detect very low levels of cadmium. The use of these urine cadmium results is limited to individual health care decisions.
Conclusion 3	*Consumption of homegrown produce harvested around Uroboros Glass is unlikely to harm the health of adults or children.*
Basis for decision	Metals like arsenic, cadmium, chromium, and lead are not well absorbed by most garden vegetables. Common gardening practices such as adding compost, mulch, and other nutrients to the soil further reduce uptake of heavy metals into plants. The greatest risk to gardeners is consumption of soil particles that are stuck to the outside of garden vegetables. Metal concentrations measured in soil around Uroboros are similar to those measured in urban areas around Portland and around the country. Concentrations of metals are too low to harm the health of people who ingest small amounts of soil particles stuck to the outside of their homegrown produce.
Conclusion 4	*EHAP found no increase of cancer incidence in the census tracts around Uroboros Glass.*

Basis for decision	Review of lung and bladder cancer data for two census tracts around Uroboros Glass showed higher than predicted rates of bladder cancer between 1999 and 2003; however, there were no statistically significant differences in the time periods 2004-2008 and 2009-2013. Because of the small number of bladder cancer cases and inconsistent pattern of increased cancers over time, EHAP did not have sufficient evidence that the reported bladder and lung cancer cases could be attributable to air or soil concentrations observed in the area around Uroboros Glass.

For more information	If you have questions about this report, you can contact EHAP at 971-673-0977 or toll free at 1-877-290-6767 or via email: ehap.info@state.or.us.

Background and Statement of Issues

Site Location and Characteristics

Uroboros Glass is located at 2139 North Kerby Avenue in Portland between North Tillamook St. and North Thompson St. (Figure 1), in the Eliot neighborhood of Portland, Oregon. The facility ceased operations in September 2017. It was inside a warehouse building that occupies a half-acre lot. The facility began operating in 1973 and manufactured colored glass that is used by glass artists (for sculptures, stain-glass art, dishware, and architecture). Uroboros Glass used some heavy metals as coloring agents in the glass it produced.

Uroboros Glass is zoned as General Industrial (1), as are all properties immediately surrounding it. The I-5 highway is less than 500 feet east of the facility, and North Interstate Avenue (a north-south major thoroughfare) is approximately 1,000 feet to the west. The facility is less than a half mile from the Port of Portland loading facilities and Union Pacific Railroad's Albina train yards. All areas to the immediate north, south, west, are zoned for industrial or commercial use. To the immediate east (on the other side of I-5) of Uroboros Glass is the Faubion-Tubman School (serves grades pre-kindergarten through eighth grade), Lillis-Albina Park, and several residential areas. To the northeast of the facility is the Legacy Emanuel Medical Center. Within a half-mile of Uroboros Glass are a daycare center and several restaurants. The facility and surrounding areas are part of the Eliot neighborhood of Portland.

A more in-depth map that describes Uroboros Glass and the surrounding areas can be found in Appendix A.

Figure 1. *Location of Uroboros Glass site, Portland, Oregon. The red circle indicates half-mile radius.*

Site Background, Investigations, and EHAP Activities

Past regulatory activities

State and federal agency activities near Uroboros Glass stem from Oregon Department of Environmental Quality's (DEQ) work to understand and reduce air toxics in the Portland Metro area. From 2009-2012, DEQ conducted the Portland Air Toxics Solutions (PATS) project in the Portland Metro area (2). DEQ worked with an advisory committee (whose members included representatives of Oregon Health Authority (OHA), the public, advocacy groups, permitted air facilities, and other stakeholders) to develop recommendations for reducing air toxics emissions.

As part of the PATS project, in 2011, DEQ produced a computer model (a simulation based on known emission sources) that projected air toxics concentrations for the year 2017. The model included several types of metals associated with industrial emissions, vehicle traffic, and other urban activities. DEQ used this model to better understand sources of pollutants and their concentrations.

DEQ compared the modeled results to actual measurements taken with air monitoring equipment at specific locations from 2005. The comparison was done to make sure that PATS predicted concentrations that corresponded to actual measurements. DEQ found that the model under-predicted some metals concentrations. Actual measurements were higher than the values predicted by the computer simulation. This indicated that there were sources of airborne metals, especially cadmium, which were not accounted for in the PATS model.

The PATS project ended with a final report published in 2012 in which the advisory committee recommended that DEQ identify the missing sources of cadmium and arsenic in Portland's air. To this end, they recommended that industrial facilities that emit metals collect better data about the materials they use and the emissions they create around their facilities. At that time, DEQ did not identify colored glass manufacturing facilities as metals sources.

In 2013, DEQ analyzed an entire year of meteorology and monitoring data to identify cadmium sources in Portland. This study was inconclusive, indicating that there were likely several sources of the cadmium and that more monitoring was needed.

U.S. Forest Service and DEQ 2013 Moss Study

In 2013, DEQ collaborated with researchers from the U.S. Forest Service (USFS) to address data gaps in metals concentrations in Portland. USFS researchers developed a study to analyze chemical concentrations in urban moss samples and correlated them to measured or modeled air concentrations. Moss that grows on trees absorbs air pollutants from the air through deposition of settling particles and pollutants in rainwater hitting the moss. Moss in trees does not come into contact with the soil, meaning that all pollutants on the moss come from air pollution. Throughout 2013, upon DEQ's request, USFS researchers collected the moss samples and analyzed them for metals including arsenic, cadmium, and chromium.

In May 2015, DEQ received initial moss metals concentration data from USFS and identified art glass manufacturing facilities as potential sources of arsenic, cadmium, and chromium by examining air permit data for several businesses located near moss sampling sites. Most businesses or industrial facilities that release air emissions must have a DEQ-approved permit that lists the materials they use in their processes.

The areas of highest cadmium and arsenic concentrations in moss did not match information with data from the permitted facilities. This meant that DEQ could not make a conclusion about the sources of these metals.

Uroboros Glass was one of the facilities that was within an area where high levels of cadmium were found in moss. Before the moss study, DEQ did not have information about the level of cadmium emissions at this facility. DEQ knew Uroboros Glass used metals to color glass, but did not know what types (other than past use of arsenic) were used, how much was used to make glass, or how much of the metals were released as emissions.

Certain glass manufacturers must have a DEQ air permit that complies with federal National Emission Standards for Hazardous Air Pollutants (NESHAP). NESHAP requires certain facilities that could emit toxic air pollutants to control how they use and emit raw materials, such as additives that contain heavy metals. Before 2016, NESHAP standards for glass manufacturing facilities (known as NESHAP 6s) applied only to operations whose furnaces operated continuously. Since Uroboros Glass did not have a continuous operation furnace (they made colored glass in intermittent batches), they were not required to follow the standards.

USFS cannot confirm how metals in moss samples corresponded with actual concentrations of pollutants in the air. In October 2015, DEQ conducted additional air monitoring next to the largest art glass facility in Portland, Bullseye Glass. DEQ did not conduct similar monitoring at Uroboros Glass at that time. In January 2016, DEQ received and evaluated the Bullseye Glass data with assistance from OHA. At the Bullseye location, DEQ and OHA determined that cadmium and arsenic air concentrations were up to 150 times above DEQ's annual Ambient Benchmark Concentrations (ABC). ABCs are non-regulatory, health-based clean air goals published and used by DEQ to identify air quality areas of concern.

Past Public Health Activities

DEQ and OHA responded to concerns about the public being exposed to arsenic and cadmium. In February 2016, Oregon came to agreements with both glass facilities (including Uroboros Glass) to immediately stop using cadmium and hexavalent chromium. Uroboros Glass had not used arsenic for many years. They also agreed to stop using trivalent chromium

Following the January 2016 analysis, DEQ and USFS conducted additional statistical analysis of moss samples and air monitoring. This allowed researchers to produce a more accurate map. The map showed estimated cadmium air concentration that decreased with distance from the Bullseye Glass and Uroboros Glass facilities (3). With this information, DEQ, OHA, and Multnomah County Public Health staff were able to target communications and determine follow up actions, such as recommendations for soil testing.

To better understand concentrations of metals emitted from Uroboros Glass, in February 2016, DEQ placed four air monitoring stations around the facility. Stations were placed so that DEQ could measure air quality in all directions around the facility. The monitoring stations ran in consecutive 24-hour cycles from March 1 until late July (emissions had been reduced by then). DEQ also collected soil samples from this area, including at a public park, a community garden, and a daycare center. Community groups, DEQ, Public Health Division (PHD) leadership, and the governor of Oregon requested that OHA's Environmental Health Assessment Program (EHAP) evaluate the air data, soil data, and biological and health outcome data.

People were concerned about cadmium levels in outdoor air and soil. In March 2016, OHA responded by funding urine cadmium testing for residents who lived, worked, or went to school within a half-mile radius of the Uroboros Glass or Bullseye Glass facilities. OHA made elevated urinary cadmium levels a reportable condition in Oregon. EHAP provided the analysis of the urine testing results from around the Uroboros Glass facility in the Biological and Health Outcome Data section of this PHA.

As of the writing of this PHA, the state of Oregon has drafted and enacted new rules that DEQ now applies to art glass manufacturers statewide. These new rules require facilities to have appropriate emissions control devices when using heavy metals to make batches of colored glass.

Demographics

Uroboros Glass is within the Eliot Neighborhood in the City of Portland, Oregon. In 2016, there were 1,481 residents living within a half mile of the facility with an average annual per capita income of $33,160 (4). This community has nearly three times the amount of renter occupied housing as owner occupied housing (4). Over 65% of this population identifies as Non-Hispanic white, 24% as black, 7% as Hispanic, and 4% as other race (4). Non-English speakers at home make up 10% of the community with 33% of linguistically isolated households speaking Spanish, and 48% other languages (4). Within a half mile of the facility, children age 0 to 17 make up 12% of the population. Children ages 0-4 make-up 5% of the total population within a half mile (4). The Tubman Pre-K-8 School (currently housing Faubion School students) and a daycare center are also located within one half mile of the site. See the site map profile in Appendix A for more information about demographics around the area.

Faubion School at Tubman

The Portland Public Schools (PPS) Tubman building is within a half mile of the Uroboros Glass site at 2231 N Flint Ave, Portland, OR 97227. Tubman is currently home to a Head Start program for 1-4 year olds; as well as the Faubion School, a pre-K to 8th grade school. The Faubion School hours are from 8:30 am – 3:00 pm. Faubion School receives Title I funding. The purpose of Title I is to provide additional support for schools that serve children who have risk factors like poverty or high mobility. Many of the students (82%) qualify for free or reduced lunch (5). In addition to serving a large population of low-income students, the school is also one of the most racially and ethnically diverse schools in the PPS District. Total enrollment for Faubion in 2015 was listed at 479 students, with 30.5% Hispanic or Latino, 28.4% African American, 27.8 % white, 8.4% multiple races, and 4.9% Asian, Native American, or Pacific Islander (6). Previously the PPS Tubman building served the following uses:

1952 - Spring 1980: Eliot Elementary School
Fall 1980 - Spring 1985: Closed for construction and renovation
Fall 1985 - Spring 2007: Harriet Tubman Middle School
Fall 2007 - Spring 2012: Harriet Tubman Young Leadership Academy (high school, girls)
Fall 2015 - Spring 2017: Faubion PK-8 (while new Faubion building is being built) (7)

Daycare

There is a daycare facility near the Uroboros Glass Site and it provides care for infants ages 6 weeks to children up to 5 years of age. No other demographic data are publicly accessible for this privately-run daycare.

Environmental Justice

Low income communities and communities of color often live and work in areas where the burdens of environmental exposure are the greatest. These same communities tend to be more susceptible to the health effects of environmental exposure (8; 9; 10; 11) and may also face barriers in getting the information, resources, and time they need to become meaningfully

involved[1] in environmental decisions. EHAP works to ensure environmental justice by describing demographic indicators that may highlight disproportionate exposures, increased susceptibility to disease, and barriers to participation.

There are groups and individuals in the community surrounding Uroboros Glass who may be particularly sensitive to the impacts of environmental contaminants due to economic and psychosocial factors, sensitive life stages, and pre-existing health conditions.

Data from the American Community Survey indicate a 40% minority population living near Uroboros Glass (4). Within half a mile, 10% of the community speaks a language other than English at home (4). Housing status (owner/renter) around Uroboros Glass is 73% renter and 27% owner occupied (4). These data indicate that the community, when compared to the city of Portland, or the regional average, has a higher minority population, with health inequities pertaining to home ownership and potential language access barriers for services and information.

Data from EPA's EJScreen Tool indicate communities within half a mile of Uroboros Glass have higher exposure values associated with various environmental hazards (including but not limited to particulate matter, traffic proximity, lead paint, and superfund proximity) when compared to state averages (4).

[1] Meaningful involvement means that (a) potentially affected community residents have an appropriate opportunity to participate in decisions about a proposed activity that will affect their environment and/or health; (b) the public's contribution can influence agency decisions; (c) the concerns of all participants involved will be considered in the decision-making process; and (d) the decision-makers seek out and facilitate the involvement of those potentially affected.

Community Concerns

An integral part of the public health assessment process is addressing community concerns related to environmental health. Throughout this process, EHAP has been working with, and continues to work with, the community advisory committee (CAC) to define specific health concerns, questions, and advice. Meeting with community members was critical in identifying and understanding health concerns. Appendix B includes information about the CAC process.

EHAP collected a number of community concerns from CAC meetings, public events, and phone and e-mail communications. These concerns are listed and summarized below. Responses to these concerns are in Appendix C.

1. **Gardening**
   Community members are concerned that heavy metals associated with site activities are accumulating in garden soil and garden grown plants and thereby, might expose the nearby residents who garden or consume the vegetables.
2. **Children attend Tubman school, within a half a mile of Uroboros Glass**
   Community members requested that OHA coordinate with the administration of Faubion School at Tubman specifically to engage them in the PHA process, public comment period, and final report. Specific questions pertaining to risks to children attending Tubman school include: "I'm concerned about environmental health risks for kids going to school at Tubman."; "When was the previous outside air monitoring done at Tubman school? What were the results?"; "How long has air quality been monitored in our neighborhood at Tubman school?" and "Has indoor air and drinking water been tested at Tubman? What was discovered?"
3. **Recreation and Exercise**
   Community members expressed concern over encouraging safe routes to school (children biking and walking to school in the neighborhood) particularly near Uroboros Glass. Community members expressed that many people bike commute within the neighborhood. Community members expressed interest in knowing if people who are physically active are exposed to metals air emissions in different ways and if exercising is safe in the neighborhood.
4. **Children's Health**
   Community members expressed concern about health risks to young children breathing air emissions of metals while playing outside, recreating in the neighborhood, playing at parks near the site, attending the nearby daycare, and eating vegetables from home gardens. Community members expressed going months without leaving the neighborhood, stating that some kids have lived in the neighborhood their entire lives.
5. **Cumulative risks**
   Community members expressed interest in the health implications of being exposed to environmental contaminants from other sources in the neighborhood, such as emissions from other industrial facilities, particulate matter and other contaminants coming from traffic corridors (from I-5 and in-neighborhood truck traffic from local industry), and a rail yard related to manufacturing and industrial uses within the neighborhood. The community

asked EHAP how local residents could find out more about other potential sources of environmental exposures present within their neighborhood.

6. **Preventing and Reducing Exposures**
   Community members wanted to know what actions they can take to reduce their exposures to pollutants from air emissions and other environmental contaminants. Specific questions include: “How do I get exposed?”; “How do children get exposed?”; “How do pets get exposed?”
7. **Odors**
   Community members expressed concerns about smelling odors in the morning, described as “acrid”, “chemically”, “plastic burning-like” on daily bike commutes through the neighborhood. Community members noticed this odor most prominently as they bike commute over the Broadway Bridge, from the East side of the Willamette River to the West side.
8. **Cancer and other health issues in the neighborhood**
   Community members expressed concerns about cancer rates in the neighborhood. Community members also asked if other health outcomes in the neighborhood such as asthma and attention deficit hyperactivity disorder (ADHD) are related to air emissions.
9. **Confusion pertaining to OHA funded urine analysis testing and results**
   Community members expressed confusion about getting their urine tested for cadmium through the OHA funded process. Some community members said that they had their urine tested and were confused about what the results of their testing meant for their health.
10. **Gap in state industrial air emission regulations**
    Community members expressed that they would like to know what is being done with regard to the gap in regulations that allowed for harmful air emissions of metals from colored glass facilities in Portland, Oregon. Community members expressed interest in knowing what will happen to colored glass manufacturing facilities from a regulatory and enforcement perspective.
11. **Bullseye Glass vs Uroboros Glass operations**
    Community members expressed concern that a ‘cease and desist’ order was issued for Bullseye Glass, but not for Uroboros Glass.
12. **History of mistrust**
    Community members expressed a history of longstanding trust issues with state agencies. The history shared by the community includes a lack of responsiveness to concerns and a lack of actions that are respectful of community interests, and protective of community health.

Discussion

Data sources

The data EHAP evaluated in this report were collected by DEQ during soil and air sampling events. DEQ collected these samples in response to the discovery of air quality issues described in the Site Background/Investigation section.

After DEQ performed initial air quality monitoring at Bullseye Glass and identified Bullseye Glass and Uroboros Glass as sources of heavy metal emissions, they put air monitoring equipment at four locations around Uroboros. These locations (Figure 2) were chosen so that there was a monitor north, south, east, and west of the plant. They were also based on where people, especially sensitive individuals such as children, were likely to be (for example, the nearby Tubman School east of Uroboros Glass).

DEQ conducted air sampling from March 1 through late July of 2016. Four air samplers were placed on adjacent properties around the facility and at Tubman school to determine how metals from the plant were distributed. One sample was taken every 24-hour period, resulting in a total of 354 individual air samples collected. Samples were analyzed for arsenic, beryllium, cadmium, total chromium, hexavalent chromium, cobalt, lead, manganese, nickel, and selenium.

EHAP evaluated past air quality using air sampling results from a study done by EPA in 2009 and 2011 at Tubman School. This study was part of an investigation of air quality near schools across the United States (12). In 2009, particulate matter (specifically PM10, particles 10 micrometers or less) outdoor air samples were taken on the Tubman School campus every sixth day, beginning August 23 through November 23, 2009 (13 samples total). In 2011, particulate matter samples were taken on the school campus every day beginning May 27 to July 17, 2011 (46 samples taken). EHAP evaluated these samples for antimony, arsenic, beryllium, cadmium, total chromium, cobalt, lead, manganese, mercury, nickel, and selenium. EPA did not analyze samples for hexavalent chromium during the study and only reported total chromium. To represent past exposures, EHAP used the 2009 and 2011 data by choosing the chemical concentration that was highest of the two periods to represent past exposures. This ensures a conservative estimate of past exposure.

DEQ conducted soil sampling between February 19 and February 23, 2016. They collected soil samples from three different areas: Albina Park, Albina Community Gardens, and a daycare facility. They collected 27 soil samples total (Figure 2). Soil was taken using grab samples at shallow depths up to six inches below the ground surface, and were representative of surface soil. DEQ collected samples in areas they considered the most likely locations of exposure (such as garden beds or play areas) (13). These samples were used to identify potential contamination near Uroboros Glass and in areas used by community members. Soil samples were analyzed for concentrations of arsenic, cadmium, total chromium, hexavalent chromium, cobalt, lead, nickel, selenium, mercury, iron, manganese, aluminum, and boron.

