Health Consultation

Initial and Public Comment Release

J.H. BAXTER NEIGHBORHOOD INVESTIGATION
EUGENE, OREGON

Prepared by:
Environmental Health Assessment Program
Oregon Health Authority, Public Health Division

Under a Cooperative Agreement with:
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

February 27, 2023

Health Consultation: A Note of Explanation

A Health Consultation (HC) is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. To prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You may contact ATSDR toll free at 1-800-CDC-INFO or visit our home page at: https://www.atsdr.cdc.gov

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Abbreviations and Acronyms

AT - Averaging Time

ATSDR - Agency for Toxic Substances and Disease Registry

CDC - Centers for Disease Control and Prevention

COC - Contaminant of Concern

CREG - Cancer Risk Evaluation Guide

CSF - Cancer Slope Factor

CV - Comparison Value

DEQ - (Oregon) Department of Environmental Quality

ED - Exposure Duration

EHAP - (Oregon Health Authority) Environmental Health Assessment Program

EJ - Environmental Justice

EMEG - Environmental Media Evaluation Guide

EPA - (U.S.) Environmental Protection Agency

HC - Health Consultation

HI - Hazard Index

HQ - Hazard Quotient

IR - Ingestion Rate

IRIS - Integrated Risk Information System

LRAPA - (Lane County) Lane Regional Air Protection Agency

MRL - Minimal Risk Level

OHA - Oregon Health Authority

OSCaR - Oregon State Cancer Registry

RfD - Reference Dose

RMEG – Reference Dose Media Evaluation Guide

Summary

Introduction

Through a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), the Oregon Health Authority (OHA) Public Health Division's (PHD) Environmental Health Assessment Program (EHAP) works to ensure that a community around the site of a possible environmental hazard exposure has the best information possible to protect its health.

The goal of this report is to provide information to the community to make informed health-based decisions. EHAP evaluates people's exposures to hazardous substances and determines whether these exposures pose a health risk. We make recommendations to eliminate or reduce exposures. EHAP worked with the City of Eugene, Oregon State University (OSU), Lane County Health Department, Lane Regional Air Protection Agency (LRAPA), ATSDR, the U.S. Environmental Protection Agency (EPA), the Oregon Department of Environmental Quality (DEQ), Beyond Toxics, the Active Bethel Community neighborhood group, and individual community members. EHAP also collaborated with a subset of the noted organizations in a "JH Baxter Core Team." This Health Consultation (HC) summarizes the public health assessment activities.

JH Baxter & Co. Inc. ("JH Baxter", "Baxter", "Baxter facility", "the facility") is located in West Eugene, on Roosevelt Boulevard. It is adjacent to the Bethel neighborhood, a residential area. In September 2020, DEQ evaluated soil samples adjacent to the Baxter facility for contaminants related to emissions from the wood treatment facility. The levels of contaminants in the soil samples (dioxin, pentachlorophenol, metals, and PAHs) suggested that additional sampling should be done in residential areas near the Baxter facility, to determine if residential areas have been impacted by these contaminants.

To better understand the potential impact of JH Baxter's operations to the environment, DEQ and EPA collected surface soil samples from nearby residential yards and comparison locations far from the facility in September 2021 and in May 2022. Community members in the Bethel neighborhood have long held concerns about JH Baxter's impacts on their environment and to their health.

DEQ's and EPA's sampling results became available in 2021 and 2022. Sampling showed levels of dioxin in soil in seven residential yards above 40 parts per trillion (ppt). These are levels that warrant expedited clean-up. When people living in and near these residential properties learned about dioxin in the soil, they asked EHAP about their health risks. EHAP responded by conducting a Health Consultation (HC). In this HC, EHAP evaluated soil data taken from residential areas north of JH Baxter. Since the community expressed concern that they could be exposed to dioxin through several pathways, EHAP also evaluated groundwater and surface water.

Part of the DEQ sampling revealed elevated levels of dioxins in soils at Trainsong Park, also located in West Eugene. There is some limited discussion of Trainsong Park in this HC, but EHAP will address it more completely and thoroughly in a separate HC dedicated solely to Trainsong. Dioxins in soil at Trainsong Park are not likely related to activities at JH Baxter.

Conclusions

OHA reached six conclusions (*See executive summary in Table 1 below*):

CONCLUSION 1

At seven residences near Baxter that DEQ and EPA sampled, soil with dioxin concentrations over 40 parts per trillion (ppt) could harm the health of children under six years of age who come into contact with bare soil regularly for a year or longer.

BASIS FOR CONCLUSION

Seven residences near JH Baxter have soil dioxin concentrations greater than 40 ppt. When exposed regularly for a year or more, concentrations of dioxin above 40 ppt in soil increases non-cancer health risk in children under six years of age. Specifically, exposures to soil for a year or more could cause harm to the male reproductive system, resulting in reduced sperm production in males later in life. This exposure happens through swallowing soil and, to a lesser extent, making skin contact with it. Children under six years are more vulnerable to dioxin exposure because their bodies are smaller and closer to the ground than older children and adults, and they swallow larger amounts of soil through playing and hand-to-mouth contact.

The concentrations of dioxin in the area that DEQ sampled are too low to result in health effects to older children and adults including pregnant women. Adults and children over 6 years are less vulnerable to dioxin exposure because their bodies are larger, and they tend to swallow less soil than smaller children.

RECOMMENDATIONS

EHAP recommendations for yards with dioxin levels above 40 ppt:

- Yards should be remediated to eliminate or reduce dioxin concentrations so that dioxin cannot harm the health of residents who use their yards.
- Until the remediation/clean-up is complete, all residents who have yards with soil dioxin over 40 ppt should take steps to reduce exposure to loose soil until remediation is complete. These steps are especially important for households with children under six. The primary path of exposure to dioxins is by swallowing soil, and a smaller amount happens through making skin contact with it. Ways you can limit exposure to dioxin-contaminated soil include:
    - Remove shoes and wipe feet before entering the house to avoid tracking in dust from outside.
    - Wipe visible dirt off your pets before letting them into your home.

- Wash hands with soap and water right after doing landscaping or gardening, even if you use gloves.
- Soil finds its way into houses and can be present in house dust. Use indoor cleaning methods that reduce overall dust. For example, damp-mopping floors instead of sweeping stops dust from being kicked up. Use vacuum cleaners with HEPA filters which efficiently capture dust.
- You are less likely to come into contact with soil when using or playing in areas that have landscape covering above the soil (for example, areas covered with landscape fabric, sandboxes, wood chips, lawn or gravel). Avoid using or playing in areas with bare soil.
- Avoid activities that disturb large amounts of soil, such as digging holes or leaving piles of exposed soil.

NEXT STEPS

EHAP will:

- Continue working with DEQ and EPA on sampling soil and reviewing soil dioxin data in yards.
- Review plans for remediation until work is complete and surface soils are safe for all residents.
- Consult with community members to provide health information related to dioxin levels in their yards.

CONCLUSION 2

Residences in the Bethel and other west Eugene neighborhoods that are outside of the areas of investigation are unlikely to have been contaminated by dioxin emissions from JH Baxter.

BASIS FOR CONCLUSION

Oregon DEQ and LRAPA did extensive investigations of JH Baxter's emissions using local weather data and considered how far pollutant particles containing dioxin can travel. This analysis showed that dioxin levels could be higher in residential areas adjacent to Baxter. This was confirmed by comparison samples from Emerald Park, Petersen Park, Hawkins Heights, and two residential properties not near the Baxter facility – these areas showed lower dioxin levels than were found in the residential areas near the Baxter facility.

CONCLUSION 3

At residential yards that were sampled near Baxter, dioxin in soil is unlikely to have contaminated edible portions of fruits and vegetables grown in backyard gardens.

BASIS FOR CONCLUSION

Fruits and vegetables take up only a very small fraction of dioxins from soil. Consuming home-grown produce that is thoroughly washed and peeled (for ground vegetables) will have negligible amounts of dioxin and will not harm a person's health.

RECOMMENDATIONS

EHAP still recommends standard urban gardening guidance to protect from other contaminants that are commonly found in urban soil, such as lead. Urban gardeners should:

- Wash hands after gardening.
- Take off shoes before entering the home to avoid tracking soil inside.
- Wash homegrown produce before consuming it.

EHAP has more guidance for healthy gardening can be found at the following link or going to www.healthoregon.gov and searching for "healthy gardening".

CONCLUSION 4

Eating eggs from backyard chickens that live in yards at residences near Baxter that have dioxin levels above 4.7 ppt could be harmful to health.

BASIS FOR CONCLUSION

Dioxin can accumulate in eggs since it is a chemical that easily binds to fatty tissue. Chickens spend a lot of time scratching on the ground, eating soil and smaller organisms (insects, worms). Organisms that live in the soil could also have higher levels of dioxin than the soil itself. It is possible that chicken eggs could have levels of dioxin higher than that of the soil.

RECOMMENDATIONS

EHAP recommends that anyone living on property with dioxin levels above 4.7 ppt (or on a property that is awaiting testing) house their chickens so they do not have access to contaminated soil. Chickens' contact with soil can be minimized by fencing the chicken coop and run area, and covering the fenced-in ground with six inches of coarse wood chips or other material that acts as a barrier to the soil. If this cannot be done, residents should not eat backyard chicken eggs.

EHAP will:

- Continue working with DEQ and EPA on sampling soil and reviewing soil dioxin data in yards and review plans for remediation, until work is completed and surface soils are safe for residents to raise backyard chickens.
- Consult with Oregon State University's Extension Service on ways to house chickens such that they are not in contact with contaminated soil.

CONCLUSION 5

Surface water and ground water near the Baxter facility will not harm people's health.

BASIS FOR CONCLUSION

Surface water sample data taken near the facility showed levels of chemicals that were too low to harm people's health. Groundwater near JH Baxter has pentachlorophenol (PCP) in it, but houses in this residential area are connected to a municipal water supply. Using groundwater to irrigate fruits and vegetables will not harm people's health since PCP is not easily taken up by fruits and vegetables.

NEXT STEPS

EHAP will review any new surface water and ground water data that become available.

CONCLUSION 6

Soil sampling results at Trainsong Park, which was intended to be a comparison area far from the Baxter facility, showed levels of dioxin in some locations that could be high enough to harm the health of young children who play in those spots every day.

BASIS FOR CONCLUSION

Some areas of the park had dioxin levels in soil higher than health-based Comparison Values (CVs) designed for park use scenario. This contamination at Trainsong Park is unlikely to be related to activities at JH Baxter. DEQ is working to determine the source of contamination at the park.

EHAP recommends that:

- DEQ continue efforts to collect and analyze additional samples to find the extent of contamination, identify the source, and determine the best way to prevent contact with the contamination.
- Park users heed signage and stay out of closed areas of the park. Open areas of the park have dioxin levels that are too low to harm the health of park users of any age.

EHAP will:

- Evaluate health risks from dioxin in soil in parts of Trainsong Park in a separate health assessment document
- Provide DEQ and city of Eugene with technical assistance in future sampling and other work done at the park.
- Help community members find information about the risk and ongoing work at Trainsong Park in other documents and media.

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@dhsoha.state.or.us.

Table 1. Summary of JH Baxter health conclusions, by environmental exposure for all scenarios.

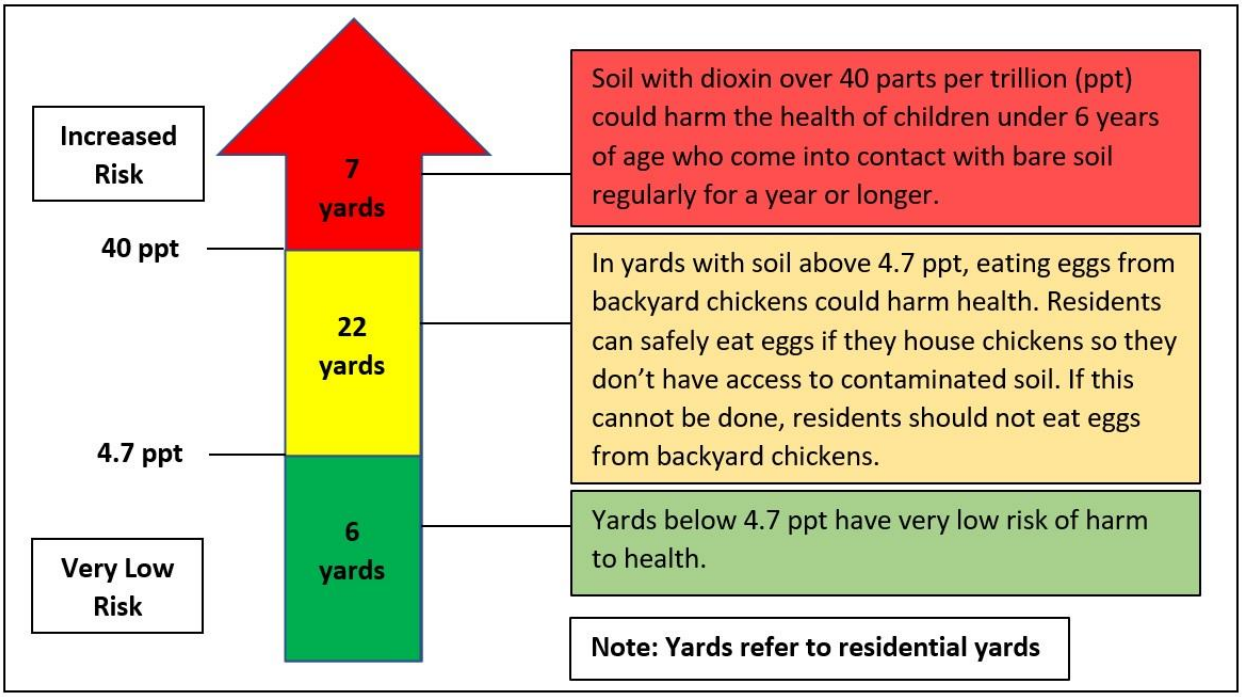
Exposure Scenario	Possible harm to health		
	Cancer* risk from chronic§ exposure	**Non-cancer† risk from chronic exposure**	**Non-cancer risk from acute§§ exposure**
Soil	Low	Yes, children <6 years	No
Surface Water	Low	No	No
Groundwater	Low	No	No
Backyard Fruits and Vegetables	Low	No	No
Backyard Chicken Eggs	Low	Yes	No

*Cancer risk refers to the probability to develop cancer over a lifetime related to contaminant exposure from JH Baxter.
†Non-cancer risk refers to the risk to develop a health effect other than cancer under various exposures scenarios related to JH Baxter. See text of report for details on health effects.
§ Chronic refers to exposures that last a year or longer.
§§ Acute refers to short-term exposures, less than two weeks.

Table 2. Summary of levels of dioxins in residential yards.

Soil Concentration	Number of Yards
Above 40 ppt	7
Between 4.7 ppt and 40 ppt	22
Below 4.7 ppt	6

Figure 1. Illustration of the risk implications of dioxin levels in soil of residential yards.



History of the JH Baxter Facility

The J.H. Baxter & Co. facility began operation in 1943 and stopped production in January 2022. The property is located at 85 North Baxter Road on approximately 42 acres of land (Figure 2). The facility treated various wood products such as railroad ties, electrical service poles, and crossarms with water and oil-based chemicals. As the city of Eugene grew around the facility, environmental concerns from their processes grew. Odor complaints from creosote and pentachlorophenol, chemicals used in the wood treatment process, were an ongoing concern and issue for community members while the facility was in operation.

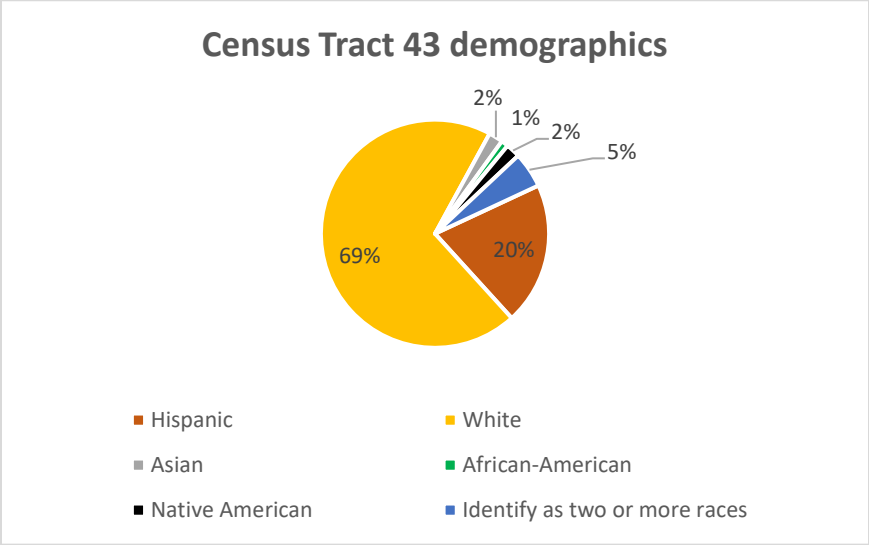
Figure 2. Overhead view of the JH Baxter facility (photo courtesy of Oregon DEQ).

Community

JH Baxter is within the boundaries of the Bethel neighborhood. Adjacent and to the north of the facility are residential areas. The Bethel neighborhood has nearly thirty thousand residents, and most of the neighborhood is zoned for low density residential housing (City of Eugene, 2011). The residential neighborhoods within this area make up census tract 43 in Lane County, with approximately 1,792 persons (US Census Bureau, 2019). The racial and ethnic makeup is approximately 20% Hispanic, 69% white, 2% Asian, 1% African American, 2% Native American, and 5% of people who identify as two or more races (Figure 3). This census tract has

higher percentages of people of color than Lane County and Oregon. Eleven percent of the population was born outside of the US, and 72% of those were born in Latin America. The median household income is $34,314 and approximately 25.7% persons live below the poverty line (US Census Bureau, 2019). The residential area of West Eugene is comprised of moderate to higher rates of economic and social vulnerabilities as compared to the other census tracts in the city.

Figure 3. Demographics of census tract 43 (which includes the Bethel neighborhood) in Lane County.



<u>The Bethel Neighborhood and Environmental Justice</u>

The Bethel neighborhood is part of an industrial corridor made up of 35 out of a total 36 manufacturing companies located within the city limits. This neighborhood is also bisected by Highway 69, and bordered by Highway 99 and Highway 126. The city of Eugene Toxics Reporting Program suggests that 696,526 pounds of toxic chemicals were emitted in West Eugene in the year 2020 alone. Land use zoning laws historically have created inequitable spatial patterns where residential areas have proliferated close to polluting industries (Alvarez, 2022).

According to ATSDR's Environmental Justice Index (ATSDR, 2022), the census tract in which the neighborhood is included (census tract 43 of Lane County) scores high for several environmental indicators such as diesel particulate matter, Toxics Release Inventory sites, high volume roads and railroad activity. The tract also scores high for poverty, unemployment, and households that are lower income. It also has a high prevalence of chronic health conditions such as asthma and diabetes.

The above-mentioned socioeconomic inequalities, inequitable spatial patterns, and multiple sources of air pollutants makes Bethel neighborhood an environmental justice community.

Community Concerns

The Bethel neighborhood has experienced numerous air quality problems during JH Baxter's operational history. Many of these complaints have been associated with odors coming from the facility. The Lane Regional Air Protection Agency (LRAPA) maintains a database of air quality complaints received from across the county. The first recorded air quality complaint on the facility was made in 1977. Air quality complaints attributed to the facility peaked in 2004 with 762 air quality complaints. People from the community have commonly expressed concerns related to 1) pungent smell affecting their daily life, 2) worsening of health conditions due to odor, 3) difficulty in breathing, 4) asthma rates in children, and 5) increased rates of lung cancer and Hodgkin's Lymphoma.

As previously mentioned, the Bethel neighborhood is part of the industrial corridor with a comparatively high percentage of working-class residents and people of color. These social and economic inequalities have overlapped with a long-standing history of community concerns about health issues due to environmental toxic exposure. The primary concern has been exposure to airborne contaminants from JH Baxter, which could be inhaled or deposited into their backyards. There has been particular interest among community members in understanding the health risks of eating food grown in soil/gardens within the area surrounding JH Baxter. During a Core Team meeting, the community members echoed worries associated with cumulative health impacts caused by exposure to multiple environmental contaminants, as expressed at a June 2021 JH Baxter Core Team meeting.

The Bethel residents also indicated high levels of stress and frustration that the health and well-being of their community have been compromised. They also feel that in the past, their community needs and health concerns have not been heard by government agencies. The community members have reported experiencing anxiety related to their properties' values being reduced because of pollutants.