All of the analytical data used in this report were evaluated and approved by DEQ in accordance with the approved sampling plans for Uroboros Glass. The air sampling and analyses were performed by DEQ and received three levels of review. Soil samples were collected by DEQ staff and sent to a nationally accredited laboratory for analysis. Quality control for both air and soil data met the project requirements in the Uroboros Glass soil/air sampling and analysis plans.

The recent air and soil sampling events provided enough data to identify potential contaminants that could pose threats to public health. EHAP considers the present soil and air investigations sufficient for a comprehensive evaluation.

While 2009 and 2011 air quality data were used to evaluate if past air concentrations could harm people's health, it should be noted that these data are limited. For example, EPA took 13 air samples in 2009, over a period of 13 weeks. In 2011, they took 46 samples over a period of eight weeks. These sampling events also took place during different times of the year (August through November and May through July). This limited data set means there is uncertainty such as variability in chemical concentrations, which can affect confidence in EHAP's statistical analyses.

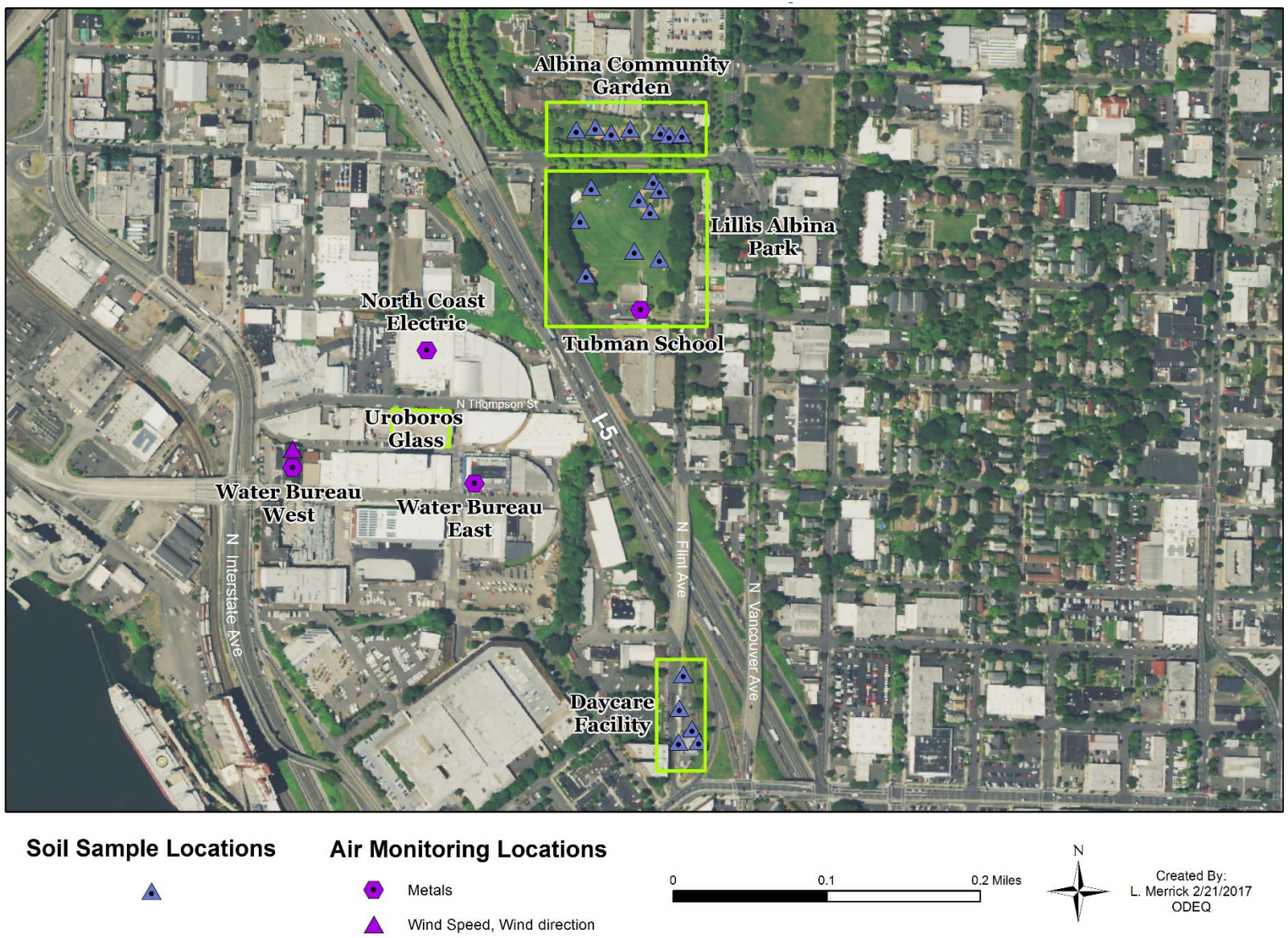

Figure 2. *Location of air monitoring stations and soil sampling locations near and around Uroboros Glass, Portland, Oregon.*

Exposure pathways

In order for a contaminant to harm human health, there must be a way for people to come into contact with the chemical. To determine if, and how, people could be exposed to air- and soil-related contamination around Uroboros Glass, EHAP conducted an exposure pathway analysis. An exposure pathway analysis describes how a chemical moves from its source and comes into physical contact with people. An exposure pathway has the following five elements:

1) A source from which the chemicals originate
2) A medium (for example, air, soil, or water) for chemicals to move through the environment to a place where people could come into contact with them
3) A location (point or area) where people come into contact with the chemicals
4) A way (route) by which people have contact with the chemicals (for example, breathing it, swallowing it, or absorbing it through the skin)
5) A population that comes into contact with the chemicals

Depending on how much information is available about the five elements listed above, an exposure pathway is considered completed, potential, or eliminated. In a completed exposure pathway, all five of these elements are present. A completed pathway means there is a strong likelihood that people have been, are currently being, or will be exposed to a chemical. However, it does not necessarily mean that the chemical is harming people's health. In a potential exposure pathway, it is unknown whether one or more of these elements is present. In an eliminated exposure pathway, one or more of the five elements is known to be absent. This means that exposure to a chemical is unlikely.

EHAP identified two completed exposure pathways and one potential exposure pathway during our evaluation of the air and soil data.

<u>Completed Exposure Pathways</u>

Table 1 below describes the completed exposure pathways for the Uroboros Glass Public Health Assessment.

Table 1. *Completed exposure pathways at Uroboros Glass.*

PATHWAY	SOURCE OF EXPOSURE	LOCATION AND POINT OF EXPOSURE	EXPOSURE ROUTE	POTENTIAL EXPOSURE POPULATION AND SCENARIOS	NOTES
INHALATION OF AIR (in areas within ½ mile of Uroboros Glass)	Emissions from Uroboros Glass.	Outdoor air near Uroboros facility.	Inhalation of air.	*Adults*[*]: Long-term resident. *Children*[*]: Long-term resident, long-term non-resident child attending daycare center, long-term student at Tubman School, and long-time park user.	COMPLETED EXPOSURE PATHWAY: past, present and future.
INGESTION OF SOIL (in areas within ½ mile of Uroboros Glass)	Emissions from Uroboros Glass.	Soil near Uroboros Glass.	Ingestion of soil.	*Adults*[*]: Long-term resident *Children*[*]: Long-term resident, long-term non-resident child attending daycare center, long-term student at Tubman School, and long-time park user.	COMPLETED EXPOSURE PATHWAY: past, present, and future.

*see Appendix F for durations of exposure

Potential Exposure Pathways

Table 2 describes the potential exposure pathways identified for Uroboros Glass. The consumption of produce pathway is designated as potential because of the lack of sampling data of produce. It is known that many people consume vegetables grown near Uroboros Glass. EHAP did not address this exposure pathway quantitatively in this health assessment, but did address it qualitatively in the Health Evaluation section of this report.

Inhalation of indoor air is also listed as a potential pathway because of lack of environmental sampling data for indoor air. In the absence of data for indoor air, EHAP assumed that indoor air was the same as outdoor air for residential adults and children and for non-residential daycare and school children.

The ingestion of indoor dust pathway is also listed as potential because of lack of environmental sampling data for indoor dust. The largest contributor to contamination of indoor dust is soil tracked in from outdoors on shoes that becomes part of the indoor dust. Therefore, EHAP's assessment of risks from contact with outdoor soil partially addresses this pathway and assumes that children swallow 200 milligrams of soil per day (adults swallow 100 milligrams of soil per day).

***Table 2**. Potential exposure pathways at Uroboros Glass.*

PATHWAY	SOURCE OF EXPOSURE	LOCATION AND POINT OF EXPOSURE	EXPOSURE ROUTE	POTENTIAL EXPOSURE POPULATION AND SCENARIOS	NOTES
CONSUMPTION OF LOCALLY GROWN PRODUCE (grown in areas within ½ mile of Uroboros Glass)	Metals in soil.	Soil near Uroboros Glass.	Ingestion of locally-grown produce.	*Adults*: Ingestion of locally-grown produce. *Children*: Ingestion of locally-grown produce.	POTENTIAL EXPOSURE PATHWAY: Past, present, and future exposure. DEQ has not tested for the presence of metals in produce grown in the area. Some community members have individually had their produce tested.
INHALATION OF INDOOR AIR	Emissions from Bullseye Glass	Indoor spaces near Bullseye Glass	Inhalation of indoor air	Adults: Inhalation of indoor air Children: Inhalation of indoor air	Potential Exposure Pathway: Past, present
INGESTION OF INDOOR DUST	Emissions from Bullseye Glass	Indoor spaces near Bullseye Glass	Ingestion of dust that sticks to hands	Adults: Ingestion of dust that sticks to hands Children: Ingestion of dust that sticks to hands	Potential Exposure Pathway: Past, present

<u>Eliminated Exposure Pathways</u>

Table 3 shows the eliminated exposure pathways identified for the Uroboros Glass Public Health Assessment.

Metals in soil exist as inorganic compounds (there is no carbon atom in the molecule). When an individual comes into contact with metals contamination in soil, inorganic metals do not easily penetrate the skin barrier and enter the body. This is because they do not pass through the skin's outer layer (known as the epidermis) (14).The epidermis acts as a barrier between the environment and tissues and organs within the body, and prevents inorganic metals found in soil from entering the bloodstream. When soil does stick to the skin, exposure occurs mainly through swallowing soil particles by hand-to-mouth contact. For these reasons, dermal (skin) exposure was eliminated as an exposure pathway and was not further evaluated in this public health assessment.

Exposure through groundwater as eliminated as an exposure pathway because the homes in the areas are served by Portland's municipal water supply and there are no known drinking water wells in the area.

***Table 3**. Eliminated exposure pathways at Uroboros Glass.*

PATHWAY	SOURCE OF EXPOSURE	LOCATION AND POINT OF EXPOSURE	EXPOSURE ROUTE	POTENTIAL EXPOSURE POPULATION AND SCENARIOS	NOTES
DERMAL CONTACT WITH SOIL (in areas within ½ mile of Uroboros Glass)	Emissions from Uroboros Glass.	Soil near Uroboros Glass.	Dermal exposure	*Adults:* Long-term resident *Children:* Long-term resident, non-resident child who attends daycare near Uroboros Glass, non-resident student at Tubman School, and non-resident child who uses the park.	Metals in soil do not pass through skin.
GROUND WATER	Soil contamination from Uroboros Glass leaching from soil into groundwater	Well water at nearby residences or other buildings (no use of groundwater)	Ingestion of water	Portland is served by a municipal water supply and there are no known drinking wells in the area around Uroboros	No use of groundwater.

Identifying Contaminants of Concern

Chemical concentrations measured in and around the site were compared to comparison values (CVs) determined by ATSDR and other federal and state government agencies. CVs are specific for each chemical and each contaminated medium (soil and air). EHAP screened air and soil data using the following CVs:

- ATSDR Cancer Risk Evaluation Guides (CREG)
- ATSDR Environmental Media Evaluation Guides (EMEG)
- ATSDR Minimal Risk Levels (MRL)
- EPA Regional Screening Levels (RSL)
- California Environmental Protection Agency (CA-EPA) Reference Exposure Levels (RELs)

When determining which CV to use, EHAP follows ATSDR's general hierarchy and uses best professional judgment. EHAP used EPA's ProUCL software to calculate the 95th Upper Confidence Level (UCL) of the arithmetic mean of surface soil samples and air monitoring data. This means that the sample values used are realistic (less than the maximum value but more than the average or median value) and also health protective. These data can be found in Appendix D and Appendix E. A contaminant is selected for further evaluation when the UCL is above a CV, and becomes known as a contaminant of concern (COC). CVs, however, are not thresholds that indicate toxic health effects. EHAP and ATSDR do not use CVs to predict health effects or to establish clean-up levels. A chemical concentration above a CV does not mean harmful health effects will occur. It indicates the need to

further evaluate the chemical. UCL concentrations below comparison values are not likely to cause health effects, and EHAP and ATSDR do not evaluate them further.

In selecting COCs, EHAP evaluated air and soil sampling locations separately, rather than evaluate all data as one area. Each location was considered a separate place where a person could be exposed to air or soil. Figure 2 shows the locations where air and soil were sampled. For soil, series of samples were taken at three locations: Albina Park (north of the Tubman School), Albina Community Gardens (near Legacy Emanuel Medical Center), and a daycare facility. For air, four air monitors were placed around Uroboros Glass: on the grounds of Tubman School (to the east), the North Coast Electric facility (to the north), a Portland Water Bureau property to the west ("Water Bureau West"), and a second Portland Water Bureau property to the southeast ("Water Bureau East").

Soil

For soil, EHAP did not select any metals for further evaluation, since all UCL contaminant concentrations at all three soil sampling locations were below their respective CVs (Appendix D). In addition, levels of arsenic, cadmium, total chromium (hexavalent chromium concentrations were not measured in the analysis), manganese, mercury, nickel, and selenium were within the range of levels that have been measured in the soil in the Portland metropolitan region and in Oregon overall (15). DEQ did not have background levels of hexavalent chromium, cobalt, iron, aluminum, and boron.

While there is no health based comparison value for lead, the lead levels seen in soil sampling around Uroboros Glass were not different from other places in the Portland area (15). The two highest levels of lead at the daycare center, 101 and 105 mg/kg, were slightly higher than the range measured in background levels (100 mg/kg). This area of Portland likely has higher levels of lead in soil due to proximity to past and present sources of lead such as the I-5 highway and other industrial facilities. The safeguards OHA recommends for preventing lead exposure near the facility is not any different from the recommendations for all individuals in urban areas. These recommendations include handwashing before eating, and washing produce from home gardens.

Air

For present (2016) air monitoring, EHAP selected cadmium, hexavalent chromium, and arsenic as COCs, since their concentrations at nearly all locations[2] exceeded the cancer-based CV (Appendix E). EHAP only evaluated cancer risk for these metals since the levels exceeded the cancer-based CV but not the non-cancer-based CV.

For past (2009 and 2011) air monitoring, EHAP selected cadmium, chromium[3], and arsenic as COCs for cancer effects, since their levels in both 2009 and 2011 exceeded the respective cancer-based CVs. For

[2] Cadmium exceeded the CREG at two of three locations measured in air. EHAP evaluated cancer risk from cadmium at all three locations for consistency and to avoid confusion.

[3] Only total chromium was evaluated in EPA's 2009/2011 air monitoring that was conducted at Tubman School. In the absence of data that speciates total chromium, EHAP made a conservative assumption that all total chromium was of the hexavalent (the more toxic) variety.

non-cancer effects, EHAP selected chromium[3] and cadmium since their concentrations exceeded their respective non-cancer-based CVs in one of those periods (*i.e.*, levels of cadmium in 2009 exceeded its non-cancer CV but not in 2011, and levels of chromium exceeded its non-cancer CV in 2011 but not 2009).

All air monitors around Uroboros Glass, for both 2016 and past monitoring, showed air lead concentrations that were consistently below the National Ambient Air Quality Standard (NAAQS) of 150 nanograms per cubic meter (ng/m^3). Since the NAAQS is based on a "rolling average" over three months, comparing data over five months would not be appropriate. EHAP compared the highest daily values (the highest concentrations from past and 2016 data) to the NAAQS, which is considered protective. These values, 59.8 ng/m^3 (from past), and 3.4 ng/m^3 (2016), were far below the NAAQS and EHAP did not consider lead for further analysis.

Contaminants of Concern

Arsenic

Arsenic is a naturally-occurring metal widely distributed in soil and found in air pollutants. Its toxicity has been recognized since ancient times. Arsenic is a known cancer-causing chemical. The types of cancer most often associated with arsenic exposure are skin, bladder, and lung (when inhaled) cancers (16). At higher doses, arsenic can also cause skin conditions that involve discoloration and hardening of the skin as well as appearance of corns or warts on the palms, soles, and torso (16). Arsenic can also cause nerve damage such as numbness in the extremities at high doses and more subtle effects on the brain at lower doses over a long time (16).

State and federal environmental agencies base their arsenic cleanup standards on workplace studies and laboratory animal studies. Because of uncertainties in these studies, their cleanup standards include large safety factors to ensure public health protection. As a result of Oregon's unique volcanic geology, soils naturally contain high levels of arsenic. Because of this, many natural soils in Oregon can sometimes have levels of arsenic that are higher than health screening and cleanup levels.

Cadmium

Cadmium is a soft, silver-white metal that occurs naturally in the earth's crust. It has many industrial uses and is used in consumer products including batteries, pigments, metal coatings, plastics, and some alloys (17).

Low levels of cadmium are present in most foods with the highest levels in shellfish, liver, and kidney meats (17). Cigarette smoke also contains cadmium and can double the daily intake when compared to a non-smoker. Ingestion of high levels of cadmium in contaminated food or water can severely irritate the stomach, leading to vomiting and diarrhea, and sometimes death. Cadmium is a cumulative toxicant. This means that if cadmium is ingested at lower levels for a long period of time, a buildup of cadmium in the kidneys and kidney damage can occur. The kidney is the main organ affected by cadmium toxicity.

The exposure route of concern for cadmium at the site is through ingestion of soil or through inhalation of contaminated air. The EPA classifies cadmium as a probable human carcinogen by

inhalation. This is based on limited evidence of an increase in lung cancer in humans from occupational exposure to cadmium fumes and dust. This effect occurs at concentrations higher than what has been measured around Uroboros Glass. This is further supported by inhalation studies in rats that show lung cancer from cadmium exposure (17).

Chromium

Chromium is a naturally occurring element found in rocks, animals, plants, and soil. It can exist in several different forms. The trivalent form and hexavalent form are the most common forms of chromium measured in the environment. Hexavalent chromium is much more toxic than trivalent chromium (18). Small amounts of trivalent chromium are considered to be a necessity for human health. Chromium is widely used in manufacturing and is found in products such as treated wood, tanned leather, and stainless steel cookware (18).

The main health problems seen in animals following ingestion of hexavalent chromium are anemia and irritation and ulcers in the stomach and small intestine. Trivalent chromium compounds are much less toxic and do not appear to cause these problems. Sperm damage and damage to the male reproductive system have been seen in laboratory animals exposed to hexavalent chromium. Some people are extremely sensitive to chromium. Allergic reactions consisting of severe redness and swelling of the skin have been noted.