EHAP's Community Outreach and Education Activities

Listening to the Bethel Neighborhood Community and Providing Resources

An important part of our public health assessment activities is the collection, documentation, and response to community health and exposure concerns. EHAP was not able to visit the site or meet in person with residents due to the COVID-19 pandemic and OHA restrictions on in-person public meetings. We were, however, able to virtually meet with residents from some of the properties tested, members of the Bethel neighborhood, community groups such as Beyond Toxics and Active Bethel Community, and other concerned individuals in the Eugene area. We also responded to many phone calls and emails from community members with questions regarding health and exposure concerns related to the site.

On March 1, 2022, EHAP hosted a virtual community meeting to discuss potential health impacts on people living on properties that had high levels of measured soil dioxin (this meeting

followed a DEQ virtual meeting where the agency shared results with the community the prior week). EHAP's meeting provided time for residents to ask questions and contact information for follow-up questions. The meeting included a Spanish language interpreter. In the meeting, EHAP shared:

- what dioxins are and how they can enter the body,
- health effects of dioxins,
- that yards with dioxin levels over 40 ppt should be prioritized for cleanup,
- steps residents can take to reduce potential exposure until their properties are remediated, and
- next steps in our health assessment process.

JH Baxter Core Team

The agencies partnering on the JH Baxter site sought to create a forum for discussions with neighbors and community members, to build relationships and establish trust. DEQ hired a neutral third party facilitator in November 2020 to help convene such a group; the facilitator reached out to community organizations and advocacy groups to identify those who might be willing to engage with state and local agencies about soil sampling, additional testing, and cleanup of properties affected by dioxin. Community members who were interested included residents from around the affected areas, advocacy groups including Beyond Toxics, and other community members.

After identifying willing community members and coordinating with the agencies partnering on the J.H. Baxter site, the facilitator convened the JH Baxter Core Team ("Core Team"). The purpose of the Core Team was to bring a group of community, agency, and local government representatives together to discuss information on environmental pollution regarding the J.H. Baxter facility in the Bethel Neighborhood of West Eugene, and to help EHAP and other agencies prepare communications and engagement with the broader public. The Core Team shares environmental and public health information and discusses the impact of the data on the community. The objective is to develop a cohesive plan for trust-building community engagement, while working together to improve the quality of life by reducing pollution in the air, water, and soil in West Eugene now and into the future.

Past Investigations

Health Consultations

In 2004, EHAP authored a Health Consultation due to neighborhood concerns about the Baxter facility. Residents near the facility asked LRAPA (then called the Lane Regional Air Pollution Authority) and EHAP (then called the SHINE program) if persons living near Baxter were at risk of harmful health effects from the facility's emissions. EHAP characterized the chemicals (and the amount) used at Baxter, and how these chemicals can affect human health. This Health Consultation concluded that the facility was an "Indeterminate Public Health Hazard." Further conclusions were not possible at the time, since there was not enough information about levels of

contaminants in air, soil, and water). The Health Consultation did highlight community concerns expressed by residents of the surrounding neighborhoods, which include complaints about frequent and intense odors, and reporting multiple health effects (especially headaches, dizziness, nausea, eye irritation, and difficulty in breathing). EHAP recommended that LRAPA develop a plan for air monitoring in residential areas near the facility, and that the Oregon State Cancer Registry conduct a cancer investigation for several nearby neighborhoods in Eugene.

EHAP completed a follow-up Health Consultation in 2007 that evaluated the impact of air emissions from near the JH Baxter facility on the public's health when new monitoring data from LRAPA became available. In 2005, LRAPA collected short-term and long-term air samples when emissions from J.H. Baxter were expected to be at maximum levels and meteorological conditions were most likely to carry emissions into areas north of the facility. They also used computer dispersion modeling to estimate naphthalene concentrations. Air sampling detected chemicals used in the wood preserving process, including volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs). Some air samples showed levels of naphthalene that exceeded health CVs. Dispersion modeling predicted that there was naphthalene around the facility. EHAP concluded that residents living near the Baxter facility are unlikely to experience short-term or long-term health effects (including cancer and non-cancer) from levels of naphthalene and other chemicals.

Cancer Registry Investigation

In 2008, EHAP examined Oregon Cancer Registry information for people living in Bethel, River Road and Trainsong neighborhoods in northwest Eugene. Residents expressed concern that the rates of lung cancer, acute myelogenous leukemia (AML) and brain cancer in their neighborhoods were high, and possibly caused by contaminants from JH Baxter and other nearby industries. They asked EHAP to investigate local rates of cancer to determine whether they were significantly elevated. EHAP reviewed cancer incidence rates and found some types of cancer were higher than expected, such as brain cancer, lung cancer, and AML. EHAP found that brain cancer and AML were elevated in some time periods and in some census tracts, but these cancers were not consistent over time (for example, a cancer was seen in 1996-2002, but not during 2003-2006) and were not seen throughout the area (for example, an increase in cancer was only seen in one out of seven census tracts analyzed). Lung cancer was elevated in nearly all census tracts over most of the period studied, and further investigation found a strong link to tobacco smoking among those affected. Because of the small number of cases involved and limited information on individual case histories, EHAP was unable to determine the role that environmental contaminants (from the Baxter facility or other sources of air contamination nearby) might have played in these cancer cases.

202*0 Soil Sampling Analysis*

In September 2020, an environmental consultant under DEQ supervision collected soil samples from six locations around the Baxter site. Sample locations included the residential area between Roosevelt Boulevard and Elmira Road. These samples were from public rights of way and not

from yards in private residences. DEQ also sampled soil from two areas as comparison sites (that is, not near Baxter, unlikely to be potentially affected by the facility).

DEQ had the soil samples analyzed by a laboratory for metals (arsenic, zinc, copper, and mercury), polycyclic aromatic hydrocarbons (PAHs), pentachlorophenol (PCP), naphthalene, and dioxins/furans. Sampling from the residential area was only tested for dioxins and zinc.

After DEQ received the results for these samples, EHAP evaluated the levels of contamination and found that they were too low to harm health. However, levels of dioxins were above DEQ's clean-up levels, and EHAP supported DEQ's additional sampling efforts to see whether levels of contaminants could be higher in the yards of residents across Roosevelt Boulevard from JH Baxter.

Discussion

Data used in this Health Consultation

In September 2021, DEQ developed a sampling plan to collect and analyze soil samples from residential properties nearest to JH Baxter. DEQ chose an area of investigation outside of the boundaries of the Baxter facility that included residential properties north of Roosevelt Boulevard. DEQ identified properties using LRAPA's modeling of wind direction patterns to identify where winds were likely to disperse pollutants. With permission of the property owners, an environmental consultant, under DEQ supervision, took soil samples from the ten yards in this area in September 2021 (Figure 4). They collected surface soil, at depths up to six inches, at 30 locations on each property.

DEQ took soil samples in seven areas that were far enough from Baxter or not in the prevailing wind direction of the facility to serve as comparison sites that show "background" levels of contaminants in the area. The purpose of sampling these comparison areas was to determine levels of dioxins not attributable to Baxter's operations. Low levels of dioxin are commonly found in the environment (ATSDR, 1998), and their presence in urban soils is due to the wide variety of sources such as waste burning, combustion of fuels, backyard burning, and various industrial sources (Urban *et al.*, 2014). To determine comparison levels of dioxin in the city of Eugene, consultants took soil samples from several places including Emerald Park, Petersen Barn, two residential properties in West Eugene, a drainage ditch alongside Roosevelt Boulevard, Hawkins Heights, and Trainsong Park (Figure 5). All these areas are far enough from JH Baxter that it is unlikely they could be affected by the facility.

Figure 4. The area north of JH Baxter where soil samples were taken from residential yards.