The National Toxicology Program (NTP), the International Agency for Research on Cancer (IARC), and EPA have determined that hexavalent chromium compounds are “known” human carcinogens through the exposure route of inhalation. In workers, inhalation of hexavalent chromium has been shown to cause lung cancer. An increase in stomach tumors was observed in humans and animals exposed to hexavalent chromium in drinking water (18).

Children are more sensitive than adults to the cancer effects because hexavalent chromium has a “mutagenic mode of action”. This means that the carcinogen reacts and binds to the DNA in cells (19). This is because their bodies are growing and their cells are rapidly replicating. It is thought that a child’s DNA repair mechanisms may not be able to keep up with the rapid cell replication (19).

Scientific studies of chromium have not fully demonstrated if exposure to chromium could result in birth defects or other developmental effects in people. Some developmental effects have been observed in animals exposed to hexavalent chromium. In animals, some studies show that exposure to high doses during pregnancy may cause miscarriage, low birth weight, and some changes in development of the skeleton and reproductive system.

Health Effects Evaluation

To accurately assess whether or not environmental contaminants could harm the health of people who are exposed to them, we must estimate how much of each contaminant could be getting into people's bodies. In toxicology, the term "dose" is used to refer to the amount that gets into people's bodies. EHAP uses a process similar to EPA's human health risk assessment to calculate doses. For this assessment, EHAP calculated doses of each of the COCs based on six exposure scenarios (see Table 4). These exposure scenarios were developed using information gathered from community input. The scenarios incorporate the various exposure pathways identified in the previous section. It is possible that more than one exposure scenario could apply to a person. EHAP calculated doses based on inhalation of air from around Uroboros Glass. Since measured concentrations of metals in soil were below levels of health concern, EHAP did not calculate risk from ingesting soil.

For each exposure scenario, EHAP chose an air sampling location that was most representative of that particular scenario. For example, for the "Non-resident child student" scenario, EHAP used the air monitoring data from Tubman School because that is representative of where the children go to school. For full-time resident adults and children, EHAP evaluated exposure in all air sampling locations because it's possible that a long-time resident could be exposed in any of these areas.

***Table 4**. List of inhalation exposure scenarios evaluated in the Uroboros Glass Public Health Assessment.*

Exposure Scenario	Ages	Exposure	Rationale
1. Long-term resident as both child and adult (43 years)	Child (birth to age 21[a]) and Adult (ages 21+)	Inhalation	Residents who were born, grew up as children, and lived as adults around Uroboros Glass for 43 years[a,b].
2. Long-term resident as adult only (43 years)	Adult (ages 21+)	Inhalation	Adult residents who lived around Uroboros Glass for 43 years[c].
3. Long-term resident as child only (21 years)	Child (birth to age 21)	Inhalation	Child residents who have lived, worked, gone to school, and played in the area for 21 years (but did not live there as adults).
4. Non-resident child who attends daycare near Uroboros Glass or Head Start at Tubman School.	Preschool age children (ages 6 weeks to 6 years)	Inhalation	Community members noted that a daycare facility was near Uroboros Glass. Tubman School has a Head Start program for children ages 1-4. Head Start children would be exposed for a shorter duration than daycare center children, but are still protected under this exposure scenario.
5. Non-resident student at Tubman School (pre-K through 8th grades)	Children ages 4-14 attending pre-K through grade 8 (ten years)	Inhalation	Tubman School is near Uroboros Glass, and is currently being used by a student population that is mostly children who do not live in the area around Uroboros Glass.
6. Non-resident child park user	Child (birth to age 21)	Inhalation	Albina Park and the Albina Community gardens are both near Uroboros Glass.

a. Humans continue to grow until the age of 21. Therefore, individuals ≤21 years old were considered children in this health assessment.

b. Uroboros Glass has been in operation since 1973, so 43 years is the maximum number of years a person could be exposed.

c. Adults are evaluated separately from children because environmental exposures affect adults and children differently.

This next section describes how doses were calculated for each scenario and compared with health guidelines to determine risk. It then summarizes the health implications for people in each exposure scenario.

Dose Calculation

Dose calculation requires some assumptions about the frequency and intensity with which people come into contact with COCs. Wherever possible, EHAP used site-specific information obtained mostly through community input. When site-specific information was unavailable, default values established by ATSDR or the EPA were used. Where default values were unavailable, EHAP used best professional judgment. For the complete list of the exposure assumptions and methods used to calculate doses of COCs in this report, see Appendices F and G, respectively. Both non-cancer and cancer risk dose calculations were evaluated.

Non-Cancer Risk

EHAP evaluated non-cancer effects of cadmium and chromium in air (measured as total chromium, and assumed to be hexavalent) monitoring from 2009 and 2011 (for both adults and children), because both chemicals exceeded their chronic CVs (10 ng/m^3 and 5 ng/m^3, respectively). It should be noted that cadmium exceeded its CV in 2009 but not in 2011, and chromium exceeded its CV in 2011 but not in 2009. EHAP chose to use the highest air concentration of each chemical, even though they are from different times, when evaluating past non-cancer risk. This is the most conservative estimate of non-cancer effects. Air and soil data collected in 2016 did not show any metals that exceeded their non-cancer CV.

To evaluate non-cancer risk, EHAP divided time adjusted air concentrations of hexavalent chromium by the health guideline (see Appendix G). The resulting number is called the hazard quotient (HQ). If the HQ is greater than 1 for a contaminant in any given scenario, EHAP further evaluates the risk from hexavalent chromium for that scenario. Further evaluation does not necessarily mean that the contaminant will harm human health, but that the contaminant needs another step of analysis. For more information on how HQ is calculated, see Appendix G.

It should be noted that non-cancer risk for metals was evaluated separately, rather than added together. This is because the metals in question affect different target organ systems. For example, exposure to chromium in air will affect lung function while exposure to cadmium in air will affect kidney function.

Cancer Risk

For soil, EHAP did not do a cancer risk evaluation because all metals were below the values we use to select chemicals for further cancer review, and because the soil concentrations were similar or below the background concentrations in the region and across the state.

For exposure to air, estimated cancer risk was calculated by multiplying the time adjusted concentration (the adjusted level of exposure based on the amount of time spent in the area) by the Inhalation Unit Risk (IUR). The IUR is an estimate of increased cancer risk from inhalation of a measured amount of a substance in a measured volume of air, calculated over a lifetime. EHAP used

IURs published by EPA's IRIS (see Appendix F). The calculated cancer risk can be thought of as additional cancer cases per million people exposed.

For 2016 data, EHAP calculated cancer risk levels of arsenic, chromium, and cadmium using the concentrations that were monitored during this period. For past (2009/2011) air monitoring, the greater of the air concentrations (during those two periods) of arsenic, cadmium, and chromium was chosen to calculate cancer risk. Since EPA only measured total chromium and not hexavalent chromium, total chromium was assumed to be all hexavalent. These assumptions about past air concentration data provide for the most conservative estimate of cancer risk.

Cancer risk from a particular environmental exposure is considered in addition to the "background" risk of developing cancer over a lifetime. The American Cancer Society estimates that one in three women and one in two men will develop some type of cancer over the course of their life (20). These background cancers are attributed to a combination of genetic mutations (a change in a cell that can alter how it works), inherited conditions (traits that are passed on to children), tobacco use, lifestyle, common environmental exposures, and occupational exposures. Scientist and medical professionals are not able to predict or quantify the contributions of each factor to the incidence of cancer in individuals and communities.

When assessing cancer risk from a site-specific exposure, a cancer risk of one in a million ($1x10^{-6}$ or 0.000001) means that for every one million people with that same site-specific exposure for the same period of time, one *additional* person will develop cancer (due to that exposure) at some point in their lifetime. This one-in-a-million increase of cancer is *in addition* to the roughly 400,000 people out of one million (approximate background rate for men and women) that would be expected to get cancer from all causes combined. It is not possible to determine which one of the 400,001 cancer cases is the additional case due to a site-specific exposure.

When evaluating risk from cancer-causing metals from Uroboros Glass, EHAP considered a range of cancer risk levels. The low end of the range is one additional case of cancer per million people ($1x10^{-6}$), and the high end is one additional case per ten thousand people ($1x10^{-4}$). Cancer risk that falls between these values is generally considered low. The value is expressed as a range because EHAP, and risk assessors in general, use exposure factors that make an assumption for an entire population. Many of these exposure factors are rounded in increments of 10 or 100. Cancer risks below one additional case of cancer per million people are considered an unlikely increased risk. It is important to know that this range is *in addition to* the one out of three women or one out of two men who will develop cancer over their lifetime.

EXPOSURE SCENARIO 1 – LONG-TERM RESIDENT AS BOTH CHILD AND ADULT (INHALATION FOR 43 YEARS)

This exposure scenario includes adults who lived their entire childhood near Uroboros Glass, and continued to live in the area through adulthood. This scenario considers exposure to air for 43 years (the maximum amount of time a person could have been exposed to emissions). EHAP assumed the 43 years were spent as 21 years as a child and another 22 years as an adult. See Table 5 for the summaries of cancer and non-cancer risks for exposure to air. See Appendix G for more details about dose calculations and Appendix F for assumptions made for those calculations.

AIR - Past risk based on 2009 and 2011 air monitoring data

Cancer

Based on past air monitoring, adults who grew up in this area breathing air with arsenic, cadmium, and hexavalent chromium would have an increased lifetime risk of 1 additional cancer case for every 10,000 people exposed. EHAP considers this increased chance of getting cancer from this exposure to be low.

Air monitoring used in 2009 and 2011 did not differentiate between total chromium and hexavalent chromium. The most toxic form of chromium is hexavalent chromium, while trivalent chromium is much less toxic (and isn't associated with cancer). Because we don't know the ratio of hexavalent chromium to total chromium, EHAP assumed that 100% of chromium measured was hexavalent which is most likely an overestimate. EPA studies have found that hexavalent chromium levels in background air concentrations, away from facilities emitting hexavalent chromium, are less than 10% of total chromium concentrations (21). For these reasons, it is likely the actual cancer risk was much lower.

Since hexavalent chromium is likely to be a small amount of total chromium, EHAP concludes that the health of long-term residents (who grew up in this area) would not be harmed by exposure to levels of arsenic, cadmium, and hexavalent chromium measured in the past. Chromium accounted for nearly half of all past cancer risk, so actual risk is likely to be lower than 1 out of 10,000.

Non-cancer

Chromium - Based on 2011 air monitoring, an adult who grew up in this area breathing air with hexavalent chromium would have a HQ of approximately 1. This HQ is at the threshold for an in-depth analysis. The measured concentration, in air, of total chromium (7 ng/m^3) is over 80 times lower than levels in studies that have shown to cause non-cancer health effects in people.

ATSDR's MRL for hexavalent chromium is based on a study of chrome plating facility where workers were exposed to a form of hexavalent chromium called chromic acid mist (18). Workers exposed at 2,000 ng/m^3 (the Lowest Observed Adverse Effect Level) or more experienced respiratory irritation, mucosal atrophy (reduced function of the mucous membranes in the mouth and throat), and poorer lung function. Other forms of hexavalent chromium, such as sodium dichromate particles, are much less (60 times less) toxic than chromic acid mist. The study did not differentiate between chromic acid mist and sodium dichromate particles. However, the chemistry of glass making is different from chrome plating (hexavalent chrome plating uses chromic acid, a liquid, whereas making colored glass uses a particle-form of chromium). It is likely that the chromium measured near Uroboros Glass in 2009/2011 would not completely have been composed of chromic acid mist.

EHAP calculated risk assuming all of the total chromium was in the most toxic form of hexavalent chromium (chromic acid mist). The calculation is very protective of health because it is based on a worst-case assumption. With this assumption, the HQ of 1 suggests that measured levels of hexavalent chromium were too low to cause non-cancer health effects in long-term residents around Uroboros Glass.

Cadmium – Based on 2009 air monitoring, an adult who grew up in this area breathing air with cadmium would have a HQ of approximately 2. HQs greater than 1 trigger the need for a more in-depth analysis.

The 95th upper confidence limit (UCL) for cadmium (21.33 ng/m^3) was twice the amount of its chronic MRL (10 ng/m^3). This MRL is set based on studies of communities exposed to cadmium by conditions in their local environments (17). The health effect of concern is increased β2-microglobulin proteinuria (protein in the urine), which is an early indication of potential kidney damage. This MRL has an uncertainty factor of 10 meaning that air concentration associated with actual observed effects in the test sample was 100 ng/m^3. The UCL (21.33 ng/m^3) was nearly five times lower than the than the concentration that caused health effects in human populations that included children. It is unlikely this concentration was high enough to cause increased protein in the urine of residents, including children.

In addition to the health-protectiveness of the cadmium MRL, it is likely that the samples taken in 2009 were not representative of what actual conditions were, and actual overall cadmium concentrations could have been lower. Only 13 samples were taken, as opposed to 46 in 2011. The number of samples taken in the 2016 sampling event ranged from 72 to 122 samples, depending on the station. Using a small number of samples in a statistical analysis can result in high variability in data which indicates more uncertainty of actual conditions. This is demonstrated in the three-fold difference between the 2009 mean cadmium concentration (7.29 ng/m^3) and the 95th UCL (21.33 ng/m^3). Results of 2011 sampling showed slightly less variability.

EHAP concludes that the health of long-term residents (who grew up in the area) has not and would not be expected to be harmed by exposure to levels of arsenic, cadmium, and hexavalent chromium measured in the air near Uroboros Glass, based on 2009 and 2011 data.

<u>AIR - Current and future risk based on 2016 air monitoring data</u>

Cancer

Based on 2016 air monitoring, adults (who grew up in this area) breathing air with arsenic, cadmium, and hexavalent chromium would have a lifetime cancer risk of 4 additional cases for every 1,000,000 people. EHAP considers this increased chance of getting cancer from this exposure to be low. This risk is based on concentrations measured at the North Coast Electric and Water Bureau East air monitoring stations (cancer risks were identical for both). Cancer risk at the Tubman and Water Bureau West stations were lower (Table 5).

EHAP concludes that the health of the long-term adult residents (who grew up in this area) would not be harmed by levels of arsenic, cadmium, and hexavalent chromium measured in the air near Uroboros Glass in 2016.

Table 5. Summary of estimated cancer and noncancer risk from inhalation, at the four air monitoring locations near Uroboros Glass.

Scenario	Monitoring Station	Cancer Risk from Arsenic, Cadmium, and Chromium^{6+} (Present)	Cancer Risk from Arsenic, Cadmium, and Chromium^{6+} (Past)	Non-cancer Hazard Quotient (Past)	
				2009 (Cd)	2011 (Cr)
Scenario 1: Long-term resident as both child and adult (43 years)	Tubman	3 out of 1,000,000	1 out of 10,000	2	1
	Water Bureau (E)	4 out of 1,000,000	NA	NA	NA
	Water Bureau (W)	3 out of 1,000,000	NA	NA	NA
	N. Coast Electric	4 out of 1,000,000	NA	NA	NA
Scenario 2: Long-term resident as adult only (43 years)	Tubman	2 out of 1,000,000	6 out of 100,000	2	1
	Water Bureau (E)	3 out of 1,000,000	NA	NA	NA
	Water Bureau (W)	2 out of 1,000,000	NA	NA	NA
	N. Coast Electric	3 out of 1,000,000	NA	NA	NA
Scenario 3: Long-term resident as child only (21 years)	Tubman	1 out of 1,000,000	8 out of 100,000	2	1
	Water Bureau (E)	3 out of 1,000,000	NA	NA	NA
	Water Bureau (W)	2 out of 1,000,000	NA	NA	NA
	N. Coast Electric	3 out of 1,000,000	NA	NA	NA
Scenario 4: Non-resident child who attends daycare (6 years)	Tubman	2 out of 10,000,000	1 out of 100,000	0.6	0.4
Scenario 5: Non-resident student at Tubman School (10 years)	Tubman	1 out of 10,000,000	6 out of 1,000,000	0.4	0.2
Scenario 6: Non-resident child park user (21 years)	Tubman	9 out of 1,000,000,000	5 out of 10,000,000	0.01	0.01

The "past data" refers to data from monitoring that EPA conducted in 2009 and 2011 at Tubman School. The "present data" refers to data collected in 2016. For child and adult long-term residents, risk was calculated at all four monitoring locations. NA—not available for this location in 2009 or 2011. Non-cancer risk for cadmium was calculated in 2009 and chromium was calculated in 2011 – this is because for both chemicals, non-cancer CVs were exceeded in one year but not the other year.

For long-term adult resident exposures (43 years), EHAP did two different risk calculations: (1) an adult who lived solely as an adult near Uroboros Glass and (2) a person who was born and grew up near the facility, 21 years as a child and 22 years as an adult. 43 years is approximately the number of years Uroboros Glass has been in operation.

EXPOSURE SCENARIO 2 – LONG TERM RESIDENT AS ADULT ONLY (INHALATION FOR 43 YEARS)

This exposure scenario includes people who lived entirely as an adult (they grew up elsewhere and moved to the area as an adult) near Uroboros Glass for the entire time it operated (since 1973), or 43 years. This is evaluated separately than an adult who grew up in the area because chemical exposures can affect children differently than adults. EHAP assumed that individuals would spend 365 days per year in the area for a total of 43 years (entirely as an adult). This is the number of years the facility has been operating. See Table 5 for the summaries of cancer and non-cancer risks for exposure to air. See Appendix G for more details about dose calculations and Appendix F for assumptions made for those calculations.

<u>AIR - Past risk based on 2009/2011 air monitoring data</u>

Cancer

Based on past air monitoring, adults who lived near Uroboros Glass as an adult breathing air with arsenic, cadmium, and chromium (assumed to be hexavalent) would have a maximum increased lifetime risk of 6 additional cancer cases for every 100,000 people exposed. EHAP considers this increased chance of getting cancer from this exposure to be low.

Similar to the rationale in the Exposure Scenario 1, it is likely actual cancer risk was much lower, since assuming 100% of total chromium to be hexavalent.

Non-cancer

Chromium - Based on 2011 air monitoring[4], adults who lived in the area breathing air with hexavalent chromium would have a HQ of approximately 1. This HQ is at the threshold for further evaluation. Because the rationale described in Exposure Scenario 1 also applies to this scenario, it is unlikely that measured levels of hexavalent chromium based on 2009 and 2011 data will cause non-cancer health effects to long-term resident adults (who grew up elsewhere) around the Uroboros Glass facility.

Cadmium – Based on 2009 air monitoring, an adult who lived in this area breathing air with cadmium would have a HQ of approximately 2. Because the rationale described in Exposure Scenario 1 also applies to this scenario, it is unlikely that past levels of cadmium will cause non-cancer health effects to long-term resident adults (who grew up elsewhere) around the Uroboros Glass facility.

EHAP concludes that the health of people who lived entirely as an adult near Uroboros Glass has not and would not be expected to be harmed by exposure to levels of arsenic, cadmium, and hexavalent chromium measured in the air near the facility, based on 2009 and 2011 data.

<u>AIR - Current risk based on 2016 air monitoring data</u>

Cancer

Based on 2016 air monitoring, adults who lived near Uroboros Glass as an adult breathing air with arsenic, cadmium, and hexavalent chromium would have a maximum increased lifetime risk of 3

[4] Monitoring methods and equipment that EPA used in 2009/2011 did not differentiate hexavalent chromium from total chromium. Hexavalent chromium is the most toxic form, and EHAP made the health protective (worst-case) assumption that 100% of the total chromium measured was in the hexavalent form.

additional cancer cases for every 1,000,000 people exposed. EHAP considers this increased chance of getting cancer from this exposure to be low. This risk is based on concentrations measured at the North Coast Electric and Water Bureau East air monitoring stations (cancer risks were identical for both). Cancer risk at the Tubman and Water Bureau West stations were lower (Table 5).

Non-cancer
None of the metals measured in the 2016 timeframe were above their CVs for non-cancer health effects, so it is unlikely that non-cancer health effects will occur.

EHAP concludes that the health of long-term adult residents has not been and would not be harmed by levels of arsenic, cadmium, and hexavalent chromium measured in the air near Uroboros Glass in 2016.

EXPOSURE SCENARIO 3 – LONG-TERM RESIDENT AS CHILD ONLY (INHALATION FOR 21 YEARS)
This exposure scenario includes people under age 21 years, who may come into contact with air from the area around Uroboros Glass. EHAP assumed that children would spend 365 days per year in the area, from the time of birth until they reach 21 years of age. Twenty-one years was chosen because we assumed children continued growing until they reached the age of 21. See Table 5 for the summaries of cancer and non-cancer risks for exposure to air. See Appendix F for more details about dose calculation and Appendix G for assumptions made for those calculations.

<u>AIR- Past risk based on 2009/2011 air monitoring data</u>

Cancer
Based on past air monitoring, children breathing air with arsenic, cadmium, and hexavalent chromium would have an increased lifetime risk of 8 additional cancer cases for every 100,000 people exposed. EHAP considers this increased chance of getting cancer from this exposure to be low.

Non-cancer
Chromium - Based on 2011 air monitoring, a child breathing air with measured levels of hexavalent chromium[5] would have a HQ of approximately 1. This HQ is at the threshold for further evaluation. Because the rationale described in Exposure Scenario 1 also applies to this scenario, it is unlikely that measured levels of hexavalent chromium based on 2009 and 2011 monitoring will cause non-cancer health effects to long-term resident children around Uroboros Glass.

Cadmium – Based on 2009 air monitoring, a child who grew up in this area breathing air with cadmium would have a HQ of approximately 2. Because the rationale described in Exposure Scenario 1 also applies to this scenario, it is unlikely that measured levels of cadmium based on 2009 and 2011 data will cause non-cancer health effects to children who grew up around the Uroboros Glass facility.

[5] Monitoring methods and equipment that EPA used in 2009 did not differentiate hexavalent chromium from total chromium. Hexavalent chromium is the most toxic form, and EHAP made the health protective (worst-case) assumption that 100% of the total chromium measured was in the hexavalent form.

EHAP concludes that the health of people who lived entirely as a child near Uroboros Glass has not and would not be expected to be harmed by exposure to levels of arsenic, cadmium, and hexavalent chromium measured in the air near the facility, based on 2009 and 2011 data.

AIR - Current and future risk based on 2016 air monitoring data

Cancer
Based on 2016 air monitoring, a child breathing air with arsenic, cadmium, and hexavalent chromium from birth to age 21 would have an increased lifetime risk of 3 additional cancer cases out of 1,000,000 people exposed. EHAP considers this increased chance of getting cancer from this exposure to be low. This risk is based on concentrations measured at the North Coast Electric and the Water Bureau East air monitoring stations (risk from air exposure was identical at both stations; see Table 5). Cancer risk at the Tubman and Water Bureau West stations were lower (Table 5).

Non-cancer
Air monitoring data from 2016 were below CVs for non-cancer effects for all metals measured, and are therefore too low to cause non-cancer health effects in long-term child residents.

EHAP concludes that the health of the long-term child residents has not been and would not be harmed by levels of arsenic, cadmium, and hexavalent chromium measured in the air near Uroboros Glass in 2016.

EXPOSURE SCENARIO 4 – CHILD NON-RESIDENT DAYCARE (INHALATION FOR 6 YEARS)
This exposure scenario includes children who did not grow up in or live in the area, but attended the daycare center near Uroboros Glass. This scenario also represents children that attend the Head Start Program at Tubman School. This scenario is evaluated separately because they would receive a different exposure than a resident, student, or park user. EHAP assumed that children would spend 250 days per year (approximately the number of weekdays per year) in daycare for a total of six years. Head Start children are only exposed for four years rather than six, which means this exposure scenario overestimates their exposure, and therefore is protective. See Table 5 for the summaries of cancer and non-cancer risks for exposure to air. See Appendix G for more details about dose calculations and Appendix F for assumptions made for those calculations.

AIR - Past risk based on 2009 and 2011 data

Cancer
Based on past air monitoring (the risk was the same for both), daycare center children breathing air with arsenic, cadmium, and hexavalent chromium[6] would have a maximum increased lifetime risk of 1 additional cancer case for every 100,000 people exposed. EHAP considers this increased chance of getting cancer from this exposure to be low.

[6] Monitoring methods and equipment that EPA used in 2009 did not differentiate hexavalent chromium from total chromium. Hexavalent chromium is the most toxic form, and EHAP made the health protective (worst-case) assumption that 100% of the total chromium measured was in the hexavalent form.

Non-cancer

Chromium - Based on 2011 air monitoring, a daycare center child breathing air with hexavalent chromium would have a HQ of approximately 0.4. This is below the HQ threshold of 1. It is unlikely that measured levels of hexavalent chromium based on 2009 and 2011 data would have caused non-cancer health effects to daycare center children near Uroboros Glass.

Cadmium – Based on 2009 air monitoring, a daycare center child breathing air with cadmium would have a HQ of approximately 0.6. This is below the HQ threshold of 1. It is unlikely that measured levels of cadmium based on 2009 and 2011 data would have caused non-cancer health effects to daycare center children near Uroboros Glass.

EHAP concludes that the health of daycare center children has not been and would not be harmed by levels of arsenic, cadmium, and hexavalent chromium measured in the air near Uroboros Glass in 2009 and 2011.

AIR - Current risk based on 2016 monitoring data

Cancer

Based on 2016 air monitoring, non-resident daycare center children breathing air with arsenic, cadmium, and hexavalent chromium would have a maximum increased lifetime risk of 2 additional cancer cases for every 10,000,000 people exposed. EHAP considers this increased chance of getting cancer from this exposure to be very low. This is the risk based on concentrations from the Tubman School air monitoring station – the station nearest the daycare center.

Non-cancer

Air monitoring data from 2016 were below CVs for non-cancer effects for all metals measured, and are therefore too low to cause non-cancer health effects in nonresident daycare center children.

EHAP concludes that the health of non-resident daycare center children has not been and would not be harmed by levels of arsenic, cadmium, and hexavalent chromium measured in the air near Uroboros Glass in 2016.

EXPOSURE SCENARIO 5 –NON-RESIDENT STUDENT (INHALATION FOR 10 YEARS)

This exposure scenario includes children who did not grow up in or live in the area, but attended the pre-kindergarten through 8th grade school (Tubman School) near Uroboros Glass. This is evaluated separately because they would receive a different exposure than a resident, daycare center child, or park user (because there is a different amount of time per day and days per year spent in the area). EHAP assumed that children would spend approximately 180 days per year (the number of school days required by public schools in Oregon) in school for a total of 10 years (from pre-kindergarten through 8th grade). See Table 5 for the summaries of cancer and non-cancer risks for exposure to soil and air. See Appendix G for more details about dose calculations and Appendix F for assumptions made for those calculations.

AIR - Past risk based on 2009 and 2011 air monitoring

Cancer
Based on past air monitoring, Tubman School students breathing air with arsenic, cadmium, and hexavalent chromium[7] would have a maximum increased lifetime risk of 6 additional cancer cases for every 1,000,000 people exposed. EHAP considers this increased chance of getting cancer from this exposure to be low.

Non-cancer
Chromium - Based on 2011 air monitoring, a Tubman School student breathing air with hexavalent chromium would have a HQ of approximately 0.2. This is below the HQ threshold of 1, therefore it is unlikely that measured levels of hexavalent chromium would have caused non-cancer health effects to Tubman School students near Uroboros Glass.

Cadmium - Based on 2009 air monitoring, a Tubman School student breathing air with cadmium would have a HQ of approximately 0.4. This is below the HQ threshold of 1. It is unlikely that measured levels of cadmium based on 2009 and 2011 data would have caused non-cancer health effects to Tubman School students near Uroboros Glass.

EHAP concludes that the health of Tubman School students has not been and would not be harmed by levels of arsenic, cadmium, and hexavalent chromium measured in the air near Uroboros Glass in 2009 and 2011.

<u>AIR - Current risk from based on 2016 air monitoring</u>

Cancer
Based on 2016 air monitoring, Tubman School students breathing air with arsenic, cadmium, and hexavalent chromium would have a maximum increased lifetime risk of 1 additional cancer case for every 10,000,000 people exposed. EHAP considers this increased chance of getting cancer from this exposure to be very low. This is the risk based on concentrations from the Tubman School air monitoring station.

Non-cancer
Air monitoring data from 2016 were below CVs for non-cancer effects for all metals measured, and are therefore too low to cause non-cancer health effects in nonresident students.

EHAP is confident that the health of Tubman School students has not been and would not be harmed by levels of arsenic, cadmium, and hexavalent chromium measured in the air near Uroboros Glass in 2016.

EXPOSURE SCENARIO 6 –NON-RESIDENT CHILD PARK USER (INHALATION FOR 21 YEARS)
This exposure scenario includes children who did not grow up in or live in the area, but played at the park (Albina Park) or the community garden (Albina Community Gardens) near Uroboros Glass. This is

[7] Monitoring methods and equipment that EPA used in 2009/2011 did not differentiate hexavalent chromium from total chromium. EHAP made the health protective (worst-case) assumption that 100% of the total chromium measured was in the hexavalent form.

evaluated separately because a child non-resident park user would receive a different exposure than a resident child, daycare center child, or student. EHAP assumed that park children would spend approximately 27 days per year in the park (an estimate of park use by the Portland Development Commission) (22), for a total of 21 years. See Table 5 for the summaries of cancer and non-cancer risks for exposure to air. See Appendix G for more details about dose calculations and Appendix F for assumptions made for those calculations.

AIR - Past risk based on 2009/2011 monitoring data

Cancer
Based on past air monitoring, child park users breathing air with arsenic, cadmium, and hexavalent chromium[8] would have a maximum increased lifetime risk of 5 additional cancer cases for every 10,000,000 people exposed. EHAP considers this increased chance of getting cancer from this exposure to be unlikely.

Non-cancer
Chromium - Based on 2011 air monitoring, a child park user breathing air with hexavalent chromium would have a HQ of approximately 0.01. This is below the HQ threshold of 1. It is unlikely that measured levels of hexavalent chromium in the air would have caused non-cancer health effects to child park users near Uroboros Glass.

Cadmium - Based on 2009 air monitoring, a child park user breathing air with cadmium would have a HQ of approximately 0.01. This is below the HQ threshold of 1. It is unlikely that measured levels of cadmium based on 2009 and 2011 data would have caused non-cancer health effects to child park users near Uroboros Glass.

EHAP concludes that the health of child park users has not been and would not be harmed by levels of arsenic, cadmium, and hexavalent chromium measured near Uroboros Glass in 2009 and2011.

AIR - Current risk based on 2016 data

Cancer
Based on 2016 air monitoring, child park users breathing air with arsenic, cadmium, and hexavalent chromium would have a maximum increased lifetime risk of 9 additional cancer cases for every 1,000,000,000 people exposed. EHAP considers this increased chance of getting cancer from this exposure to be unlikely. This is the risk based on concentrations from the Tubman School air monitoring station (which is nearest to the park and community garden).

Non-cancer
Air monitoring data from 2016 were below CVs for non-cancer effects for all metals measured, and are therefore too low to cause non-cancer health effects in nonresident students.

[8] Monitoring methods and equipment that EPA used in 2009/2011 did not differentiate hexavalent chromium from total chromium. Hexavalent chromium is the most toxic form, and EHAP made the health protective (worst-case) assumption that 100% of the total chromium measured was in the hexavalent form.

EHAP concludes that the health of child park users has not been and would not be harmed by levels of arsenic, cadmium, and hexavalent chromium measured in air near Uroboros Glass in 2016.

Risk from Locally-Grown Produce

Many community members had considerable concerns about the safety of consuming fruits and vegetables grown near Uroboros Glass. People expressed doubts that produce was safe to eat. People were also worried that eating these fruits and vegetables was exposing them to high levels of metals from the facility. Neither DEQ nor OHA tested garden produce in the area. There is no environmental data (aside from soil samples) to directly evaluate the levels of metals in locally-grown fruits and vegetables.

The presence of metals in soils does not mean plants grown in them will contain high levels of those metals. Metals are often found in urban soils from past or present land use activities and proximity to pollution sources (23). Although plants and their roots can come into contact with heavy metals, studies have shown that plants from urban gardens near industrial emissions or traffic do not have high levels of metals in their plant tissue (24). Studies that examined metals in edible plants found that the rate of metals uptake was not significant (25; 26). This is because metals like arsenic, cadmium, chromium, and lead are not readily taken up by or accumulated in most garden plants (27; 28; 29; 30; 31).

Also, the sources of soil and soil quality in urban gardens is different from urban soil found in parks, sidewalks, and streets. The presence of urban infrastructure (for example, buildings, roads, and sidewalks) changes soil characteristics and often results in compaction, poor drainage, and lower soil quality in urban areas (32). Most urban gardeners do not use these soils, and typically amend their gardens with compost, mulch, imported topsoil, other soil amendments, and nutrients/minerals. The amendments help garden soil reduce any uptake of metals into plants. Urban gardening studies have found that heavy metal concentrations are reduced by several factors, such as addition of organic matter (for example, adding compost or mulch), presence of other less-toxic metals (for example, zinc reduces a plant's uptake of cadmium), or adding phosphorus fertilizer (33). These amendments result in metals concentrations that are lower than the urban soil around it.

Last, the most significant exposure pathway for gardeners is ingesting the soil itself, as it sticks to the gardener's hands or to the outside of the produce (34).

Due to the above reasons, EHAP concludes that it is unlikely that produce from nearby gardens would pose a threat to the health of residents. There are significant health benefits from growing and consuming fresh vegetables. These health benefits outweigh any negligible risks from the levels of metals measured in soil.

Children's Health

EHAP and ATSDR recognize that infants and children may be more vulnerable than adults to contaminated air, water, soil, or food. This is because:

- Children are more likely to play outdoors and bring food into contaminated areas.
- Children are shorter. They are more likely to breathe airborne particles from dust and soil.
- Children are smaller. Their size results in higher doses of chemical exposure per body weight.
- Children are more likely to put soil and contaminated objects in their mouths compared to adults.
- Children are still developing. Permanent damage can occur if toxic exposures happen during critical stages of growth.

Because children depend on adults, EHAP and ATSDR are committed to evaluating their special interests at and around Uroboros Glass. It is important to note that the health-based screening values EHAP used for air and soil were based on health guidelines that incorporate a high level of protectiveness for children and other sensitive individuals.

In this PHA, children were identified as the most vulnerable to health problems caused by metals in the soil and air. This PHA takes into account the special vulnerabilities of children. EHAP also considered specific age and weight ranges for each exposure scenario. EHAP carefully evaluated child exposures to cancer-causing agents. For example, EHAP evaluated cancer risk with consideration for mutagenic mode of action for hexavalent chromium.

Biological and Health Outcome Data

Cadmium in urine testing results

When the public learned about the moss study results and the elevated cadmium and arsenic levels in the air around the Bullseye Glass and Uroboros Glass facilities in Portland, many people wanted medical tests to measure their exposure.

OHA did not recommend testing, but recognized that many community members were independently obtaining urine cadmium tests. OHA did reimburse individuals who obtained urine cadmium testing who lived within 1 mile of Uroboros Glass or Bullseye Glass. OHA consulted with partners at ATSDR, Multnomah County Health Department, the Oregon Poison Center, and the Northwest Pediatric Environmental Health Specialty Unit (PEHSU) to develop guidance for clinicians on how to order the appropriate test and interpret the results. OHA also communicated that the medical testing (urine collection) results would have limited use informing individual health care decisions. Samples were not collected in a systematic manner. Because of this, the results would not give answers about the general population or to determine causation. OHA and partners made several revisions to the guidance document, as additional concerns with results interpretation and laboratory detection limits were identified.

<u>Measuring cadmium in urine</u>

Typical clinical laboratory test methods for detecting cadmium in urine are designed to address occupational exposures. Occupational exposures are typically much greater than exposures outside of the workplace. For example, the Occupational Health and Safety Administration's (OSHA) permissible exposure limit for inorganic cadmium compounds in the workplace is 5,000 ng/m^3 averaged over 8 hours, while the maximum cadmium air concentration near Uroboros Glass was 25 ng/m^3 in 2009/2011 (Appendix E). Because of this, occupational laboratory detection limits are often higher than the concentrations seen in the non-occupationally exposed population (lower detection limits require more complex laboratory methods).

Results using occupational laboratory methods cannot be compared to results of CDC's National Center for Environmental Health (NCEH) National Report on Human Exposure to Environmental Chemicals, which publishes background levels of metals in the urine of adults and children. This is because the CDC's laboratory methods have much lower detection limits for cadmium than typical clinical laboratories. As a result, concerned community members were not able to compare their results against the national background levels in the NCEH report. This was particularly true for children. National urinary cadmium levels tend to be lower in children than adults (35).

When a health care laboratory measures the amount of a contaminant in urine, they also measure creatinine, a natural waste product. Creatinine is measured because the amount that comes out of the kidney does not depend on the volume of urine produced. For example, a person would excrete the same amount of creatinine in three hours, regardless if they drank five glasses of water or one glass of water. When measuring urine samples, concentrations of a chemical are divided by the measured amount of creatinine excreted. This adjusts for how concentrated or diluted the urine is.

Children normally excrete less creatinine than adults do. When no cadmium was detected in urine samples (the concentration was below the detection limit, the level below which analytical equipment cannot accurately detect or determine the actual concentration), some laboratories divided the detection limit concentration by the naturally low creatinine levels in children's urine samples. Dividing the detection limit instead of the actual concentration can result in an artificially high number that some community members misinterpreted as high levels of cadmium in their children's urine.

Also, some laboratories reported values below detection limits in boldface type or with a "less than" sign (<). Some community members interpreted this to mean that cadmium had been detected, when in fact it had not been detected by the laboratory. The amount of cadmium that may (or may not) have been present was below the level that could be determined by the laboratory methods used. OHA updated the clinician guidance to provide clarity around these issues.

Cadmium Results Reporting

In February 2016, OHA issued an Administrative Rule. The rule requires health care providers and testing laboratories to report positive results of cadmium urine testing in Oregon residents. As of July 1, 2016, OHA received cadmium in urine test results for 865 Oregonians statewide. The results included tests done because of concerns about exposure to glass factory emissions, but also included people exposed in an occupational setting. There were 90 individuals statewide with detectable cadmium levels and 33 of them lived in Multnomah County. Of the 33 individuals in the county with detectable cadmium levels, 10 were less than 18 years of age and 23 were adults. Of the 33 individuals in the county, 12 of them had test results that indicated the need for additional testing and clinical follow-up.