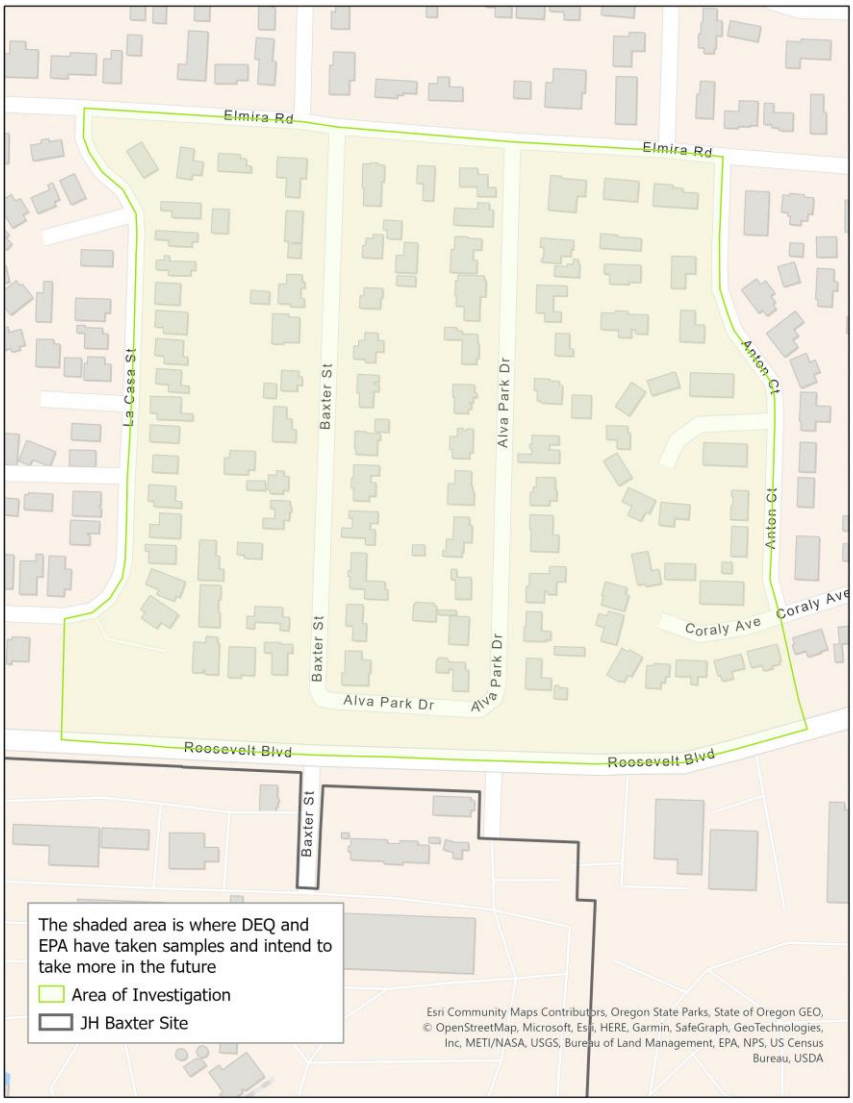
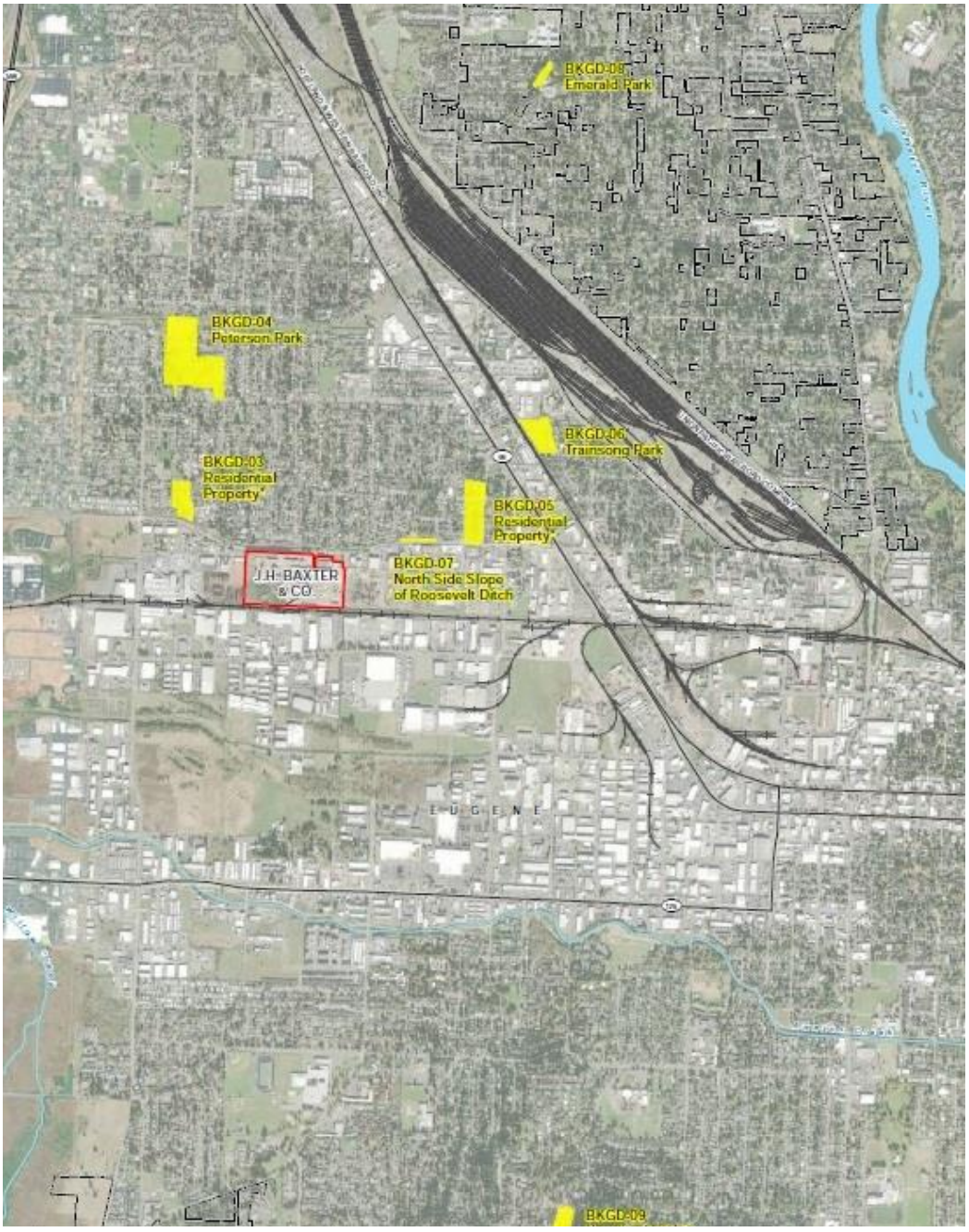


Figure 5. Locations of comparison sampling locations (map courtesy of GSI Water Solutions).



Both residential and comparison samples were analyzed for dioxin and other agents, including arsenic, chromium, copper, zinc, and benzo[a]pyrene.

DEQ received its sampling results in January 2022. Four residential properties in the vicinity of the Baxter property showed levels of dioxin above DEQ's Risk-Based Concentrations (RBCs), prompting DEQ to ask the US Environmental Protection Agency (EPA) to conduct additional sampling. EPA and DEQ developed another sampling plan to collect and analyze soil samples from additional residential yards near where the first eight houses were sampled; this was similar to the method used in the 2021 sampling event. With permission of the property owners and under DEQ/EPA supervision, an environmental consultant collected 24 more samples in May 2022. As of December 2022, EPA is still taking samples from other properties in the area of investigation. When EPA shares the results of that sampling, EHAP will evaluate the findings in terms of health risks to the community.

How were dioxin levels measured?

There are over 200 individual dioxin and "dioxin-like" congeners; DEQ tested for most, but not all congeners. A "congener" is a molecule of specific shape and size. Many of these congeners were included in evaluating health risk to residents. This is done by using toxicity equivalency factors (TEFs) that relate the toxicity of dioxin congeners to that of *2,3,7,8-Tetrachlorodibenzodioxin* (TCDD), the most toxic dioxin congener. The TEF for TCDD is defined as "1", whereas TEF values for all other congeners are between 0 and 1. A TEF value of 1 means the congener is as toxic as TCDD. Congeners with TEF value less than 1 means they have less toxicity than TCDD.

The concentration of each dioxin is multiplied by its TEF to obtain its toxic equivalency (TEQ). For example, if the detected *1,2,3,4,6,7,8,9-octachlorinated-dibenzo-p-dioxin* (OCDD) concentration is 500 parts per trillion (ppt), and the TEF of OCDD is 0.0001 (meaning it is 10,000 times less toxic than TCDD), then the TEQ of OCDD is 0.05 ppt (500 x 0.0001).

All the TEQs are added together to obtain the total TCDD TEQ, which is an estimate of the toxicity of the congeners in terms of TCDD toxicity. From now on in the report, we will refer to measured TCDD TEQ as "dioxin levels."

Soil sampling results

In January 2022, DEQ notified property owners and residents about the soil sampling results and shared the results with EHAP. In August 2022, DEQ also notified owners/residents about the soil sampling conducted by EPA.

Identifying Contaminants of Concern

To identify which properties would need further evaluation, EHAP used Comparison Values (CVs) to screen each soil sample. CVs are chemical-specific screening levels developed by ATSDR and EPA that EHAP uses to identify contaminants requiring further evaluation. CV concentrations are calculated as parts per million (ppm) in soil. When soil concentration is below the CV, the chemical does not require further evaluation since it is not expected to harm health. If the maximum concentration is above the CV, it requires further evaluation, and becomes known as a *contaminant of concern* (COC). A chemical that is a COC does not mean harmful health effects will occur, rather it indicates the need to further evaluate whether people are being exposed to harmful levels of the contaminants.

What is a CV?

Comparison Values (CVs) are screening tools to identify contaminants of concern at a site. CVs represent the contaminant levels in air, soil, or water that people could be exposed to on a daily basis and not experience harmful health effects. CVs are developed to evaluate exposures that are short term (acute), intermediate, and chronic (long term).

CVs are not environmental clean-up levels. Because CVs are created using very health protective assumptions, contaminants that exceed their CVs will not necessarily pose health risks.

There are two types of CVs for determining COCs. Most chemicals have a *non-cancer CV* that evaluates for all health effects other than cancer. For chemicals that could cause cancer, a separate *cancer-based CV* is also used. This is based on the concentration of a cancer-causing chemical that could cause one case of cancer per million people exposed to the same dose of that chemical. Tables 3 and 4 list the non-cancer CV and, if applicable, cancer-based CV for each chemical that was tested in soil samples.

Table 3 lists maximum chemical concentrations from the comparison locations. Levels of arsenic, chromium, copper, zinc, and benzo[a]pyrene were below health-based CVs, except at one location. Concentrations of arsenic and chromium at the Hawkins Heights comparison sampling location exceeded their respective CVs. EHAP evaluated these levels using ATSDR's Public Health Assessment Screening Tool (PHAST) and found that the levels at Hawkins Heights will not harm health. CVs are meant to be protective for daily exposure in residential scenarios, and people tend to use parks less frequently. Levels of dioxin at Trainsong Park exceeded both the non-cancer and cancer-based CVs for dioxin (Table 3), which was unexpected. EHAP has been working with DEQ and the city of Eugene to make sure public health is protected and will issue a separate Health Consultation about dioxin levels at Trainsong Park. **EHAP considers dioxin a contaminant of concern at Trainsong Park.** EHAP will evaluate this in a future Health Consultation.

Table 3. Soil data summary of six comparison sampling locations taken September 2021.

Chemical	Maximum	Comparison Value		Number of comparison areas over CV
		Cancer	Non-cancer	
TCDD (ppt)	71	4.7[a]	40[d]	1 (Trainsong Park)
Arsenic (ppm)	23.7[§]	NA[b]	17[d]	1 (Hawkins Heights) [§]
Chromium (ppm)	62.3[§]	NA	51[d]	1 (Hawkins Heights) [§]
Copper (ppm)	44.6	NA	3,100[e]	0
Zinc (ppm)	125	NA	17,000[d]	0
Benzo(a)pyrene (ppt)	0.0169	0.17[c]	66[d]	0

Abbreviations: ppt = parts per trillion; ppm = parts per million; ATSDR = Agency for Toxic Substances and Disease Registry; CV = Comparison Value; NA = not applicable.
§ Levels of arsenic and chromium exceeded their respective CVs. However, these concentrations will not harm health, because CVs are protective for residential exposure, that is, exposure every day rather than a park where a child spends less time. EHAP used ATSDR's Public Health Assessment Screening Tool (PHAST) tool to verify this.
CV sources:
a. DEQ's Risk Based Concentration for residential soil, which is based on one-in-a-million cancer risk.
b. EHAP does not use the cancer-based CV for arsenic because Oregon soil naturally contains arsenic at levels much higher than the CV.
c. ATSDR Cancer Risk Evaluation Guide (CREG).
d. ATSDR Reference Dose Media Evaluation Guide (RMEG) for a child, non-cancer.
e. ATSDR Environmental Media Evaluation Guide (EMEG) for a child, non-cancer.

Table 4. Summary of September 2021 residential soil test results of metals and PAHs from DEQ's initial analysis of ten residential properties.