These reported cadmium data from health care providers and testing laboratories are not sufficient for EHAP to make a public health conclusion about individual exposures at Uroboros Glass. The test results can only tell us if a person who got tested had a detectable urinary concentration for cadmium above general population levels (as compared to the National Health and Nutrition Examination Survey, or NHANES, upper 95th percentile). It does not tell us meaningful information about individuals or the entire population living near (or spending time in proximity to) the facility.

To determine if levels of cadmium in individuals living near (or spending time in proximity to) Uroboros Glass are higher than the general population, EHAP would need levels of cadmium in urine from a random sample of children and adults from the area around Uroboros Glass, rather than results taken from people who sought or were recommended to have testing. For each person participating in the study, EHAP would need detailed personal information about their potential for exposure to cadmium from other sources (such as from smoking or from occupational exposure).

Oregon State Cancer Registry Results

When the public learned about the preliminary moss study results and the elevated cadmium and arsenic levels in the air around the Bullseye facility in Portland, many people wanted to know if cancer rates in the area were increased.

In March 2016, the Oregon State Cancer Registry (OSCaR) conducted a cancer rate evaluation of the areas around Uroboros Glass (36). OSCaR is a statewide, population-based registry that collects and analyzes information about all reported cancer cases occurring in Oregon. This work is important in the development of ways to prevent and monitor cancer in Oregon. All diagnoses of cancer in Oregon must be reported to OSCaR, including place of residence at the time of diagnosis.

For the area around Uroboros Glass, OSCaR evaluated the rates of cancer diagnoses from two census tracts. A census tract is a small geographic area defined by the U.S. Census. These two tracts were chosen because they best fit the area where moss concentrations were measured. The two tracts were also chosen because they include locations of community concern: Harriet Tubman School and Boise-Eliot/Humboldt Elementary School.

OSCaR evaluated observed rates of cancer incidence (the number of new cases reported, rather than the number of existing cases) of bladder cancer because bladder cancer is associated with arsenic exposure. OSCAR also evaluated rates of cancer incidence of lung cancer which is associated with both arsenic and cadmium exposure for the years 1999-2013. This date range was chosen for several reasons. First, OSCaR decided to "look back" 15 years, following the standard practice for cancer data analysis of selected a range of years that could be broken out into 5 year increments (1999-2003, 2004-2008, and 2009-2013). Second, the most recent complete year of data available for analysis was for cases diagnosed in 2013 and the first year that OSCaR began receiving cancer reports was 1996. Last, since Uroboros Glass had been operating for over 40 years, cancers that might have developed in response to individuals being exposed would likely have developed over time. This would be reflected in the statistical analysis as higher than expected incidence of bladder and/or lung cancer in the areas of concern between 1999 and 2013. For each time period, OSCaR calculated the expected number of new cancer diagnoses for the population within this area. This was done by gathering lung and bladder cancer rates seen in all of Multnomah County, and applying those rates to the population in the selected census tracts.

It should be noted that cancer registry data cannot be used to show cause and effect, cancer latency, when and where exposure occurred, and cannot account for other unknown risk factors (such as smoking status and occupational history).

OSCaR then compared the expected number of new diagnoses to the actual number of new diagnoses. This was done through calculating Standardized Incidence Ratios (SIRs), which compares the observed number of new cases to the expected number of new cases for the same area (SIR = Observed Cases ÷ Expected Cases), standardized by age. An SIR greater than 1.0 indicates that the number of observed cases is greater than expected. For each SIR, OSCaR also calculated a 95% confidence interval (the range of values that describes uncertainty surrounding the estimate) to determine how likely it is that the SIR is high or low due to chance (random fluctuations in the data). The SIR is considered statistically significant when the 95% confidence interval does not include the number 1.0.

OSCaR included two census tracts in their evaluation: tracts 23.03 and 22.03 (Figure 3). They evaluated lung and bladder cancer rates for census tract 23.03 by itself. OSCaR did not evaluate tract 22.03 by itself because most of the estimated cadmium in air around Uroboros Glass (which was based on moss sampling data) were in census tract 23.03 and only a small amount of the estimated cadmium was in

tract 22.03 (37). Because of this, OSCaR combined the lung and bladder cancer rates with the rates from Census tract 23.03 to increase the validity of the measure and reliability of the data.

Figure 3*. Census tracts included in the Oregon State Cancer Registry rate results for areas surrounding Uroboros Glass.*

Tract 23.03

For tract 23.03 (Table 6), comparing the observed versus expected number of lung cancer and bladder cancer cases during the 1999-2003, 2004-2008, and 2009-2013 periods resulted in SIRs that were similar to 1.0 (the confidence intervals were above and below 1.0). This indicates that there was no meaningful difference between the observed and expected number of new lung and bladder cancer cases.

***Table 6**. Lung cancer and bladder cancer for census tract 23.03, 1999-2013. Observed diagnosed cases, expected cases (based on countywide diagnosis rates), and Standardized Incidence Ratios (SIR).*

CANCER TYPE	Observed, Expected, SIR	YEARS		
		1999-2003	2004-2008	2009-2013
Lung Cancer	Observed cases	5	6	5
	Expected cases	7.6	7.8	7.5
	SIR (95% Confidence Interval)	0.7 (0.2-1.5)	0.8 (0.3-1.7)	0.7 (0.2-1.6)
Bladder Cancer	Observed cases	7	6	1
	Expected cases	2.9	2.7	3.0
	SIR (95% Confidence Interval)	2.4 (1.0-5.0)	2.2 (0.8-4.8)	0.3 (0.0-1.8)

Tracts 22.03 and 23.03 combined

For tracts 22.03 and 23.03 combined (Table 7), comparing the observed versus expected number of lung cancer during the 1999-2003, 2004-2008, and 2009-2013 periods resulted in SIRs that were similar to 1.0 (the confidence intervals were above and below 1.0). For bladder cancer cases, the 2004-2008 and 2009-2013 periods resulted in SIRs that were similar to 1.0. However, the SIR for bladder cancer during the 1999-2003 period was statistically significant – the number of observed new cases were higher than the number of expected cases.

***Table 7.** Lung cancer and bladder cancer for census tracts 22.03 and 23.03 combined, 1999-2013. Observed diagnosed cases, expected cases (based on countywide diagnosis rates), and Standardized Incidence Ratios (SIR).*

CANCER TYPE	Observed, Expected, SIR	YEARS		
		1999-2003	2004-2008	2009-2013
Lung Cancer	Observed cases	12	13	11
	Expected cases	15.3	15.4	13.3
	SIR (95% Confidence Interval)	0.8 (0.4-1.4)	0.9 (0.5-1.5)	0.8 (0.4-1.5)
Bladder Cancer	Observed cases	12	7	3
	Expected cases	5.2	4.9	4.9
	SIR (95% Confidence Interval)	*2.3‡ (1.2-4.1)*	1.4 (0.6-3.0)	0.6 (0.1-1.8)

‡ This value is statistically significant

Although bladder cancer rates were statistically higher for the combined census tracts 22.03 and 23.03 in the 1999-2003 period, this is not sufficient evidence to conclude that the bladder cancer cases are attributable to air or soil concentrations observed in the area around Uroboros Glass. This is for several reasons. First, because studies show arsenic is linked to bladder cancer, we would expect the SIR (if it were actually linked to arsenic exposure) to be significantly higher through all three time periods. For census tracts 22.03 and 23.03, the SIRs in the two periods after 1999-2003 were consistently similar to 1.0. Also, bladder cancer has a lower incidence rate than lung cancer, meaning fewer cases in the population. A suspected cancer cluster investigation with a small number of cases will result in less statistical power to detect an actual association (38). Since there is no consistent pattern of increased bladder cancer incidence throughout the 1999-2013 period, it is likely the statistically higher number during 1999-2003 is due to chance.

Uncertainties and Data Gaps

In any PHA, there are uncertainties. Scientists use assumptions, judgments, and at times, limited data sets. These contribute to the uncertainty in our health evaluations. While these limitations are described below, EHAP considered the air and soil data of good quality and sufficient quantity to evaluate in this health assessment.

Limitations in data sets

Although every attempt was made to collect comprehensive environmental data from around Uroboros Glass, there are limitations in these data sets. For air sampling data, there are several uncertainties with the 2009/2011 sampling taken at Tubman School. Analysis of chromium included only total chromium and not hexavalent chromium. EHAP assumed that all total chromium was hexavalent. This is the most health-protective assumption. It is possible that actual concentrations of hexavalent chromium were lower. If that is the case, EHAP may have overestimated cancer and non-cancer risks from past exposures to hexavalent chromium. Also, EHAP was unable to obtain data qualifiers and detection limits from the 2009/2011 data. However, EPA posted these results on their website indicating that they had enough confidence in the data to support their conclusions. EHAP does not have data that shows metal concentrations between the 2009 monitoring, 2011 monitoring, and 2016 monitoring.

Monitoring locations and time of year

Metals that were measured in air during 2016 came from specific points around the area of Uroboros Glass (Figure 2). Some exposure points were not in the exact location as an air monitor (for example, the daycare facility). Local meteorology (such as the effects of wind or air pressure) and geography (such as elevation or proximity to a large building) can result in lower or higher actual concentrations in nearby areas where there is no air monitor but there could be a person breathing air. Measured concentrations of metals were taken from August through November 2009, May through July 2011, and March through July 2016. EHAP is uncertain if this represents year-round concentrations of metals in air. Levels of metals in air can be affected by events that can vary over the year, such as rain or lack of rain, levels of car and truck traffic, or wind direction. Despite these limitations, EHAP decided that the data were sufficient to make initial conclusions about impacts to human health around the site.

In addition, air monitors cannot determine from where air pollutants originate. Uroboros Glass was not using any of the hazardous metals being measured by the four DEQ monitors after February 2016. This was in response to actions taken by DEQ. The facility has since announced their intention to cease operations in 2017, which means that metals levels around the facility are expected to be the same or lower than what was measured in 2016. EHAP is certain that Uroboros Glass contributed to the concentrations of metals measured at the EPA monitor at Tubman School in 2009/2011, but it is uncertain how much, since it is not possible to trace sources in air monitoring data that was taken several years ago.

Dose reconstruction

Another area of uncertainty has to do with the dose reconstruction (the estimation of actual chemical dose through the use of exposure factors). For the Uroboros Glass PHA, this type of uncertainty has

two parts – the concentration in air used for dose reconstruction and the amount of air people breathe.

It is not possible for EHAP to know exactly how much air each person breathes, how much an individual weighs, or how much total time an individual spends in the area near Uroboros Glass. In the absence of that type of specific information, EHAP used standard default values that are developed by ATSDR and EPA, and are based on studies that measured how much people weigh and how much soil people ingest during their daily activities. Appendix F contains the detailed assumptions made in calculating doses and the rationale used to support them. Where there was uncertainty about default values, EHAP tried to overestimate exposure to be protective of health.

Testing for cadmium in urine

The methodology of collecting urine samples from volunteers has too many uncertainties to support health conclusions in this PHA. These tests were meant to aid in individual health care decisions, not for use in a scientific study. A urinary cadmium test result does not distinguish one source of cadmium exposure from another. Because there are other sources of cadmium in our bodies (diet, exposure to cigarette smoke, etc.), urine data collected in a non-systematic manner cannot be used to determine whether or not measured cadmium levels are related to emissions from Uroboros Glass.

Use of cancer data

Cancer registry data cannot be used to show cause and effect, cancer latency, when and where exposure occurred, and cannot account for other unknown risk factors such as smoking status and occupational history.

Conclusions

EHAP reached *four* conclusions in this PHA:

Conclusion 1: EHAP concludes exposure to metals in areas around Uroboros Glass are not expected to harm the health of adults or children in the area, based on the current data. This includes past, present, and future ingestion of metals in soil and inhalation of metals in air in areas around the facility. This applies to our evaluation of long-term resident, short-term resident, and non-resident exposure scenarios such as children at daycare centers, schools and parks.

Conclusion 2: Methods used to collect urine samples for cadmium analysis have too many uncertainties and too many scientific limitations to a draw a health conclusion in this assessment. The 865 urine cadmium samples, collected statewide, were voluntarily obtained by individuals and not collected in a systematic manner. While the testing results were reported to OHA, the results did not contain enough site-specific information on location or risk factors to evaluate. The laboratories used for testing could not detect very low levels of cadmium. The use of these urine cadmium results is limited to individual health care decisions.

Conclusion 3: Consumption of homegrown produce harvested around Uroboros Glass was unlikely to harm the health of adults or children. Metals like arsenic, cadmium, chromium, and lead are not well absorbed by most garden vegetables. Common gardening practices such as adding compost, mulch, and other nutrients to the soil further reduce uptake of heavy metals into plants. The greatest risk to gardeners is consumption of soil particles that are stuck to the outside of garden vegetables. Metals concentrations measured in soil around Uroboros were similar to those measured in urban areas around Portland and around the country. Concentrations of metals are too low to harm the health of people who ingest small amounts of soil particles stuck to the outside of their homegrown produce.

Conclusion 4: *EHAP found no increase of cancer incidence in the census tracts around Uroboros Glass.* Review of lung and bladder cancer data for two census tracts around Uroboros Glass showed higher than predicted rates of bladder cancer between 1999 and 2003; however, there were no statistically significant differences in the time periods 2004-2008 and 2009-2013. EHAP does not expect that this increase is associated with exposure to contaminants from Uroboros Glass.

Recommendations

EHAP has **no additional recommendations at this time**. Uroboros implemented changes to reduce emissions. State agencies have been taking actions to ensure those changes remain permanent. These actions are documented in the *Public Health Action Plan* section below.

Public Health Action Plan

A Public Health Action Plan describes the specific actions EHAP has taken and will take. While no recommendations are listed in this report, EHAP has implemented or will implement the actions listed below in collaboration with community members and partner agencies, with the goal of preventing and reducing people's exposure to hazardous substances in the environment.

Completed Public Health Actions

To date, EHAP has taken the following actions:

- Worked with Oregon DEQ on drafting regulations that ensure glass manufacturers (and all industrial operations with air permits) have pollution controls that are fully protective of public health.
- Collaborated with Oregon DEQ on soil sampling plans and placement of air monitors to ensure that data would be representative of public health.
- Assisted Oregon DEQ with reviewing preliminary soil sampling and air monitoring data that was performed immediately after air quality issues at the facility were discovered.
- Developed clinician guidance, with partners, on urine cadmium testing.
- Revised the gardening fact sheet for the community around Uroboros Glass.
- Created garden soil test interpretation guidelines for concerned residents conducting their own soil tests.
- Created a list of environmental labs that will test garden soil for concerned residents conducting their own soil tests.
- Convened three community advisory committee meetings for Uroboros Glass to inventory community concerns and gather input for exposure pathways, exposure scenarios, and exposure factors.
- Created a factsheet describing Public Health Assessments (PHAs) and our plans for preparing PHAs for the Bullseye Glass Company and Uroboros Glass.
- Attended and participated in a community meeting for residents at the Harriet Tubman Middle School.
- Participated in and spoke on the "Grow PDX" radio show about the Portland metals emissions issues and gardening.
- Developed and regularly updated Frequently Asked Questions for southeast and north Portland community members about the Bullseye Glass Company and Uroboros Glass.
- Presented on the ongoing Portland air toxics issue to OHA's Grand Rounds seminar, to interested, non-environmental Public Health Division staff.
- Developed "Heavy Metals and the Protective Benefits of a Healthy Diet" fact sheet as a part of the PHA process, in response to CAC requests.
- Participated in a Cleaner Air webinar to answer questions related to air toxics and health. Webinar was broadcast on YouTube.

- Developed "Garden Grown Food and Air Toxics-Metals" fact sheet as a part of the PHA process, in response to CAC requests.
- Held a public "SoilSHOP" (soil screening health outreach and partnership) event to screen community members' soil from their gardens and provided guidance on best health practices when gardening in urban areas.

Planned Public Health Actions

EHAP will take the following public health actions:

- Continue working with Oregon DEQ on the statewide Cleaner Air Oregon effort, which aims to implement regulations that ensure all industrial operations have pollution controls that are fully protective of public health.
- Collaborate and provide input with other government agencies regarding air toxics issues from other sources such as diesel exhaust and wood smoke.
- Provide environmental health resources to Tubman School and the nearby daycare. Examples include EPA's Tools for Schools resources.
- Ensure that this Public Health Assessment is made available to all interested community members and stakeholders.

References

1. **Portland Maps Online.** Zoning details for 2139 N Kerby Ave. Portland Ave. [Online] 2016. https://www.portlandmaps.com/detail/property/2139-N-KERBY-AVE/R102718_did/.

2. **Oregon Department of Environmental Quality (DEQ).** Portland Air Toxics Solutions Study. [Online] 2009.

3. *Using an epiphytic moss to identify previously unknown sources of atmospheric cadmium pollution.* **Donovan, Geoffrey H, et al.** s.l. : Science of the Total Environment, 2016, Vol. 559.

4. **U.S. Environmental Protection Agency .** EPA's Environmental Justice Screening and Mapping Tool. [Online] Version 2016. https://ejscreen.epa.gov/mapper/.

5. **Portland Public Schools.** Faubion Pre K-8 School Brochure. [Online] 2015.

6. **Portland Public Schools .** Faubion School 2015-2016 Enrollment Profile. [Online] 2016. http://www.pps.k12.or.us/schools-c/profiles/enrollment/enroll_out.php?rpt=1113.

7. —. Oregon Historic Site Form, Tubman School . [Online] 2009. http://www.pps.net/cms/lib8/OR01913224/Centricity/Domain/58/Historic%20Building%20Assessment/Tubman_ILS.pdf.

8. **Hicken, MT, et al.** Fine particulate matter air pollution and blood pressure: the modifying role of psychosocial stress. . *Enviro Res.* . Aug, 2014, Vol. 133.

9. **Institute of Medicine (US) Committee on Environmental Justice.** Toward Environmental Justice: Research, Education, and Health Policy Needs. [Online] 1999. http://www.nationalacademies.org/hmd/Reports/1999/Toward-Environmental-Justice-Research-Education-and-Health-Policy-Needs.aspx.

10. **Islam, T, et al.** Parental stress increases the detrimental effect of traffic exposure on children's lung function. *Am J Respir Crit Care Med.* Oct, 2011, Vol. 184, 7.

11. **Cooney, CM.** Stress-pollution interactions: an emerging issue in children's health research. *Environ Health Perspec.* 119, 2011, Vol. 10.

12. **U.S. Environmental Protection Agency (EPA).** School Air Toxics Project-An Overview and Lessons Learned. [Online] 2009. https://www3.epa.gov/ttnchie1/conference/ei19/session1/bdriscoll.pdf.

13. **Oregon Department of Environmental Quality (DEQ).** Uroboros Area Soil Sampling and Analysis Plan. [Online] February 18, 2016. https://digital.osl.state.or.us/islandora/object/osl%3A21365/datastream/OBJ/view.

14. **Tchounwou, Paul B, et al.** Heavy Metals Toxicity and the Environment. [Online] 2012. http://doi.org/10.1007/978-3-7643-8340-4_6. 133-164.