Chemical	Maximum (ppm)	Comparison Values (ppm)	
		Cancer	Non-Cancer
Arsenic	10	NA[a]	17[c]
Chromium	40	NA	51[c]
Copper	47	NA	3,100[d]
Zinc	122	NA	17,000[c]
Benzo[a]pyrene	0.05	0.12[b]	17[c]

Abbreviations: ppm = parts per million; ATSDR = Agency for Toxic Substances and Disease Registry; CV = Comparison Value; NA = not applicable.
CV sources:
a. EHAP does not use the cancer-based CV for arsenic because Oregon soil naturally contains arsenic at levels much higher than the cancer-based CV.
b. ATSDR Cancer Risk Evaluation Guide (CREG).
c. ATSDR Chronic Environmental Media Evaluation Guide (EMEG) for a child, non-cancer.
d. U.S. Environmental Protection Agency Regional Screening Level (RSL) for residential soil, non-cancer.

At all properties, levels of arsenic, chromium, copper, zinc, and benzo[a]pyrene were below health-based CVs that EHAP used (Table 4). However, levels of dioxin did exceed CVs in several yards (Table 5).

Levels of the chemicals sampled from residential yards can be seen in Tables 4 and 5. EHAP is not identifying property owners and the levels of contamination in their yards out of respect for privacy. Twenty-nine properties had levels of dioxin in soil that were higher than the comparison locations. Of those properties, seven had levels of dioxin that were above 40 ppt. The highest level of dioxin was 124 ppt. **Therefore, EHAP considered dioxin as a contaminant of concern for these yards.** Tables 5 and 6 show the range of concentrations, CVs, and the number of yards above and below the respective non-cancer and cancer CVs.

Table 5. Summary of residential soil dioxin test results.

Number of Samples	Minimum (ppt)	Maximum (ppt)	Comparison Values (ppt)	
			Cancer	Non-Cancer
35§	4.57	124	4.7[a]	40[b]
Concentrations on specific properties have not been identified in this report. ppt = parts per trillion § DEQ took 9 samples in September 2021, and EPA took an additional 26 samples in May 2022. CV sources: a. DEQ Risk Based Concentration, which is based on one-in-a-million cancer risk. b. ATSDR Chronic Reference Dose Media Evaluation Guide (RMEG) for a child, non-cancer.				

Table 6. Summary of data for residential yards with soil dioxin levels above CVs.

Soil Concentration	Number of Yards
Above 40 ppt	7
Between 4.7 ppt and 40 ppt	22
Below 4.7 ppt	6

Dioxins and Health

At the levels measured around JH Baxter, the health effect of greatest concern is male reproductive effects in adulthood following long-term exposure (a year or longer) as a young boy (under 6 years old). The dose of dioxin that a person might get depends on how much is in the soil and the ways in which the person would come into contact with the soil. The way people come into contact with a contaminant is called an "exposure pathway."

There is evidence of significant harm from exposure to dioxins, including serious impacts to skin and organs, at very high levels of exposure. These health effects are seen at levels over 100 times higher than what people could be exposed to from yards near JH Baxter. They were seen in occupational exposures and in a community that was affected by a large-scale industrial explosion (ATSDR, 1998). These health effects happened when people were exposed to an

extremely high dose of dioxin. **The concentrations in residential yards are too low to cause any of these health effects.**

In animal studies, exposure to lower levels of TCDD has been shown to cause weight loss, a weakened immune system, and disruption of hormone levels. Animal studies have also shown it can cause reproductive damage and birth defects. Increases of risk of diabetes and problems with blood sugar (glucose) have been seen in people exposed to TCDD.

Studies in humans suggest that dioxins can increase the risk of cancer when people are exposed to too much TCDD over several years. Several studies of workers exposed to high levels of dioxin (their body burden of dioxin was 50 times higher than the general population) suggest that exposure increased their risk of cancer (ATSDR, 1998). Some studies have also shown that TCDD increases cancer risk in animals. ATSDR and the International Agency for Research on Cancer (IARC) have determined that TCDD may cause cancer in humans, and EPA has said that mixtures of dioxin chemicals (including TCDD) are probable human carcinogens.

Exposure Pathways

For a contaminant to harm human health, there must be a way for people to come into contact with it. To determine if, and how, people could be exposed to soil contamination around JH Baxter, EHAP conducted an exposure pathway analysis. This 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 where the chemicals originate
2. A medium (for example, air, soil, or water) for a chemical to move through the environment to a place where people could come into contact with it
3. A location (point or area) where people come into contact with the chemical
4. A way (route) through which people have contact with the chemicals (for example, breathing it, swallowing it, or absorbing it through the skin), and
5. A population that comes into contact with the chemical.

An exposure pathway can have happened only in the past, it can be occurring presently, or could happen in the future. When it has all five of these elements is considered a *completed exposure pathway*, meaning there is evidence that people have come into contact with site-related contaminants. A *potential exposure pathway* is when some elements are present but one or more of them is uncertain (such as when a population may be coming into contact with the chemical, but their presence can't be confirmed). Finally, an *eliminated exposure pathway* is when at least one of the five elements of a pathway is not present and unlikely to be present (such as when a population cannot access contamination because of a fence or other barrier). Below, EHAP considered a variety of exposure scenarios, and for each, identified if it was completed, potential or eliminated. For completed and potential exposure pathways, EHAP estimated exposure risks.

EHAP paid special attention to children's exposures because they spend more time outdoors, are more likely to touch soil with their bare feet and hands and may put unwashed hands or dirty objects into their mouth.

Exposure Pathways EHAP Examined

EHAP looked at the following exposure scenarios for people living near the JH Baxter facility and whether that pathway was completed, possible or eliminated:

- Accidentally swallowing and touching surface soil contaminated with dioxin from activities in their front or backyard, such as sitting outside, playing, or gardening.
- Eating eggs laid from backyard chickens
- Eating soil on homegrown vegetables and fruits
- Inhaling air containing soil dust
- Chemicals in surface water, and
- Chemicals in groundwater.

Completed Exposure Pathways

EHAP identified two completed exposure pathways for people to be exposed: swallowing and touching contaminated surface soil, and eating eggs laid from backyard chickens in yards with dioxin in soil (Table 7).

Swallowing and making skin contact with surface soil containing dioxin can happen in residential yards, especially when adults or children are coming into contact with bare soil through gardening, yardwork, or playing.

Backyard chicken eggs are included because eggs, especially egg yolks, are made of high-fat material. Dioxin is a lipophilic compound (that is, the molecules bind easily to fat cells), and it is possible that consumption of eggs from backyard chickens could result in exposure to enough dioxin to be harmful to health of people of all ages.

Table 7. Completed exposure pathways.

Pathway	Source	Exposure Location	Exposure Route	Exposure population	Notes
Ingestion of and dermal contact with Soil	Emissions from JH Baxter	Soil in yard	Ingestion and dermal contact	Adults and children: residents, non-residents, outdoor workers	Completed exposure pathway: past and present.
Eating eggs laid from backyard chickens	Emissions from JH Baxter	Eggs from chickens grown on affected yards	Eating eggs	Adults and children: residents, non-residents, outdoor workers	Completed exposure pathway: past and present.

Potential Exposure Pathways

EHAP identified two potential exposure pathways where people *could* be exposed: swallowing and touching surface water from drainage areas near Baxter and swallowing and touching water from private wells (Table 8).

Exposure to potentially contaminated surface or groundwater water can happen when people use water from nearby groundwater wells or come into contact with surface water in drainage areas (such as ditches and culverts).

Table 8. Potential exposure pathways.

Pathway	Source	Exposure Location	Exposure Pathway	Exposure population	Notes
Surface Water	Emissions from JH Baxter	Drainage areas near residences	Ingestion of and dermal contact with surface water	Adults and children: ingestion and dermal contact with water from drainage areas	Potential exposure pathway: past, present
Groundwater	Emissions from JH Baxter	Private groundwater wells	Ingestion of groundwater	Adults and children: ingestion of and dermal contact with groundwater	Potential exposure pathway: past, present

Eliminated Exposure Pathways

EHAP identified two exposure scenarios where people are not exposed: consumption of homegrown produce and ingestion of indoor house dust (Table 9).

The most likely exposure to dioxin comes from soil that sticks to the vegetable/fruit surface (root, leaf, or fruit). Soil and dust can be removed by thoroughly washing vegetables and fruit. Dioxin compounds are bound to soil and not easily absorbed by roots. Therefore, consuming well-washed and peeled homegrown produce is unlikely to harm health.

EHAP evaluated the inhalation of airborne soil dust as part of soil ingestion. Most soil dust consists of large particles, and when breathed in, these particles are trapped in mucus that lines the respiratory tract and are carried back up to the throat where they are swallowed. Therefore, in most cases, dust that is inhaled does not get to the lungs and is instead ingested.

Table 9. Eliminated exposure pathways.

Pathway	Source	Exposure Location	Exposure Pathway	Exposure population	Notes
Consumption of home-grown produce.	Emissions from JH Baxter	Soil in yard	Ingestion of locally-grown produce.	Adults and children: Ingestion of home-grown produce	Eliminated exposure pathway: contaminated soil can be washed from backyard produce
Inhalation of soil dust	Emissions from JH Baxter	Soil in air	Direct inhalation of soil dust.	Adults and children: Direct inhalation of soil dust	Eliminated exposure pathway: Inhaled dust is included in the ingestion pathway.

Cancer risk

For properties where dioxin was not found or was found below the CV, the potential cancer risk is below one additional case of cancer beyond the usual number of cases we would expect to see in one million people similarly exposed. For the residences affected, we calculated the potential cancer risks based on the property with the highest detected dioxin concentrations and the one with the lowest detected dioxin concentrations found in surface soil.

We used standard health-protective assumptions to describe residential exposures for swallowing soil and contact with skin: assume exposures for 365 days per year, 21 years of residence for children, and 33 years of residence for adults; assume that children swallow up to 200 mg of soil per day and adults swallow up to 100 mg of soil per day. For contact with skin, we assumed children are barefoot all the time, and that children and adults wore shorts and T-shirts year-round. Appendix A lists the parameters and equations used.

What is 1-in-a-million cancer risk?

Cancer risk is expressed as a *probability* of additional cancer cases in a population. In risk assessment, cancer risk is the estimated number of cancer cases caused by exposure that is *in addition to* cancers from other causes. The American Cancer Society estimates that one in three women and one in two men will get cancer in their lifetime.

A 1-in-a million cancer risk means that one person out of one million people equally exposed to a chemical will get cancer over the course of their lifetime. This would be in addition to the cancer cases from other causes.

These assumptions likely overestimate dioxin exposures for most people. For instance, most children and adults will swallow less soil per day, will not go outside on some days, and will wear shoes and long pants for part of the year. Given the health-protective assumptions in this HC, the actual cancer risks from touching and swallowing soil are likely to be lower than our estimates (Table 10).

Table 10. Estimates of cancer risk.

	Cancer Risk: Children†	Cancer Risk: Adults
Lowest Dioxin (4.57 ppt)	1 out of 1,000,000	3 out of 10,000,000
Highest Dioxin (124 ppt)	3 out of 100,000§	1 out of 100,000
† This is the average HQ for three age groups: Birth to <1 year, 1 to <2 years, and 2 to <6 years. § Cancer risk appears to be higher in children than it does in adults because they have a lower body weight.		

Noncancer risk

EHAP evaluated how much exposure to dioxin people could have during normal activities, such as spending time in their individual yard, playing, and gardening. As noted earlier, we paid special attention to children's exposures because they spend more time outdoors, are more likely to touch soil with their bare feet and hands and may put hands or dirty objects into their mouth. EHAP used the same health-protective assumptions for swallowing soil and skin contact that were used in evaluating cancer effects. With non-cancer effects, a year of exposure (as opposed to decades of exposure when evaluating cancer risk) is considered to evaluate for acute health effects (reactions that happen immediately), intermediate health effects (reactions that happen after a month of exposure), and chronic health effects (reactions that happen with a year or more of exposure).

EHAP used EPA's Reference Dose (RfD) to evaluate the noncancer health risks. The RfD of $7x10^{-10}$ (that is, 0.0000000007) mg/kg/day is based on the amount of dose of dioxin that children and adults can be exposed to every day without developing health effects (EPA, 2012). This dose is based on two epidemiologic studies that looked at human populations who were exposed to dioxin, and the individual dose of dioxin that caused health effects, after an explosion at an industrial plant in Italy (Mocarelli *et al*., 2008; Baccarelli *et al*., 2008). The health effects above this dose include decreased sperm count and motility in men and increases in the thyroid stimulating hormone (TSH) in both men and women – both effects were due to exposure as children or as a fetus. The lowest dose that caused these effects was $2x10^{-8}$ (that is, 0.00000002) mg/kg/day. EPA divided this dose (known as the point-of-departure) by an uncertainty factor of 30 to account for the uncertainties of human variability and using a Lowest Observable Adverse Effect Level (or LOAEL, the lowest point at which there was an observed health effect) since a No Observed Adverse Effect Level (or NOAEL, the highest dose at which no health effect was seen) could not be identified. Dividing this dose by the uncertainty factor results in the RfD of $7x10^{-10}$ mg/kg/day. We calculated the doses from swallowing and making skin contact with residential soil and compared them to the RfD (see Appendix B for calculations). Using the dioxin concentration from each property, children's doses in seven residential yards exceed the RfD, but are slightly below the point-of-departure dose that was found in the epidemiologic studies to cause health effects.

What is a Reference Dose?

A Reference Dose (RfD) is an estimate of daily human exposure to a chemical below which is unlikely to cause noncancer health effects such as skin irritation, changes to the blood, or reproductive effects.

An RfD is different than a chemical concentration – it measures the amount of chemical ingested per standardized unit of body weight, per day (*e.g.*, milligrams of chemical per kilogram of body weight per day, or mg/kg/day). RfDs are determined through animal studies and sometimes studies of people who were exposed to a chemical.

RfDs created by ATSDR and EPA are designed to be protective of the most sensitive member of an exposed group such as children or people with chronic health conditions.

EHAP calculated the doses from swallowing backyard soil and compared them to the RfD. The resulting calculation is known as the Hazard Quotient (HQ). An HQ exceeding 1 indicates the RfD has been exceeded, and as the HQ increases beyond 1, this means it is more likely that health effects could occur. EHAP's results showed that HQs above 1 in children under six years of age, but not in older children or adults. Young children have a much smaller body weight than older children and adults, and they tend to ingest more soil. Therefore, their total dose from dioxin is higher.

The soil concentration associated with a HQ of 1 for young children in residential yards is 40 ppt. That is why EHAP used 40 ppt as a CV for non-cancer effects and as a recommended threshold for accelerated clean-up in residential yards.

EHAP decided that an HQ exceeding of 1 was a health hazard for the following reasons. First, the people most likely to come into contact with contaminated soil are young children. Second,

the total number of uncertainty factors in deriving the EPA RfD for TCDD is 30. Uncertainty factors act as a "safety buffer" when there is insufficient toxicological data and variability in individual reactions to chemical exposure. TCDD has an Uncertainty Factor of 30, which is much less than most uncertainty factors, which typically range between 100 and 1,000. When the uncertainty factor is low, it means there is stronger evidence for the health effect. This also means the safety buffer can quickly be exceeded. Last, EHAP recognizes that West Eugene is an environmental justice community where there are more environmental exposure risks than other communities. Environmental justice communities face socio-economic inequalities, which can interact with environmental exposures, worsening health outcomes. They also have disproportionately high exposures overall, meaning that individual pollutant limits in environmental regulations may not be as effective when there are multiple pollutants and multiple sources (Solomon *et al.*, 2016).

The range of dioxin concentrations above 40 ppt ranged from 62 to 124 ppt. This resulted in HQs ranging from 1.5 to 3.6 for children under six years of age. HQs for ages six years and greater were below 1, suggesting the potential to harm health is limited to young children under six years old.

Egg Consumption

When people eat foods that contain dioxin, these chemicals can accumulate in their bodies. It is unlikely that homegrown vegetables and fruits contain harmful amounts of dioxin – studies have shown that plants can only take up a small fraction of the dioxins present (Michigan Department of Agriculture, undated). Good gardening hygiene, which is recommended in any urban area, can reduce the amount of contaminated soil swallowed and tracked into the house (as described in the summary of this document).

However, animal products, such as milk, meat, and chicken eggs, can more easily accumulate dioxin (De Vries *et al*., 2006), because they contain higher amounts of lipids (fats). Dioxin compounds are lipophilic, meaning they dissolve quickly into and are stored in fats found in animals and humans (ATSDR, 1998). Because chicken eggs contain high concentrations of fats, they can have high levels of dioxin if the food or soil they are exposed to is contaminated. Egg-laying chickens, especially backyard chickens, spend most of their lives foraging and pecking in the dirt where they ingest soil, worms, and insects that can contain dioxin (MDEQ, 2016). Therefore, they can have elevated levels of dioxins in their bodies. Egg-laying hens that are exposed to contaminated soil or feed transfer a significant amount of dioxin into the yolks of the eggs that they lay.

Michigan Department of Environmental Quality (MDEQ)[1] reviewed scientific studies that evaluated the relationship between soil dioxin levels and the levels of dioxins in the eggs of backyard chickens that lived on that soil. Using the data from those studies, MDEQ was able to establish a mathematical model to predict egg dioxin level based on soil concentration.

[1] Michigan DEQ has since been renamed to Michigan Department of Environment, Great Lakes, and Energy (EGLE).

Using this model, MDEQ evaluated health risks from dioxins to people who eat eggs produced by backyard chickens based on the level of dioxins in the soil the chickens live on. Like EHAP, MDEQ considered young children and women of childbearing age to be the people most vulnerable and at highest risk. The health effects of concern for this exposure pathway are impaired thyroid function in people exposed as newborns and decreased male reproductive function in men exposed as young boys.

Risk from backyard chicken eggs is limited to the residences near JH Baxter whose soil was tested for dioxin. It is less likely that residences further from this area have dioxin levels high enough to harm health through consumption of backyard chicken eggs.

EHAP used MDEQ's mathematical model to evaluate health risks to residents from consuming eggs, based on the levels of dioxin in soil at the properties that DEQ tested. Table 11 shows the Hazard Quotients (HQs) for adults and children based on how many eggs they eat per week and the level of dioxin measured in their soil. An HQ above 1 indicates increased risk of health effects (that is, impaired thyroid function from prenatal exposure and decreased reproductive function in adult males exposed as young children).

Table 11. Human health risks from eating eggs in different amounts produced by backyard chickens that live on soil contaminated with various levels of dioxins (Michigan Department of Environmental Quality, 1996).

Dioxin TEQ in soil (ppt)	**Hazard Quotient (HQ)**			
	Child†		**Adult§**	
	5 eggs consumed per week††	**3 eggs consumed per week**	**5 eggs consumed per week**	**3 eggs consumed per week**
250	30	14	8	4
50	12	6	3	2
12	5	2	1	0.7
5.8	3	2	0.8	0.4

A HQ below 1 means that health risks from dioxin exposure are unlikely. HQs above 1 mean increased risk of health effects. As HQ increases, risk of health effects increases.
†The study defined child as 5 years and under.
§An adult is considered a woman of childbearing age.
††Medium sized eggs assumed. More information on egg size can be found in Appendix C.

Nearly all properties near Baxter had soil concentrations of dioxins within the range shown in Table 11 except for a few below the lowest concentration. This table can be used to estimate one's HQ at properties near Baxter. For example, in a property with a dioxin concentration of 4.7 ppt, a child consuming three eggs per week produced from backyard chickens in soil at this concentration would have a Hazard Quotient below 2. A child who eats five eggs per week produced at a property where the dioxin concentration in soil is 21 ppt would have an HQ between 2 and 6.

EHAP recommends that residents whose properties were tested by DEQ (or are on a property that is awaiting testing) and have levels above 4.7 ppt house their chickens in a way so they do

not have access to contaminated soil. If this cannot be done, residents should not eat eggs from backyard chickens. There are no consumption rates where the Hazard Quotient is below 1 for children, although some are below 1 for adults (Table 11). Eggs are a highly nutritious source of protein and taking these precautions will ensure that residents are not exposed to dioxin contamination exceeding acceptable levels.

Evaluation of Available Groundwater and Surface Water Data

Some residents were concerned that people could come into contact with groundwater or surface water contaminated with chemicals used by JH Baxter. They wanted to know if there was risk of exposure to pentachlorophenol, dioxin, naphthalene, or other chemicals from the Baxter facility. EHAP evaluated if there was contaminated groundwater or surface water in the area of JH Baxter, and if people could come into contact with contaminated water. The most likely ways people could be exposed has been through skin contact and accidentally swallowing contaminated groundwater and surface water.

Oregon DEQ has been investigating contamination in ground and surface waters since 1981 (DEQ, 2019). Pentachlorophenol is the primary chemical that has affected off-site groundwater. This was caused by leaks of wood-preservative on the facility property. In the 1990s, the facility installed an extraction and treatment system that has reduced the levels of groundwater contamination. This system keeps contamination from spreading beyond Baxter's property (ArcGIS, 2022).