15. **Oregon Department of Environmental Quality (DEQ).** Development of Oregon Background Metals Concentrations in Soil. [Online] 2013.

16. **Agency for Toxic Substances and Disease Registry (ATSDR).** Toxicological Profile for Arsenic. [Online] 2007. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=22&tid=3.

17. —. Toxicological Profile for Cadmium. [Online] 2012. https://www.atsdr.cdc.gov/toxprofiles/TP.asp?id=48&tid=15.

18. —. Toxicological Profile for Chromium. [Online] 2012. http://www.atsdr.cdc.gov/toxprofiles/TP.asp?id=62&tid=17.

19. **Navy and Marine Corps Public Health Center (NMCPHC).** Risk Characterization for Carcinogens that have a Mutagenic Mode of Action, Supplemental Navy Guidance for Conducting Human Health Risk Assessments. [Online] 2008. http://www.med.navy.mil/sites/nmcphc/Documents/environmental-programs/risk-assessment/Risk_Characterization_for_Chemicals_with_Mutagenic_MOA_Feb_2008.pdf.

20. **American Cancer Society.** Lifetime Probability of Developing or Dying from Cancer. [Online] November 2016. http://www.cancer.org/cancer/cancerbasics/lifetime-probability-of-developing-or-dying-from-cancer.

21. **U.S. Environmental Protection Agency (EPA).** SAT Initiative: Additional Monitoring Harriet Tubman Middle School (Portland, OR). [Online] February 17, 2014. https://www3.epa.gov/air/sat/pdfs/HarrietTubmanTechReportAddl.pdf.

22. **Oregon Department of Environmental Quality (DEQ) .** *Explanation of Significant Difference- Proposed Change to the Record of Decision for the Hoyt St Rail Yard, Multnomah County, Oregon .* 2011. ECSI No. 1080.

23. **Alloway, B.J.** Contamination of soils in domestic gardens and allotments:a brief overview. *Land Contam. Reclam.* 12, 2004, Vol. 3, 179-187.

24. **Ramirez-Andreotta, Monica.** Understanding Arsenic: From Vasculature to Vegetables. *Contaminated Site Clean-up Information.* s.l. : U.S. EPA Region 9 & National Institute of Environmental Health Sciences Superfund Research Program, 2012.

25. **Okorie, et al.** Bioavailability of Potentially Toxic Elements in Foraged Fruits from a Former Industrial Site. *Human and Ecological Risk Assessment.* 19, 2011, Vol. 4, 1028-1037.

26. **Pendergrass and Butcher.** Uptake of lead and arsenic in food plants grown in contaminated soil from Barber Orchard, NC. *Microchemical Journal.* 83, 2006, Vol. 1, 14-16.

27. **Defoe, P.P, et al.** Safety of gardening on lead and arsenic contaminated urban brownfields . *J. Environ. Qual .* 43, 2014, 2064-2078.

28. **Attanayake, C.P., et al.** Potential Bioavailability of Lead, Arsenic, and Polycyclic Aromatic Hydrocarbons in Compost-Amended Urban Soils. *Journal of Environmental Quality.* 2015, Vol. 44, 930-944.

29. **McBride, M.B., et al.** Concentrations of lead, cadmium and barium in urban garden-grown vegetables: The impact of soil variables. *Environ Pollut.* 2014, Vol. 187, 254-261.

30. **Chaney, R.L.** How does contamination of rice soils with Cd and Zn cause high incidence of human Cd disease in substinence rice farmers. *Curr. Pollut. Rept.* 2015, Vol. 1, 16-22.

31. **Brown, S.L, Chaney, R.L and Hettiarachchi, G.M.** Lead in urban soils: A real or perceived concern for urban agriculture? *Journal of Environmental Quality: Special Section-Soil in the City.* 2016, Vol. 45, 26-36.

32. **Bell, N.D, et al.** Improving Garden Soils with Organic Matter. [Online] 2003. http://extension.oregonstate.edu/deschutes/sites/default/files/Horticulture/documents/organic_matter.pdf.

33. **Roberts, TL.** Cadmium and Phosphorus Fertilizers: The Issues and the Science. *Procedia Engineering.* 2014, Vol. 83.

34. **U.S. Environmental Protection Agency (EPA).** *Reusing Potentially Contaminated Landscapes: Growing Garden in Urban Soils .* [Online] 2011. https://www.epa.gov/sites/production/files/2014-03/documents/urban_gardening_fina_fact_sheet.pdf.

35. **Centers for Disease Control and Prevention(CDC).** National Report on Human Exposure to Environmental Chemicals . [Online] January 2017. https://www.cdc.gov/exposurereport/pdf/FourthReport_UpdatedTables_Volume1_Jan2017.pdf. p254.

36. **Oregon Health Authority (OHA).** Neighborhood Cancer Rate Evaluation, Elevated Environmental Heavy Metal Levels, Southeast and North Portland, Multnomah County, OR, 1999-2013. [Online] March 31, 2016. http://public.health.oregon.gov/DiseasesConditions/ChronicDisease/Cancer/oscar/Documents/se-and-n-portland-cancer-rate-report-1999-2013.pdf.

37. **Soule, Jeff.** Oregon State Cancer Registry. *Personal Communication.* Portland , August 4, 2016.

38. **Centers for Disease Control and Prevention (CDC).** Investigating Suspected Cancer Clusters and Responding to Community Concerns: Guidelines from CDC and the Council of State and Territorial Epidemiologists. [Online] 2013. http://www.cdc.gov/mmwr/preview/mmwrhtml/rr6208a1.htm.

39. **Northwest Center for Public Health Practice.** *Effective Adult Learning: A Toolkit for Teaching Adults.* Seattle : School of Public Health, University of Washington in partnership with The Network for Public Health Law, 2012.

40. —. *Effective Presentations: A Toolkit for Engaging an Audience.* Seattle : School of Public Health, University of Washington in partnership with The Network for Public Health Law, 2012.

41. **Agency for Toxic Substances and Disease Registry (ATSDR) .** Public Health Assessment Guidance Manual (Update) . [Online] 2005. http://www.atsdr.cdc.gov/HAC/PHAmanual.

42. **California Environmental Protection Agency, Office of Environmental Health Hazard Assessment Air Toxicology and Epidemiology Branch.** Technical Support Document for Cancer Potency Factors: Methodologies for derivation, listing of available values, and adjustments to allow for early life stage exposures. [Online] May 2009.

43. **E, Lindberg and G., Hedenstierna.** Chrome plating: Symptoms, findings in the upper airways, and effects on lung function. *Arch Environ Health.* 1983, Vol. 38.

44. *Child exposure to indoor and outdoor air pollutants in schools in Barcelona, Spain.* **Rivas, I, et al.** s.l. : Environment International, February 2015, Vol. 78.

Report Preparation

This Public Health Assessment for Uroboros Glass was prepared by the Oregon Environmental Health Assessment Program (EHAP) under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, and procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented.

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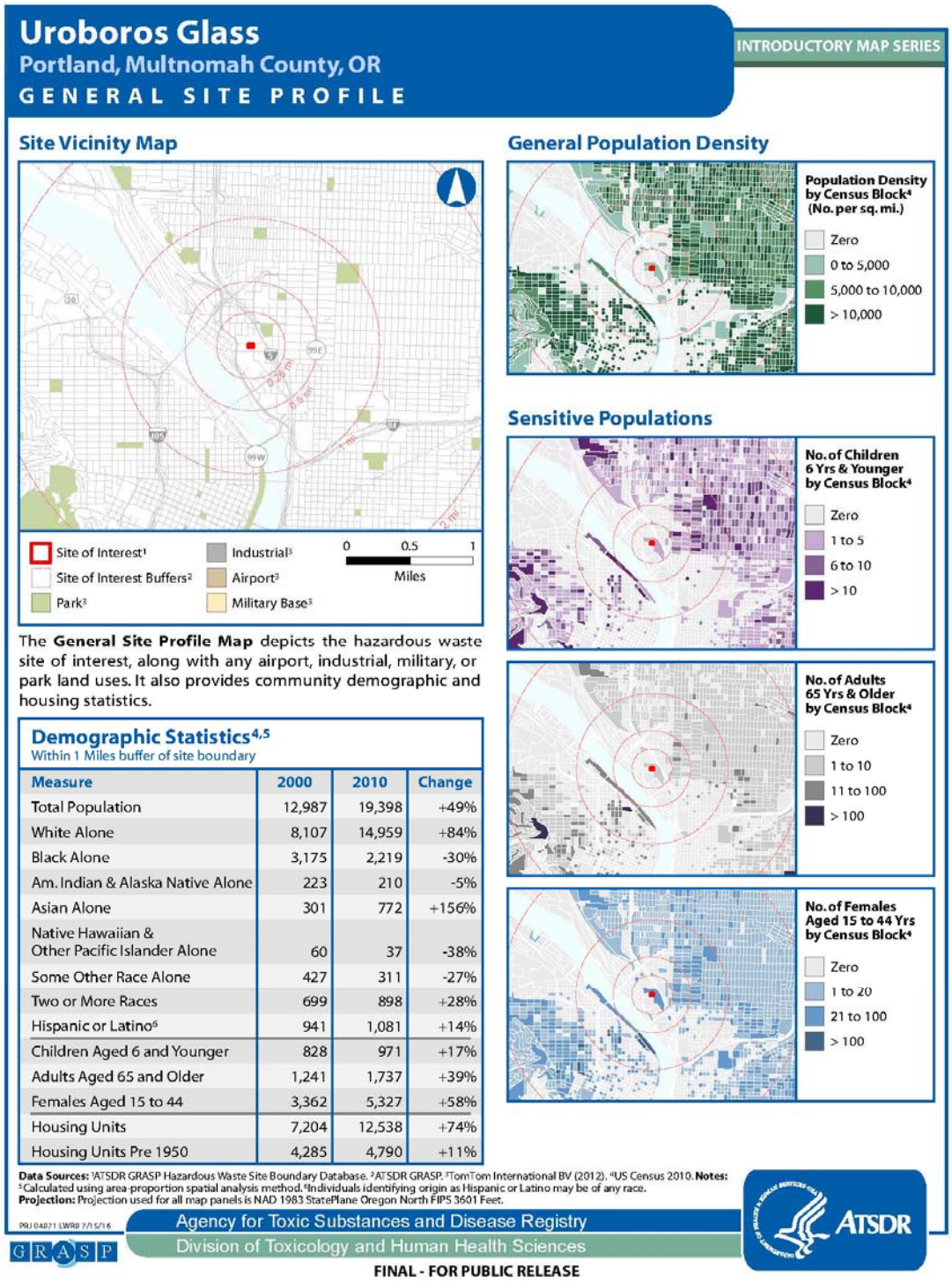
APPENDIX A. General Site Profile Map



APPENDIX B. EHAP Actions to Involve the Community

EHAP has taken the following steps to ensure meaningful involvement through the Uroboros Glass PHA by convening a Public Health Assessment Community Advisory Committee (PHA-CAC).

a. Facilitated outreach efforts that prioritized residents living in close proximity to the site (within 0.5 mile radius) and populations most sensitive and vulnerable to the effects of exposure to air emissions of metals. Developed targeted CAC recruitment materials for those groups.

b. Visited several community locations as part of the in-person outreach strategy, including: the Matt Dishman Community Center, Albina Community Gardens, nearby daycare, The Urban League, a neighborhood bookstore, and Tubman School.

c. Recruited seven Community Advisory Committee (CAC) members from the area with a diversity of perspectives including: parents of young children, long-time residents of the neighborhood, and residents with a sole purpose of representing the neighborhood's African American community.

d. Hosted CAC meetings. Strategies to remove barriers for participation included holding meetings outside of daytime work hours, serving food for participants, and allowing children. Meetings were held in the evening over the span of traditional dinner mealtime hours (from 6:00 PM to 8:00 PM). EHAP leveraged resources beyond the Agency for Toxic Substances and Disease Registry (ATSDR) Cooperative Agreement to provide food at every meeting. Due to institutional barriers, EHAP was not able to provide childcare at meetings. However, children were not excluded and were welcomed when they accompanied advisory committee members.

e. Structured the advisory committee meetings in ways that provided opportunity for meaningful participation[9]. EHAP utilized evidence based strategies (39) for effective adult education and presentations (40). The content and training provided by EHAP explained the Public Health Assessment process. Educational content, presentations, interactive activities, handouts and visual displays were informed by learning objectives and developed to increase the knowledge of the PHA process so that PHA-CAC members could in turn make informed decisions when advising EHAP on specific elements of the PHA process. Additionally, at every PHA-CAC meeting, EHAP allowed time for community advisors to make suggestions, ask questions, and share concerns. For example, EHAP included community advice when determining which exposure pathways and scenarios to assess within the PHA. The PHA-CAC also provided guidance on communication strategies for reaching the broader public, and promoting public participation during the public comment period. The PHA-CAC reviewed draft educational material (for example fact sheets, summary documents) and provided suggestions for improvement. Last, a list of CAC concerns, questions and advice was generated by EHAP and response with resources were shared with community advisors. This information is provided within the "Community Concerns" section of this PHA.

EHAP did not translate recruitment materials or directly target non-English speaking residents due to the limitations imposed by a tight timeline, funding, and staff constraints.

[9] "Meaningful participation" means engaging a diverse group of stakeholders who are representative of the communities that policies and programs will impact, not only in consultative roles to provide input, but also to co-plan or lead program development efforts, have access to data and resources to make informed decisions, have decision-making authority, and participate in the analysis of data and program impact efforts.

APPENDIX C. Community Concerns

1. **Concern: Gardening**
   Community members are concerned that heavy metals associated with site activities are accumulating in garden soil and garden grown plants and thereby, reaching the nearby residents by consuming garden vegetables.

   This PHA discusses this potential exposure pathway. OHA's preliminary assessment of acute health risks and links to soil sampling results are found within the Data section of this website: http://cleanerair.oregon.gov. In response to this concern, EHAP developed several health education materials specific to the risks of metals emissions and gardening. Educational material includes health risk communication and specific resources describing the behavior of metals in soil and garden grown plants. OHA made healthy gardening educational material available to CAC members and to the public at http://cleanerair.oregon.gov and www.healthoregon.org/gardening.

   In addition, OHA used the ATSDR Soil-screening, Health, Outreach, and Partnership (SoilSHOP) toolkit to plan a Portland SoilSHOP event in October 2016. The SoilSHOP was intended to help residents in areas nearby sources of metals emissions with concerns about gardening, to learn if their soil is contaminated with lead or other metals, and how to reduce exposures to contaminated soil and garden grown plants. The event included partners from state, regional and local government, in addition to community-based non-profit organizations. The event was planned to provide soil screening with an XRF device (a machine that determines what is in the sample), interpretation of the results, health education, blood lead level testing, and gardening advice and resources. The event welcomed over 100 community members and screened 124 bags of soil in a four-hour period.

2. **Concern: Children attend Tubman school, within a half a mile of Uroboros Glass**
   Community members requested that OHA coordinate with the administration of Faubion School at Tubman specifically to engage them in the PHA process, public comment period, and final report. Specific questions pertaining to risks to children attending Tubman school include: "I'm concerned about environmental health risks for kids going to school at Tubman."; "When was the previous outside air monitoring done at Tubman school? What were the results?"; "How long has air quality been monitored in our neighborhood at Tubman school?" and "Has indoor air and drinking water been tested at Tubman? What was discovered?"

   This PHA addresses risks for children attending school at Tubman in the Discussion of this report. The PHA also includes public health actions to follow up with Tubman School Administration for the dissemination of this PHA report.

   Since 2005, DEQ has operated a long-term air quality monitor at North Roselawn Street and North Williams. This monitor is approximately 1.5 miles northeast from Tubman School. In 2009 and 2011, the Environmental Protection Agency (EPA) conducted air monitoring (separate from DEQ's monitoring) at Tubman. Results are summarized on EPA's website

(https://www3.epa.gov/air/sat/HarrietTubInfo.html) and in the Discussion section of the document.

EPA and DEQ air and soil samples were collected using standard methods and are adequate to assess health risks to the community.

Drinking water was recently tested by PPS, and results are found here http://www.pps.k12.or.us/news-c/water/. PPS tested for radon and results can be found here: http://www.pps.k12.or.us/projects-c/radon/. PPS also did indoor air and soil testing at schools around Portland with results posted here http://saferair.oregon.gov/Pages/What-We-Know.aspx#school. These data will not be used in the PHA because they were not collected according to standard methods.

3. **Concern: Recreation and Exercise**
   Community members expressed concern over encouraging safe routes to school (children biking and walking to school in the neighborhood) particularly near Uroboros Glass. Community members expressed that many people bike commute within the neighborhood. Community members expressed interest in knowing if people who are physically active are exposed to metals air emissions in different ways and if exercising is safe in the neighborhood.

   This PHA addresses risks from recreation (physical activity) in the Discussion section. In the Health Evaluation section EHAP assumed a person would be breathing affected air for several hours a day (24-hours a day for some scenarios). This assumes averaging breathing rates over the course of those several hours, including increased rates during periods of exercise or other physical activity.

4. **Concern: Children's Health**
   Community members expressed concern about health risks to young children breathing air emissions of metals while playing outside, recreating in the neighborhood, playing at parks nearby the site, and eating vegetables from home gardens. Community members said kids go months without leaving the neighborhood and some kids have lived in the neighborhood their entire lives.

   The PHA addresses this concern in the Children's Health section and Health Evaluation section where resident child scenarios are evaluated. The PHA assumes that a child will spend 24 hours a day, 7 days a week in the neighborhood.

5. **Concern: Cumulative risks**
   Community members expressed interest in knowing what the health implications are for being exposed to environmental contaminants from other sources in the neighborhood, including: emissions from other industrial facilities, particulate matter and other contaminants coming from traffic corridors (from I-5 and in-neighborhood truck traffic from local industry), in addition to a rail yard related to manufacturing and industrial uses within the neighborhood. The community asked EHAP how local residents could find out more about other potential sources of environmental exposures present within their neighborhood.

The primary focus of this PHA is assessing health risks from Uroboros Glass. EHAP acknowledges the concern for exposures from other sources. This PHA does not include an in-depth review of exposure risks from other sources beyond the site. The EPA Transportation and Air Quality and Health program developed frequently asked questions on this issue, available at: https://www3.epa.gov/otaq/nearroadway.htm.

EHAP encourages local residents to engage with elected officials and share environmental health concerns and community-identified solutions. One way to do so is to get involved in the Cleaner Air Oregon regulatory reform (CleanerAir.Oregon.gov).
DEQ has summarized their efforts to reduce diesel emissions in Oregon at http://www.deq.state.or.us/aq/diesel/ and community members can learn more about industrial facilities and emissions at the neighborhood level through these online databases and maps:

- DEQ Facility Profiler
  http://deq12.deq.state.or.us/fp20/
  Enter an address and find locations, maps, information about industries permitted by DEQ to release emissions into the air, or discharge into the water or ground.
- DEQ Leaky Underground Storage Tanks (LUST) clean-up site database
  http://www.deq.state.or.us/lq/tanks/lust/LustPublicLookup.asp
  This database allows the public to look up information by location.
- DEQ Environmental Cleanup Site Information (ECSI) database
  http://www.deq.state.or.us/lq/ecsi/ecsiquery.asp?listtype=lis&listtitle=Environmental+Cleanup+Site%20Information+Database
  Includes information about sites that DEQ has assisted or conducted clean up enforcement.
- DEQ Air Quality Monitoring Station Map
  http://www.deq.state.or.us/lab/aqm/stations/aqmstationmap.htm
- EPA EJ Screen
  https://www.epa.gov/ejscreen
  This database combines environmental and demographic indicators in maps and reports for your location.