The Bethel neighborhood is served by Eugene Water and Electric Board (EWEB), which uses water from the McKenzie River, and does not rely on groundwater from near the Baxter facility. This means that residents do not have to rely on groundwater for drinking. However, there are at least two properties near Baxter that also have groundwater wells that are used for irrigation (DEQ, 2019). DEQ did a risk assessment for people using groundwater for irrigation of homegrown fruits and vegetables, and found that concentrations of PCP in groundwater was not high enough to harm people's health (DEQ, 2019).

Residents living near the Baxter facility could come into contact with surface water from the drainage ditch along Roosevelt Boulevard. DEQ also evaluated health risk to people swimming in the channel (including children) and found that surface water (and sediment) in the drainage ditch did not have levels of chemicals that could harm people's health (DEQ, 2019).

Conclusions

EHAP reached the following conclusions:

1. At seven residences near Baxter that were sampled, soil with dioxin concentrations over 40 parts per trillion (ppt) could harm the health of children under six years of age who come into contact with bare soil regularly for a year or longer.

Seven residences near JH Baxter had soil dioxin concentrations greater than 40 ppt. When exposed regularly for a year or more, concentrations of dioxin above 40 ppt in soil increases non-

cancer health risk in children under six years of age. Specifically, exposures to soil for a year or more could cause harm to the male reproductive system, which results in reduced sperm production in males later in life. This exposure happens through swallowing soil and, to a lesser extent, making skin contact with it. Children under six years are more vulnerable to dioxin exposure because their bodies are smaller and closer to the ground than older children and adults, and they swallow larger amounts of soil through playing and hand-to-mouth contact.

The concentrations of dioxin in the area that DEQ sampled are too low to result in health effects to older children and adults including pregnant women. Adults and children over 6 years are less vulnerable to dioxin exposure because their bodies are larger, and they tend to swallow less soil than smaller children.

2. Residences in the Bethel and other west Eugene neighborhoods that are outside of the areas of investigation are unlikely to have been contaminated by dioxin emissions from JH Baxter.

Oregon DEQ and LRAPA did extensive investigations of JH Baxter's emissions using local weather data and considered how far pollutant particles containing dioxin can travel. This analysis showed that dioxin levels could be higher in residential areas adjacent to Baxter. This was confirmed by comparison samples from Emerald Park, Petersen Park, Hawkins Heights, and two residential properties not near the Baxter facility – these areas showed lower dioxin levels than were found in the residential areas near the Baxter facility.

3. At residential yards that were sampled near Baxter, dioxin in soil is unlikely to have contaminated edible portions of fruits and vegetables grown in backyard gardens.

Fruits and vegetables take up only a very small fraction of dioxins from soil. Consuming home-grown produce that is thoroughly washed and peeled (for ground vegetables) will have negligible amounts of dioxin and will not harm a person's health.

4. Eating eggs from backyard chickens that live in yards at residences near Baxter that have dioxin levels above 4.7 ppt could be harmful to health.

Dioxin can accumulate in eggs since it is a chemical that easily binds to fatty tissue. Chickens spend a lot of time scratching on the ground, eating soil and smaller organisms (insects, worms). Organisms that live in the soil could also have higher levels of dioxin than the soil itself. It is possible that chicken eggs could have levels of dioxin higher than that of the soil.

5. Surface water and ground water near the Baxter facility will not harm people's health.

Surface water sample data taken near the facility showed levels of chemicals that were too low to harm people's health. Groundwater near JH Baxter has pentachlorophenol (PCP) in it, but houses in this residential area are connected to a municipal water supply. Using groundwater to irrigate fruits and vegetables will not harm people's health since PCP is not easily taken up by fruits and vegetables.

6. Soil sampling results at Trainsong Park, which was intended to be a comparison area far from the Baxter facility, showed levels of dioxin in some locations that could be high enough to harm the health of young children who play in those spots every day.

Some areas of the park had dioxin levels in soil higher than health-based Comparison Values (CVs) designed for park use scenario. This contamination at Trainsong Park is unlikely to be related to activities at JH Baxter. DEQ is working to determine the source of contamination at the park.

Recommendations

EHAP recommends for yards with levels above 40 ppt:

- Yards should be remediated to eliminate or reduce dioxin concentrations so that dioxin cannot harm the health of residents who use their yards.
- Until the remediation/clean-up is complete, all residents who have yards with soil dioxin over 40 ppt should take steps to reduce exposure to loose soil until remediation is complete. These steps are especially important for households with children under six. The primary path of exposure to dioxins is by swallowing soil, and a smaller amount happens through making skin contact with it. Ways you can limit exposure to dioxin-contaminated soil include:
    - Remove shoes and wipe feet before entering the house to avoid tracking in dust from outside.
    - Wipe visible dirt off your pets before letting them into your home.
    - Wash hands with soap and water right after doing landscaping or gardening, even if you use gloves.
    - Soil finds its way into houses and can be present in house dust. Use indoor cleaning methods that reduce overall dust. For example, damp-mopping floors instead of sweeping stops dust from being kicked up and use vacuum cleaners with HEPA filters which efficiently capture dust.
    - You are less likely to come into contact with soil when using or playing in areas that have landscape covering above the soil (for example, areas covered with landscape fabric, sandboxes, wood chips, lawn or gravel). Avoid using or playing in areas with bare soil.
    - Avoid activities that disturb large amounts of soil, such as digging holes or leaving piles of exposed soil.

EHAP still recommends standard urban gardening guidance to protect from other contaminants that are commonly found in urban soil, such as lead. Urban gardeners should:

- Wash hands after gardening.
- Take off shoes before entering the home to avoid tracking soil inside.
- Wash homegrown produce before consuming it.

EHAP has more guidance for healthy gardening which can be found here or by visiting www.healthoregon.org/gardening.

EHAP recommends that anyone living on property with dioxin levels above 4.7 ppt (or on a property that is awaiting testing) house their chickens so they don't have access to contaminated soil. Chickens' contact with soil can be minimized by fencing the chicken coop and run area, and covering the fenced-in ground with six inches of coarse wood chips. If this cannot be done, residents should not eat backyard chicken eggs.

Related to Trainsong Park, EHAP recommends that:

- DEQ continue efforts to collect and analyze additional samples to find the extent of contamination, identify the source, and determine the best way to prevent contact with the contamination.
- Park users heed signage and stay out of closed areas of the park. Open areas of the park have dioxin levels that are too low to harm the health of park users.

Public Health Action Plan

A Public Health Action Plan describes the specific actions EHAP has taken and will take to implement the recommendations outlined in this report, to prevent and reduce people's exposure to hazardous substances in the environment. EHAP has been involved with public health related work around the Baxter facility since 2004. Since new environmental data was available in September 2020, EHAP has taken numerous actions up through the present. Some actions described here have already taken place.

Completed Public Health Actions

To date, EHAP has taken the following actions.

Exposure prevention:

- Collaborated with Oregon DEQ to establish Cleaner Air Oregon (CAO). CAO is a statewide program designed to regulate industrial emissions of toxic air contaminants to protect the health of people nearby. The Environmental Quality Commission, which oversees DEQ, adopted CAO rules in November 2018. These rules are designed to require facilities to inventory, test their processes, devices, and equipment for emissions of concern, report their results, and demonstrate what they release cannot harm nearby communities. DEQ and OHA jointly implement the program.

- EHAP authored two previous health consultations about JH Baxter, in 2004 and 2007. The first HC was in response to neighborhood concerns at the facility. That HC recommended that LRAPA develop a plan for air monitoring in residential areas near the facility, and that the Oregon State Cancer Registry conduct a cancer investigation for several nearby neighborhoods in Eugene. The 2007 HC evaluated the impact of air emissions from near the JH Baxter facility on the public's health and found that residents living near the Baxter facility are unlikely to experience health problems from levels of

air pollution that were measured.

- In 2008, EHAP examined Oregon Cancer Registry Information for three neighborhoods in West Eugene in response to community concerns about cancer. Rates of acute myelogenous leukemia, brain, lung, and nasal cancers was higher than expected. EHAP did not have enough data to determine if environmental contaminants could have caused these cancers, because they were not consistent in all areas studied over time.

Planned Future Public Health Actions

EHAP will:

- Continue working with DEQ and EPA on sampling soil and reviewing soil dioxin data in yards and review plans for remediation, until work is complete and surface soils are safe for all residents.
- Consult with individual members of the community to provide health information related to dioxin levels in their yards.
- Evaluate health risks from dioxin in soil at Trainsong Park in a separate health assessment document.
- Provide DEQ and city of Eugene with technical assistance in future sampling and other work done at Trainsong park.
- Help community members find information about the risk and ongoing work at Trainsong Park in other documents and media.
- Consult with Oregon State University's Extension Service on ways to house chickens so that they do not come into contact with contaminated soil.
- EHAP will review any new surface water and ground water data that become available.

This publication was made possible by a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the ATSDR, or the U.S. Department of Health and Human Services.

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Appendix A. Risk assessment equations and exposure factors used to calculate soil ingestion and dermal exposure in residential yards.

This appendix contains the equations the EHAP uses to calculate health risks from dioxins in soil. These equations are used by the Public Health Assessment Screening Tool (PHAST). Appendix A also contains the site-specific exposure factors that EHAP uses for those equations. Many exposure factors such as soil intake, skin surface area, and dermal absorption fraction come from EPA's Exposure Factors Handbook (EPA, 2017).