Community members can also contact DEQ's Air Quality program at 503-229-5359, airquality.info@deq.state.or.us and inquire about facilities permitted to discharge pollutants into the air in a given neighborhood.

6. Concern: Preventing and Reducing Exposures

Community members expressed interest in learning what actions they can take to reduce their exposures to pollutants from air emissions and other environmental contaminants. Specific questions include: "How do I get exposed?"; "How do children get exposed?"; "How do pets get exposed?"

Steps for individuals to minimize exposures to metals in the environment are detailed in educational materials available at www.healthoregon.org/ehap. Exposure pathways are described in detail in the Discussion section of this PHA. The exposure pathways explain exposure routes,

determined with input from local residents who served on the CAC. Exposure routes indicate how people come into contact with metals related to the site.

7. **Concern: Odors**
   Community members expressed concerns about smelling odors in the morning, described as "acrid", "chemically", "plastic burning-like" on daily bike commutes through the neighborhood. Community members noticed this odor most prominently as they bike commute over the Broadway Bridge, from the East side of the Willamette River to the West side.

   EHAP cannot identify if any particular odor is coming from Uroboros Glass. However, OHA does have a fact sheet on "Odors and Your Health," linked below. DEQ enforces nuisance odor complaints in Oregon. EHAP encourages communities to file nuisance odor related complaints with DEQ, see resources to do so below:
   - DEQ Odors Complaint Online Form http://www.deq.state.or.us/complaints/dcomplaint.aspx
   - DEQ Odors Program in North Portland http://www.deq.state.or.us/nwr/northportland.htm
   - OHA Odors fact sheet https://public.health.oregon.gov/HealthyEnvironments/HealthyNeighborhoods/ToxicSubstances/Documents/OdorsAndYourHealth_Final.pdf
   - ATSDR Odors Resources https://www.atsdr.cdc.gov/odors

8. **Concern: Cancer and other health issues in the neighborhood**
   Community members expressed concerns about cancer rates in the neighborhood. Community members also asked if other health outcomes in the neighborhood, such as asthma and attention deficit hyperactivity disorder (ADHD), are related to air emissions.

   The Oregon State Cancer Registry (OSCaR) is the state's repository of complete cancer incidence data. Data collected from OSCaR provide an overview of all cancers diagnosed in the state, including cancer type and address at time of diagnosis. OSCaR did a cancer rate analysis for the area surrounding Uroboros Glass. Refer to the Biological and Health Outcomes section for the results of this analysis.

   There is no state registry to report diseases such as asthma, kidney disease, and neurodevelopmental problems to OHA. Therefore, it is not possible to determine if rates found in this neighborhood are more or less or the same as expected.

9. **Concern: Confusion pertaining to OHA funded urine analysis testing and results**
   Community members expressed confusion about getting their urine tested for cadmium through the OHA funded process. Some community members said that they had their urine tested and were confused about what the results of their testing meant for their health.

   Due to overwhelming public concern, OHA facilitated urine testing for cadmium for citizens living near Uroboros Glass (and Bullseye Glass). The purpose of testing was for individuals to have conversations with their physicians. Even though this service was provided, OHA did not

recommend that community members seek medical testing for heavy metals exposure. Even so, many community members got tested independent of OHA recommendations. In response, OHA, along with Multnomah County Health Department, developed a clinician guidance document (available on http://www.CleanerAir.oregon.gov) to increase the likelihood that any medical testing would be done correctly. This guidance also provides clinicians with information about how to interpret test results. The Northwest Pediatric Environmental Health Specialty Unit (NW PEHSU) can also help with interpretation, available at 206-221-8671 or visit the NW PEHSU website at www.depts.washington.edu/pehsu. A summary of the urine data, reported to OHA, is available in the Health Outcomes section of this PHA.

10. Concern: Gap in state industrial air emission regulations

Community members expressed that they would like to know what is being done about the gap in regulations that allowed for harmful air emissions of metals from colored glass facilities in Portland, Oregon. Community members expressed interest in knowing what will happen to colored glass manufacturing facilities from a regulatory and enforcement perspective.

DEQ is the agency designated in Oregon to regulate and enforce air quality emissions. DEQ's Air Quality Program includes industrial (pollution) source control, major new source review, coordination of air emissions permits and plans, data analysis, reporting, and air regulations. For more information on air quality regulations in general call 503-229-5359 or email airquality.info@deq.state.or.us

A new rule for colored glass manufacturing facility emissions is now in effect (as of Sep 29, 2016). This rule was created in response to emissions at the Bullseye Glass Facility and applies to the Uroboros Glass and any other colored glass making facility in Oregon. http://www.deq.state.or.us/about/eqc/agendas/2016/09292016-StaffReport.pdf.

The EHAP team encourages communities to get involved in a broader reform of Oregon's industrial air emissions regulations. On April 6, 2016, Governor Kate Brown announced Cleaner Air Oregon, a regulatory overhaul process to create health-based air quality rules. Visit CleanerAir.Oregon.gov to see the timeline, share input, comments or questions, and sign up for updates.

11. Concern: Bullseye Glass vs Uroboros Glass operations

Community members expressed concern that a 'cease and desist' order was issued for Bullseye Glass but not for Uroboros Glass.

In May 2016, Governor Kate Brown ordered a 'cease and desist' of operations at Bullseye Glass. This order was based on data provided by DEQ with health risk interpretation from OHA/EHAP. Air monitoring data within a half mile of Bullseye Glass (for a period in early May) indicated that there was an immediate health risk – an air monitor detected a spike in lead levels around a daycare center near Bullseye Glass. Air monitors nearby the Uroboros Glass did not indicate levels of metals that would be considered an immediate health risk. In February 2016, Uroboros Glass and Bullseye Glass voluntarily stopped use of the heavy metals cadmium, chromium, and lead. Uroboros Glass has not used arsenic in their process in many years.

12. Concern: History of mistrust

Community members expressed a history of longstanding trust issues with state agencies. The history shared by community includes a lack of responsiveness to community concerns and a lack of actions that are respectful of community interests, and protective of community health.

The EHAP team acknowledges the history of mistrust of government agencies expressed by communities living near Uroboros Glass. EHAP's knowledge of community-level mistrust is one of the factors behind the decision for EHAP to form a Community Advisory Committee for this PHA. Copies of the Uroboros Glass Public Health Assessment Community Advisory Committee meeting agendas and materials are available by contacting EHAP.

APPENDIX D. Summary of soil data for areas sampled near Uroboros Glass: Albina Park, Albina Community Gardens, and Daycare Facility.

Table D-1. Range of concentrations, 95% Upper Confidence Limit, and Comparison Values for soil samples taken from Albina Park.

Contaminant	Number of detections and samples†	Average Concentration (mg/kg)	Range of Concentrations (mg/kg)		95% UCL	Chronic CV (mg/kg)	Type of Chronic CV	More evaluation?
			MIN	MAX				
Aluminum	9/9	8,784	7,710	10,100	9,308	57,000	EMEG, Child	NO
Arsenic	9/9	5.10	2.60	8.40	6.09	17	EMEG, Child‡	NO
Boron	9/9	3.10	2.10	4.50	3.56	11,000	RMEG, Child	NO
Cadmium	7/9	0.32	0.17	0.50	0.41	5.7	EMEG, Child	NO
Chromium	9/9	14.10	9.80	21.90	16.06	86,000	RMEG, Child§	NO
Chromium VI	3/9	0.63	0.44	1.90	1.90€	51	EMEG, Child	NO
Cobalt	9/9	13.50	12	15.90	14.19	23	EPA RSL	NO
Iron	9/9	23,250	17,600	29,500	25,455	55,000	EPA RSL	NO
Lead	9/9	55.40	4.70	101	76.88	400	EPA RSL¶	NO
Manganese	9/9	588	514	713	623	1,800	EPA RSL	NO
Mercury	7/9	0.03	0.010	0.057	0.04	23	EPA RSL	NO
Nickel	9/9	17.40	12.60	24.80	19.85	840	EPA RSL	NO
Selenium	9/9	0.383	0.34	0.55	0.50	290	EMEG, Child	NO

All data was obtained from Oregon Department of Environmental Quality. All soil samples were taken between February 19 and 23, 2016.

MIN – Minimum value in the data set; MAX – Maximum value in the data set; mg/kg – milligram per kilogram; UCL – Upper Confidence Limit; CV – Comparison Value; CREG – Cancer Risk Evaluation Guide; EMEG – Environmental Media Evaluation Guide; RMEG – Reference Dose Media Evaluation Guide; RSL – Regional Screening Level; NA – Not Available

† A "non-detect" sample means the concentration of that substance was below the lowest concentration that the analytical equipment could identify.
‡ ATSDR CREG for arsenic of 0.25 ppm is less than background soil concentrations, so was not used for soil sampling results.
§ CV is for trivalent chromium, the more frequently found form of chromium in soil.
¶ No ATSDR health-based CV exists for screening lead surface soil levels because there is no clear threshold for some of the more sensitive health effects associated with lead exposures. 400 ppm is the current EPA residential soil screening level.
€ The maximum value was used because there were not enough detected samples to give reliable statistics

Table D-2. Range of concentrations, 95% Upper Confidence Limit, and Comparison Values for soil samples for Albina Community Gardens.

Contaminant	Number of detections and samples†	Average Concentration (mg/kg)	Range of Concentrations (mg/kg)		95% UCL(mg/kg)	Chronic CV (mg/kg)	Type of Chronic CV	More evaluation?
			MIN	MAX				
Aluminum	9/9	7,793	4,450	12,500	9,113	57,000	EMEG, Child	NO
Arsenic	9/9	3.70	2.40	5.40	4.36	17	EMEG, Child	NO
Boron	9/9	4.27	0.93	8.60	5.40	11,000	RMEG, Child	NO
Cadmium	9/9	0.28	0.12	0.40	0.33	5.7	EMEG, Child	NO
Chromium	9/9	13.99	7.30	26.10	17.33	86,000	RMEG, Child§	NO
Chromium VI	3/9	0.63	0.50	1.30	0.93	51	EMEG, Child	NO
Cobalt	9/9	12.1	7.50	16.70	13.79	23	EPA RSL	NO
Iron	9/9	19,722	13,200	26,600	22,147	55,000	EPA RSL	NO
Lead	9/9	33.94	10	69	47.19	400	EPA RSL¶	NO
Manganese	9/9	580	284	743	663	1,800	EPA RSL	NO
Mercury	9/9	0.04	0.02	0.06	0.05	23	EPA RSL	NO
Nickel	9/9	12.99	6.90	19.40	15	840	EPA RSL	NO
Selenium	8/9	0.38	0.25	0.60	0.45	290	EMEG, Child	NO

All data was obtained from Oregon Department of Environmental Quality. All soil samples were taken between February 19 and 23, 2016.

MIN – Minimum value in the data set; MAX – Maximum value in the data set; UCL – Upper Confidence Limit; CV – Comparison Value; CREG – Cancer Risk Evaluation Guide EMEG – Environmental Media Evaluation Guide; RSL – Regional Screening Level; NA – Not Available

†A "non-detect" sample means the concentration of that substance was below the lowest concentration that the analytical equipment could identify.
§ CV is for trivalent chromium, the more frequently found form of chromium in soil.
¶ No ATSDR health-based CV exists for screening lead surface soil levels because there is no clear threshold for some of the more sensitive health effects associated with lead exposures. 400 ppm is the current EPA residential soil screening level.

Table D-3. Range of concentrations, averages, and Comparison Values for soil samples taken from the daycare center.

Contaminant	Number of detections and samples†	Average Concentration (mg/kg)	Range of Concentrations (mg/kg)		Chronic CV (mg/kg)	Type of Chronic CV	More evaluation?
			MIN	MAX			
Aluminum	5/5	6,994	5,150	8,400	57,000	EMEG, Child	NO
Arsenic	5/5	3.62	2.20	5.70	17	EMEG, Child	NO
Boron	5/5	3.72	2.20	5.6	11,000	RMEG, Child	NO
Cadmium	5/5	0.52	0.21	1.07	5.70	EMEG, Child	NO
Chromium	5/5	12.64	9.30	15.70	86,000	RMEG, Child§	NO
Chromium VI	1/5	0.56	0.56	0.56	51	EMEG, Child	NO
Cobalt	5/5	9.6	6.0	14.10	23	EPA RSL	NO
Iron	5/5	18,040	11,900	26,100	55,000	EPA RSL	NO
Lead	5/5	49.94	10.90	105	400	EPA RSL¶	NO
Manganese	5/5	438	281	655	1,800	EPA RSL	NO
Mercury	5/5	0.03	0.02	0.04	23	EPA RSL	NO
Nickel	5/5	11.96	8.10	14.80	840	EPA RSL	NO
Selenium	4/5	0.48	0.34	0.60	290	EMEG, Child	NO

All data was obtained from Oregon Department of Environmental Quality. All soil samples were taken between February 19 and 23, 2016.

Due to the small data set, EHAP was unable to calculate reliable statistics. For CV comparison, the maximum value was used.

MIN – Minimum value in the data set; MAX – Maximum value in the data set; UCL – Upper Confidence Limit; CV – Comparison Value; CREG – Cancer Risk Evaluation Guide EMEG – Environmental Media Evaluation Guide; RSL – Regional Screening Level; NA – Not Available

†A "non-detect" sample means the concentration of that substance was below the lowest concentration that the analytical equipment could identify.

¶ No ATSDR health-based CV exists for screening lead surface soil levels because there is no clear threshold for some of the more sensitive health effects associated with lead exposures. 400 ppm is the current EPA residential soil screening level.

APPENDIX E. Summary of 2016 air monitoring data for four areas around Uroboros Glass: Tubman School, Water Bureau East, Water Bureau West, North Coast Electric, and 2009/2011 air monitoring at Tubman School.

Table E-1. Range of concentrations, 95% UCL, and CVs at the Tubman monitoring station, taken in 2016.

Contaminant	Number of detections and samples	Samples exceeding CV	Range of Concentrations (ng/m^3)		Average Concentration (ng/m^3)	95% UCL (ng/m^3)	Chronic CV (ng/m^3)	Type of CV	More evaluation?
			Min	Max					
Arsenic	122/122	91	0.10	1.93	0.46	0.59†	0.23	CREG	**YES**
							15	REL	
Beryllium	32/122	0	0.004	0.01	0.004	0.004	0.42	CREG	no
							2,000	REL	
Cadmium	93/122	4	0.04	0.86	0.12	0.18	0.56	CREG	**YES‡**
							10	EMEG	
Chromium VI	91/122	29	0.04	0.22	0.06	0.07	0.052	CREG	**YES‡**
							5	EMEG	
Cobalt	121/122	0	0.03	0.75	0.11	0.15	100	EMEG	no
Lead	122/122	0	0.45	11.60	2.06	2.28	150	NAAQS§	no
Manganese	122/122	0	1.57	104	13.44	15.45	300	EMEG	no
Nickel	84/122	0	0.41	4.72	0.78	1.03	90	EMEG	no
Selenium	122/122	0	0.04	6.68	0.29	0.29	21,000	RSL	no

All data was obtained from Oregon Department of Environmental Quality from March 1 to July 26, 2016.

CV – Comparison Value; UCL – Upper Confidence Limit; NA – Not applicable; ng/m^3 – nanograms per cubic meter.

EMEG – Environmental Media Evaluation Guide; Agency for Toxic Substances and Disease Registry (ATSDR)
CREG – Cancer Risk Evaluation Guide for cancer effects; ATSDR
REL – Reference Exposure Level for non-cancer effects; California Office of Environmental Health Hazard Assessment (OEHHA)
RSL – Regional Screening Level; Environmental Protection Agency (EPA)
NAAQS –EPA National Ambient Air Quality Standards

† – Concentrations that are shaded indicate the UCL exceeds a CV.
‡ – These metals are still considered for more evaluation since the 95% UCL concentrations are exceeded at the other monitoring stations.
§ -- Primary and secondary NAAQS for lead is 150 ng/m^3 in total suspended particles as a 3-month average.

Table E-2. Range of concentrations, 95% UCL, and CVs at the Water Bureau East air monitoring station, taken in 2016.

Contaminant	Number of detections and samples	Samples exceeding CV	Range of Concentrations (ng/m^3)		Average Concentration (ng/m^3)	95% UCL (ng/m^3)	Chronic CV (ng/m^3)	Type of CV	More evaluation?
			Min	Max					
Arsenic	72/74	72	0.18	1.61	0.48	0.54†	0.23	CREG	**YES**
							15	REL	
Beryllium	0/74	0	NA	NA	NA	NA	0.42	CREG	no
							2,000	REL	
Cadmium	61/74	32	0.09	6.60	0.88	1.23	0.56	CREG	**YES**
							10	EMEG	
Chromium VI	62/73	40	0.04	0.41	0.11	0.13	0.052	CREG	**YES**
							5	EMEG	
Cobalt	70/74	0	0.09	5.34	0.53	0.95	100	EMEG	no
Lead	74/74	0	0.38	10.80	2.98	3.42	150	NAAQS§	no
Manganese	74/74	0	1.84	113	23.93	28.03	300	EMEG	no
Nickel	69/74	0	0.58	8.08	1.68	2.36	90	EMEG	no
Selenium	53/74	0	0.35	41.20	1.97	4.49	21,000	RSL	no

All data was obtained from Oregon Department of Environmental Quality from March 1 to July 26, 2016.

CV – Comparison Value; UCL – Upper Confidence Limit; NA – Not applicable; ng/m^3 – nanograms per cubic meter.

EMEG – Environmental Media Evaluation Guide; Agency for Toxic Substances and Disease Registry (ATSDR)
CREG – Cancer Risk Evaluation Guide for cancer effects; ATSDR
REL – Reference Exposure Level for non-cancer effects; California Office of Environmental Health Hazard Assessment (OEHHA)
RSL – Regional Screening Level; Environmental Protection Agency (EPA)
NAAQS –EPA National Ambient Air Quality Standards

† – Concentrations that are shaded indicate the UCL exceeds a CV.
§ -- Primary and secondary NAAQS for lead is 150 ng/m^3 in total suspended particles as a 3-month average.

Table E-3. Range of concentrations, 95% UCL, and CVs at the Water Bureau West air monitoring station, taken in 2016.

Contaminant	Number of detections and samples	Samples exceeding CV	Range of Concentrations (ng/m^3)		Average Concentration (ng/m^3)	95% UCL (ng/m^3)	Chronic CV (ng/m^3)	Type of CV	More evaluation?
			Min	Max					
Arsenic	66/74	56	0.18	1.46	0.45	0.51†	0.23	CREG	**YES**
							15	REL	
Beryllium	0/74	0	NA	NA	NA	NA	0.42	CREG	no
							2,000	REL	
Cadmium	28/74	4	0.09	1.56	0.17	0.29	0.56	CREG	**YES‡**
							10	EMEG	
Chromium VI	59/72	43	0.05	0.27	0.10	0.12	0.052	CREG	**YES**
							5	EMEG	
Cobalt	69/74	0	0.09	0.90	0.23	0.33	100	EMEG	no
Lead	74/74	0	0.29	11.50	2.32	2.73	150	NAAQS§	no
Manganese	74/74	0	1.78	124	24.71	28.96	300	EMEG	no
Nickel	71/74	0	0.47	8.68	1.59	2.3	90	EMEG	no
Selenium	21/74	0	0.36	8.86	0.57	1.10	21,000	RSL	no

All data was obtained from Oregon Department of Environmental Quality from March 1 to July 26, 2016.

CV – Comparison Value; UCL – Upper Confidence Limit; NA – Not applicable; ng/m^3 – nanograms per cubic meter.

EMEG – Environmental Media Evaluation Guide; Agency for Toxic Substances and Disease Registry (ATSDR)
CREG – Cancer Risk Evaluation Guide for cancer effects; ATSDR
REL – Reference Exposure Level for non-cancer effects; California Office of Environmental Health Hazard Assessment (OEHHA)
RSL – Regional Screening Level; Environmental Protection Agency (EPA)
NAAQS –EPA National Ambient Air Quality Standards

† – Concentrations that are shaded indicate the UCL exceeds a CV.
‡ – These metals are still considered for more evaluation since the 95% UCL concentrations are exceeded at the other monitoring stations.
§ -- Primary and secondary NAAQS for lead is 150 ng/m^3 in total suspended particles as a 3-month average.

Table E-4. Range of concentrations, 95% Upper Confidence Limit, and Comparison Values at the North Coast Electric air monitoring station, taken in 2016.

Contaminant	Number of detections and samples	Samples exceeding CV	Range of Concentrations (ng/m^3)		Average Concentration (ng/m^3)	95% UCL (ng/m^3)	Chronic CV (ng/m^3)	Type of CV	More evaluation?
			Min	Max					
Arsenic	60/72	55	0.19	1.94	0.44	0.53	0.23	CREG	**YES**
							15	REL	
Beryllium	0/72	0	NA	NA	NA	NA	0.42	CREG	no
							2,000	REL	
Cadmium	41/72	15	0.09	5.93	0.52	0.61	0.56	CREG	**YES**
							10	EMEG	
Chromium VI	66/72	24	0.04	0.66	0.11	0.17	0.052	CREG	**YES**
							5	EMEG	
Cobalt	51/72	0	0.09	0.78	0.15	0.30	100	EMEG	no
Lead	72/72	0	0.38	10.10	2.59	3.05	150	NAAQS[§]	no
Manganese	72/72	0	1.16	109	23.39	27.67	300	EMEG	no
Nickel	69/72	0	0.46	21.90	1.91	3.33	90	EMEG	no
Selenium	31/72	0	0.35	8.15	0.56	0.98	21,000	RSL	no

All data was obtained from Oregon Department of Environmental Quality from March 1 to July 26, 2016.

CV – Comparison Value; UCL – Upper Confidence Limit; NA – Not applicable; ng/m^3 – nanograms per cubic meter.

EMEG – Environmental Media Evaluation Guide; Agency for Toxic Substances and Disease Registry (ATSDR)
CREG – Cancer Risk Evaluation Guide for cancer effects; ATSDR
REL – Reference Exposure Level for non-cancer effects; California Office of Environmental Health Hazard Assessment (OEHHA)
RSL – Regional Screening Level; Environmental Protection Agency (EPA)
NAAQS –EPA National Ambient Air Quality Standards

† – Concentrations that are shaded indicate the UCL exceeds a CV.

§ -- The EPA RSL and primary and secondary NAAQS for lead is 150 ng/m^3 in total suspended particles as a 3-month average.

Table E5. Range of concentrations, 95% Upper Confidence Limit, and Comparison Values from 2009 monitoring at Tubman School.

Contaminant	Number of detections and samples	Samples exceeding CV	Range of Concentrations (ng/m^3)		Average Concentration (ng/m^3)	95% UCL (ng/m^3)	Chronic CV (ng/m^3)	Type of CV	More evaluation?
			Min	Max					
Antimony	13/13	0	0.83	7.47	2.90	3.96	210	RSL	no
Arsenic	11/13	10	0.16	8.13	1.45	3.99	0.23	CREG	**YES**
							15	REL	
Beryllium	11/13	0	0.0003	0.05	0.01	0.03	0.42	CREG	no
							2,000	REL	
Cadmium	13/13	13	0.05	23.10	7.29	21.33	0.56	CREG	**YES**
							10	EMEG	
Chromium (Total)‡	13/13	8	1.45	6.84	3.76	4.57	0.052	CREG	**YES**
							5	EMEG	
Cobalt	12/13	0	0.18	1.03	0.41	0.54	100	EMEG	no
Lead	13/13	0	1.30	59.80	13.99	29.62	150	NAAQS§	no
Manganese	13/13	0	3.79	38.60	13.87	18.68	300	EMEG	no
Mercury	9/13	0	0.004	0.06	0.02	0.03	200	EMEG	no
Nickel	13/13	0	0.30	5.1	2	2.66	90	EMEG	no
Selenium	13/13	0	0.14	9.32	3.09	6.92	21,000	RSL	no

All data was obtained from U.S. Environmental Protection Agency from August 23 to November 3, 2009. Data qualifiers and detection limits for data were not available.

CV – Comparison Value; UCL – Upper Confidence Limit; NA – Not applicable; ng/m^3 – nanograms per cubic meter.

EMEG – Environmental Media Evaluation Guide; Agency for Toxic Substances and Disease Registry (ATSDR)

CREG – Cancer Risk Evaluation Guide for cancer effects; ATSDR

REL – Reference Exposure Level for non-cancer effects; California Office of Environmental Health Hazard Assessment (OEHHA)

RSL – Regional Screening Level; Environmental Protection Agency (EPA)

NAAQS –EPA National Ambient Air Quality Standards

† – Concentrations that are shaded indicate the UCL exceeds a CV.

‡ – Hexavalent chromium measurements unavailable. Only total chromium was sampled. For screening, EHAP/ATSDR assumed that 100 percent of total chromium measured was in the form of hexavalent chromium.

* - Antimony was measured in 2009/2011 monitoring, but not in 2016 monitoring.

§ -- Primary and secondary NAAQS for lead is 150 ng/m^3 in total suspended particles as a 3-month average.

Table E6. Range of concentrations, 95% Upper Confidence Limit, and Comparison Values from 2011 monitoring at Tubman School.

Contaminant	Number of detections and samples	Samples exceeding CV	Range of Concentrations (ng/m^3)		Average Concentration (ng/m^3)	95% UCL (ng/m^3)	Chronic CV (ng/m^3)	Type of CV	More evaluation ?
			Min	Max					
Antimony	46/46	0	0.57	4.11	1.93	2.15	210	RSL	no
Arsenic	44/46	31	0.0003	6.53	0.63	1.28	0.23	CREG	**YES**
							15	REL	
Beryllium	38/46	0	0.0002	0.02	0.005	0.006	0.42	CREG	no
							2,000	REL	
Cadmium	46/46	15	0.02	12.60	1.24	2.96	0.56	CREG	**YES**
							10	EMEG	
Chromium (Total)‡	41/46	41	0.23	21.40	5.04	7.38	0.052	CREG	**YES**
							5	EMEG	
Cobalt	46/46	0	0.06	1.57	0.29	0.34	100	EMEG	no
Lead	46/46	0	0.91	15.80	3.03	4.91	150	NAAQS§	no
Manganese	46/46	0	3.01	38.70	12.49	14.73	300	EMEG	no
Mercury	40/46	0	0.0006	0.03	0.008	0.01	200	EMEG	no
Nickel	46/46	0	0.58	28.50	3	5.70	90	EMEG	no
Selenium	46/46	0	0.02	10.6	1.36	1.98	21,000	RSL	no

All data was obtained from U.S. Environmental Protection Agency from May 27 to July 17, 2011. Data qualifiers and detection limits for data were not available.
CV – Comparison Value; UCL – Upper Confidence Limit; NA – Not applicable; ng/m^3 – nanograms per cubic meter.
EMEG – Environmental Media Evaluation Guide; Agency for Toxic Substances and Disease Registry (ATSDR)
CREG – Cancer Risk Evaluation Guide for cancer effects; ATSDR
REL – Reference Exposure Level for non-cancer effects; California Office of Environmental Health Hazard Assessment (OEHHA)
RSL – Regional Screening Level; Environmental Protection Agency (EPA)
NAAQS –EPA National Ambient Air Quality Standards
† – Concentrations that are shaded indicate the UCL exceeds a CV.
‡ – Hexavalent chromium measurements unavailable. Only total chromium was sampled. For screening, EHAP/ATSDR assumed that 100 percent of total chromium measured was in the form of hexavalent chromium.
* - Antimony was measured in 2009/2011 monitoring, but not in 2016 monitoring.
§ -- Primary and secondary NAAQS for lead is 150 ng/m^3 in total suspended particles as a 3-month average.

APPENDIX F. Exposure factors used in calculation of risk from exposure to air monitored around Uroboros Glass.

Table F-1. Exposure factors for air exposure scenarios evaluated in the Public Health Assessment.

Term	Description	Adult Long-Term Residential	Child Long-Term Residential	Non-Resident Daycare (Child)	Non-Resident Student	Park User (child)	Units	Rationale
ET	Exposure Time	24	24	10	8	2	hours/day	Based on community input. Park user scenario exposure time based on local park use statistics.
EF	Exposure frequency for inhalation	365	365	250	180	27	days/year	EPA assumption. Park user scenario exposure frequency based on local park use statistics.
ED	Exposure Duration	43 22‡	21	6	10	21	years	Based on community input and duration of Uroboros operations.
AT_c	Averaging time for cancer health effects	683,280	683,280	683,280	683,280	683,280	hours	78 year lifetime x 365 days/year x 24 hours/day
AT_{nc}	Averaging time for non-cancer health effects	192,720	183,960	52,560	87,600	183,960	hours	Exposure duration x 365 days/year x 24 hours/day
IUR	Inhalation Unit Risk	Arsenic: 4.3×10^{-3} – Cadmium: 1.80×10^{-3} – Chromium: 1.20×10^{-2}						IUR is an estimate of increased cancer risk from inhalation exposure to 1 ug/m^3 over a lifetime. The same IURs are used for all ages.

‡Adult exposures were evaluated in two ways: [1] a person who lived in the area as an adult from the time Uroboros Glass started operating (they became an adult before the plant opened) and [2] a person was born when the facility started operating and continues to live in the area today. These scenarios were evaluated separately because children are affected by chemical exposures differently than adults. Both exposure scenarios equal 43 years of exposure.

APPENDIX G. Calculation of Dose, Hazard Quotient, and Cancer Risk

This appendix describes the formulas, methods, and assumptions used to calculate contaminant of concern (COC) doses for people in various exposure scenarios. It also describes how non-cancer and cancer risk are derived from dose.

The doses calculated in this appendix were used to evaluate the risk for people exposed in the exposure scenarios listed in Table 4 and to determine whether or not they might become ill because of contaminants at or around Uroboros Glass. For air samples, the 95% Upper Confidence Limit (UCL) around the average concentration was used to calculate dose. This is protective of human health because uncertainty about the true mean is added to the concentration. People will likely be exposed to lower concentrations of these COCs. This approach is most protective of health.

Dose from exposure to air (*chronic exposure*)
This formula was used to calculate exposure concentration of metals from inhaling air from the area around Uroboros Glass:

$$\text{Exposure Concentration} = \frac{CA \times ET \times EF \times ED}{AT}$$

Calculation abbreviations:

CA = Air concentration of chemical measured in air (chemical specific, ug/m^3)
ET = Exposure Time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
AT = Averaging time

Non-cancer vs. Cancer doses
Methods for calculating doses for use in assessing non-cancer risk and for cancer risk are identical except the way in which averaging time (AT) is calculated. See below for details:

Non-Cancer:
AT_{nc} = ED x 365 days/year x 24 hours/day
Where AT = Averaging time and ED = Exposure duration (years)

Cancer:
AT_c = 683,280 hours (78 year lifetime x 365 days/year x 24 hours/day)
The rationale for this difference in AT lies in the theory that cancer is the result of multiple defects/mutation in genetic material accumulated over an entire lifetime. Therefore, the averaging time is representative of an entire statistical lifetime (78 years) for agents that cause cancer.

Non-cancer risk

Non-cancer risk, the risk of any health problem that is not cancer. Inhaled hexavalent chromium was calculated by dividing the time adjusted air concentration (the adjusted level of exposure based on the amount of time spent in the area) of hexavalent chromium by the health guideline for hexavalent chromium. A health guideline is the daily dose of a chemical, below which scientists consider it unlikely to harm people's health. EHAP followed ATSDR guidance (41) by using the health guideline established by ATSDR, called minimal risk levels (MRLs). The formula below describes how the Hazard Quotient (HQ) is determined by dividing the time-adjusted air concentration by the MRL. The HQ is a value used to determine if further evaluation is needed.

$$\textbf{Hazard Quotient} = \frac{\textbf{Time Adjusted Air Concentration}}{\textbf{Health Guideline (MRL)}}$$

Cancer risk

Estimated cancer risk was calculated by multiplying the calculated cancer dose by the Inhalation Unit Risk (IUR). An IUR is an estimate of increased cancer risk from inhalation exposure to 1 $\mu g/m^3$ over a lifetime. This unit is used for all ages. Cancer risk accumulates over the entire lifetime of an individual, so cancer dose is averaged over a 78-year lifetime. This is different from noncancer risk, which is only averaged over the duration of exposure.

The following equation was used to calculate cancer risk from exposure to contaminants in air:

Cancer Risk = Time Adjusted Air Concentration x Inhalation Unit Risk (IUR)

In addition, cancer risk for children was weighted by age for hexavalent chromium, because it causes cancer by what is known as "mutagenic mode of action." Mutagenic chemicals are those that can make multiple changes to genes in a cell. For children, mutagens pose a higher risk of cancer when exposures occur early in life. The following adjustments were made for chromium, the only COC that had a mutagenic mode of action. The following adjustments were made to reflect the potential for early-life exposure to make a greater contribution to cancers appearing later in life (41; 42). For exposures before 2 years of age, a 10-fold adjustment was made. For exposures between 2 and <16 years of age, a 3-fold adjustment was made. For exposures after turning 16 years of age, no further adjustment was made.

APPENDIX H. Glossary of Terms

This appendix lists abbreviations and defines words used in this Public Health Assessment. The definitions in this glossary are not a complete dictionary of environmental health terms.

Glossary of Terms

Absorption:	The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.
Acute exposure:	Contact with a substance that occurs once or for only a short time (up to 14 days).
Adverse health effect:	A change in body function or cell structure that might lead to disease or health problems.
Averaging time (AT):	The period over which the exposure is averaged to arrive at a time-weighted exposure factor. For assessing cancer risks, AT is averaged over a lifetime (78 years); for assessing non-cancer risks, AT is averaged over the exposure duration (years), which may or may not be a lifetime.
Background level:	An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.
Cancer:	Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.
Cancer risk:	A theoretical increased risk for getting cancer if exposed to a substance every day for 78 years (a lifetime exposure). The true risk might be lower.
Cancer Risk Evaluation Guides (CREGs):	The estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million (10^{-6}) persons exposed during their lifetime (78 years). The Agency for Toxic Substances and Disease Registry's CREGs are calculated from the U.S. Environmental Protection Agency's (EPA's) cancer slope factors for oral exposures or unit risk values for inhalation exposures. These values are based on EPA's evaluations and assumptions about hypothetical cancer risks at low levels of exposure.
Carcinogen:	A substance that causes cancer.

Comparison value (CV):	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Completed exposure pathway:	See exposure pathway.
Concentration:	The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.
Contaminant:	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
Dermal contact:	Contact with (touching) the skin (see route of exposure).
Detection limit:	The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.
Dose:	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
Environmental Justice	Environmental justice means that all people, regardless of race, color, national origin, or income are treated fairly and involved in a meaningful way in the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including a racial, ethnic, or a socioeconomic group, should bear a disproportionate share of the negative environmental consequences that result from industrial, municipal, and commercial operations or from the implementation of government programs and policies.

Environmental media:	Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants. Environmental media is the second part of an exposure pathway.
Environmental Media Evaluation Guides (EMEGs):	The estimated contaminant concentrations that are not expected to result in adverse non-cancer health effects based on the Agency for Toxic Substances and Disease Registry's (ATSDR's) evaluation. EMEGs are based on ATSDR's Minimal Risk Levels and conservative assumptions about exposure, such as intake rate, exposure frequency and duration, and body weight.
Exposure:	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term (acute exposure), of intermediate duration, or long-term (chronic exposure).
Exposure duration (ED):	The number of years that an exposure occurred.
Exposure pathway:	The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: 1) a source of contamination, 2) an environmental media, 3) a point of exposure, 4) a route of exposure, and 5) a receptor population. When all five parts are present, the exposure pathway is termed a completed exposure pathway.
Frequency of exposure (F):	How often a person is exposed to a chemical over time; for example, every day, once a week, or twice a month.
Health guideline:	See Minimal Risk Level (MRL).
Hazard quotient (HQ):	A value used to quantify non-cancer risk where an exposure dose is compared to a health guideline. Specifically, the value is the result of dividing an exposure dose by a health guideline. When an HQ is less than or equal to 1.0 (the exposure dose is lower than or equal to the health guideline), it is unlikely that non-cancer health effects will occur. If the HQ is greater than 1.0 (the exposure dose is higher than the health guideline), further evaluation is needed to determine if an

	exposed person could experience adverse health effects that are not cancer.
Ingestion:	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way (see route of exposure).
Inhalation:	The act of breathing. A hazardous substance can enter the body this way (see route of exposure).
Intermediate duration exposure:	Contact with a substance that occurs for more than 14 days and less than a year.
kg	Kilogram or 1000 grams. Usually used here as part of the dose unit mg/kg/day meaning mg (contaminant)/kg (body weight)/day.
µg	Microgram or 1 millionth of 1 gram.
mg	Milligram or 1 thousandth of 1 gram. Usually used here as in a concentration of contaminant in soil mg contaminant/kg soil or as in the dose unit mg/kg/day meaning mg (contaminant)/kg (body weight)/day.
Minimal Risk Level (MRL):	An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects.
ng	Nanogram or 1 billionth of 1 gram.
Point of exposure:	The place where someone can come into contact with a substance present in the environment (see exposure pathway).
Population:	A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).
Potential exposure pathway:	See exposure pathway.

Receptor population:	People who could come into contact with hazardous substances (see exposure pathway).
Risk:	The probability that something will cause injury or harm.
Route of exposure:	The way people come into contact with a hazardous substance. The three routes of exposure are: 1) breathing (inhalation), 2) eating or drinking (ingestion), and 3) contact with the skin (dermal contact).
Source (of contamination):	The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.
Special populations:	People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.
Standardized Incidence Ratio (SIR)	To evaluate cancer incidence (how many people get a particular type of cancer), a statistic known as a standardized incidence ratio (SIR) is calculated. An SIR is the ratio of the observed number of cancer cases to the expected number of cases.
Substance:	A chemical.
Upper Confidence Limit (UCL) Substance:	The number that specifies the endpoint of a confidence interval (an estimated range of values which is likely to include an unknown population parameter).