EQUATIONS

Soil/Sediment Ingestion Exposure Dose Equation

$$\mathbf{D_{noncancer} = (C \times IR \times EF_{noncancer} \times CF) \div BW} \qquad \textbf{Equation 1}$$

$D_{noncancer}$ = dose (mg/kg/day), C = contaminant concentration (mg/kg), IR = intake rate (mg/day), $EF_{noncancer}$ = exposure factor (unitless), CF = conversion factor (10^{-6} kg/mg), BW = body weight (kg)

Administered Dermal Dose Equation

$$\mathbf{ADD_{noncancer} = (C \times EF_{noncancer} \times CF \times AF \times ABS_d \times SA) \div (BW \times ABS_{GI})} \qquad \textbf{Equation 2}$$

$ADD_{noncancer}$ = administered dermal dose (mg/kg/day), C = contaminant concentration (mg/kg), $EF_{noncancer}$ = exposure factor (unitless), CF = conversion factor (10^{-6} kg/mg), AF = adherence factor (mg/cm^2-event), ABS_d = dermal absorption fraction (unitless), SA = skin surface area available for contact (cm^2), BW = body weight (kg), ABS_{GI} = gastrointestinal absorption factor (unitless)

Hazard Quotient

$$\mathbf{HQ = D_{noncancer} \div HG} \qquad \textbf{Equation 3}$$

HQ = hazard quotient, $D_{noncancer}$ = dose (mg/kg/day), HG = health guideline (e.g., oral MRL, RfD)

Cancer Risk Equations

$$\mathbf{CR = D_{cancer} \times CSF \times (ED \div LY)} \qquad \textbf{Equation 4}$$

$$\mathbf{ADAF\text{-}adjusted\ CR = (D_{cancer} \times CSF) \times (ED \div LY) \times ADAF} \qquad \textbf{Equation 5}$$

$$\mathbf{Total\ CR = Sum\ of\ the\ CR\ for\ all\ exposure\ groups} \qquad \textbf{Equation 6}$$

CR = cancer risk (unitless), D_{cancer} = dose, CSF = oral cancer slope factor [$(mg/kg/day)^{-1}$], EF (cancer) = exposure factor (cancer) calculated as follows: EF (noncancer; unitless) x exposure group specific exposure duration (years) ÷ lifetime of 78 years, ADAF = age-dependent adjustment factor (unitless), ED = exposure duration (years), LY = lifetime years (78 years)

Site-specific Exposure Factors

Duration Category	Days per Week	Weeks per Year	Years	Exposure Group Specific $EF_{noncancer}$	Exposure Group Specific* EF_{cancer}
Acute	-	-	-	1	-
Intermediate	7	-	-	1	-
Chronic	7	52.14	78	1	= $EF_{noncancer}$ x Exposure Duration for $Cancer_{Exposure\ Group}$ (years) ÷ 78 years

Abbreviations: EF = exposure factor; NC = not calculated
Note: The dermal absorbed dose equation includes 1 event/day EF parameter.
* Cancer risk is averaged over a lifetime of exposure (78 years).

Site-specific Exposure Parameters

Exposure Group	Body Weight (kg)	Exposure Duration (years)	CTE Intake Rate (mg/day)	RME Intake Rate (mg/day)	Custom Intake Rate (mg/day)	Soil-pica Intake Rate (mg/day)	Adherence Factor to Skin (mg/cm^2/event)	Combined Skin Surface Area (cm^2)	Notes
Birth to < 1 year	7.8	1	55	150	-	-	0.2	1,772	-
1 to < 2 years	11.4	1	90	200	-	5,000	0.2	2,299	-
2 to < 6 years	17.4	4	60	200	-	5,000	0.2	2,592	-
6 to < 11 years	31.8	5	60	200	-	-	0.2	3,824	-
11 to < 16 years	56.8	5	30	100	-	-	0.2	5,454	-
16 to < 21 years	71.6	5	30	100	-	-	0.2	6,083	-
Total Child (all age groups)	-	21	-	-	-	-	-	-	-
Adult	80	78	30	100	-	-	0.07	6,030	-

Abbreviations: cm^2 = centimeters square skin; CTE = central tendency exposure (typical); kg = kilograms; mg/cm^2/event = milligram chemical per centimeter square of skin per event; mg/day = milligram soil per day; RME = reasonable maximum exposure (higher)

Contaminant Information

Contaminant Name	Entered Concentration	EPC Type	Converted Concentration*	Dermal Absorption Fraction	ABS_{GI}	Bioavailability Factor
2,3,7,8-tetrachlorodibenzo-p-dioxin	124 ppt	Maximum	0.00012 mg/kg	0.03	1	1

Abbreviations: ABS_{GI} = gastrointestinal absorption factor; EPC = exposure point concentration; mg/kg = milligram chemical per kilogram soil; ppt = parts per trillion

* Contaminant concentration converted to standard unit for calculating exposure.

Appendix B. Calculation of risk from residential soil.

This appendix is an example of how risk is calculated using the equations and exposure factors listed in Appendix A. The calculation below was the output of calculations created by ATSDR's Public Health Assessment Screening Tool (PHAST) that was used to evaluate health risk to all age groups through ingestion of and dermal contact with soil.

Residential: Site-specific combined ingestion and dermal exposure doses for chronic exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin in soil at 0.00012 mg/kg along with non-cancer hazard quotients and cancer risk estimates (124 ppt)*

Exposure Group	CTE Dose (mg/kg/day)	CTE Non-cancer Hazard Quotient	CTE Cancer Risk	RME Dose (mg/kg/day)	RME Non-cancer Hazard Quotient	RME Cancer Risk	Exposure Duration (yrs)
Birth to < 1 year	1.0E-09	1.5 †	-	2.6E-09	3.6 †	-	1
1 to < 2 years	1.1E-09	1.6 †	-	2.3E-09	3.3 †	-	1
2 to < 6 years	5.4E-10	0.77	-	1.5E-09	2.2 †	-	4
6 to < 11 years	3.2E-10	0.46	-	8.7E-10	1.2 †	-	5
11 to < 16 years	1.4E-10	0.20	-	2.9E-10	0.41	-	5
16 to < 21 years	1.2E-10	0.16	-	2.4E-10	0.34	-	5
Total Child	-	-	1.2E-5 ‡	-	-	3.0E-5 ‡	21
Adult	6.6E-11	0.094	3.6E-6 ‡	1.7E-10	0.25	9.6E-6 ‡	33

Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/kg = milligram chemical per kilogram soil; RME = reasonable maximum exposure (higher); yrs = years

* The calculations in this table were generated using ATSDR's PHAST v2.2.0.0. The non-cancer hazard quotients were calculated using the chronic (lifetime) reference dose of 7E-10 mg/kg/day and the cancer risks were calculated using the cancer slope factor of 130,000 $(mg/kg/day)^{-1}$.

† A shaded cell indicates the hazard quotient is greater than 1, which ATSDR evaluates further.

‡ A shaded cell indicates that the cancer risk exceeds one extra case in a million people similarly exposed, which ATSDR evaluates further.

Appendix C. Information on egg size from MDEQ (2016).

When EHAP used MDEQ's model (MDEQ, 2016) that estimates dioxin concentration in eggs, we assumed that people eat medium-sized eggs from their backyard chickens. This appendix shows the size of a medium egg compared to other eggs. If eggs from backyard chickens are smaller, risk from dioxin exposure is lower. Likewise, larger backyard chicken eggs will contain larger amounts of dioxin.

USDA Weight Class	Net weight per dozen eggs (ounces)	Home Produced Weekly Egg Consumption	
		Child	Adult
Peewee	15	7.4	10.6
Small	18	6.2	8.9
Medium	**21**	**5.3**	**7.6**
Large	24	4.6	6.7
X-Large	27	4.1	5.8
Jumbo	30	3.7	5.3

Appendix D. What are dioxins?

"Dioxin" is the generic name for a group of chemicals including both polychlorinated dibenzodioxins and polychlorinated dibenzofurans. There are approximately 200 individual chemicals in this group, and each unique individual compound in this group is called a congener. Among all compounds of this group, 2,3,7,8-tetrachloro-p-dioxin (TCDD) is the most studied and believed to be the most toxic. Not all dioxins and furans are as toxic as TCDD, but all are thought to cause adverse effects through the same mechanisms (ATSDR, 1998).

Low levels of dioxin are commonly found in soils in urban areas. Dioxin is formed naturally and unintentionally during forest fires, backyard burning, chlorine bleaching in paper manufacturing, some chemical manufacturing processes, and burning of gasoline and diesel fuel. Dioxins are often found in higher amounts in industrial areas. Dioxin compounds are considered "environmentally persistent" compounds, meaning they do not naturally break down over time. They tend to bind tightly to organic matter in soils and sediment. They are not likely to be in air as a vapor, but can be attached to particulate matter emitted from sources such as diesel exhaust and industrial emissions.

Non-Cancer Effects

At low concentrations of dioxin exposure, dioxin exposure can cause reproductive effects in males. Mocarelli *et al.* (2008) reported decreased sperm concentrations and decreased motile sperm counts in men who were 1–9 years of age when they were exposed to dioxin by a large industrial explosion in Italy (the Seveso disaster). The study reported decreased sperm concentrations and decreased motile sperm counts in men who were 1–9 years of age at the time of the accident. This reduction in sperm concentrations in men who were exposed as children has been seen in other epidemiologic studies and in studies with rodents (Mocarelli *et al.*, 2011; Simanainen *et al.*, 2004). This effect on sperm production can happen through childhood exposure, and can also happen from exposure in utero or through breast feeding.

Low levels of TCDD exposure in utero, during infant lactation, and as a child can also result in changes in thyroid hormones. Baccarelli *et al.* (2008) reported increased levels of thyroid stimulating hormone (TSH) in newborns exposed to TCDD in utero, indicating a possible dysregulation of thyroid hormone metabolism. TCDD exposure causes increased metabolism and clearance of the thyroid hormone, thyroxine (T4), which results in the brain releasing more TSH. Adequate levels of thyroid hormone are essential in the newborn and young infant because it is a period of active brain development (Zoeller and Rovet, 2004). Thyroid hormone disruption during pregnancy and in the neonatal period can lead to neurological deficiencies, particularly in attention and memory (Oerbeck *et al.*, 2005).

Higher levels of dioxin exposure cause more serious health effects. The most frequently noted health effect in people exposed to excessive amounts of the most toxic member of the dioxin family [2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)] is chloracne, a severe skin rash

characterized by acne-like lesions that occur mainly on the face, neck, and upper body. Other skin effects noted in people exposed to high doses of 2,3,7,8- TCDD include other skin rashes, skin discoloration, and excessive body hair. Another non-cancer health effect caused by high dioxin exposure is transient mild hepatotoxicity (liver damage). Peripheral neuropathy (a form of peripheral nerve damage) has been reported in some individuals exposed to high levels of dioxins. Lastly, exposure to high concentrations of PCDDs may induce long-term alterations in glucose metabolism and subtle changes in hormonal levels. Other non-cancer health effects that are suspected, but not yet confirmed, to be associated with dioxin exposures, include *porphyria cutanea tarda* (characterized by liver dysfunction and photosensitive skin lesions), type 2 diabetes, and neurobehavioral development effects in infants (ATSDR, 1998).

Cancer Effects

TCDD is believed to be a cancer promoter, rather than a cancer initiator. Cancer initiators cause direct genetic damage that can also lead to mutations. The initial mechanism by which dioxins are thought to induce adverse health effects, including cancer promotion, is by binding with a cellular protein known as the aryl hydrocarbon receptor (AhR). The AhR protein is part of a family of cellular proteins that is thought to play an important role in normal physiological function (ATSDR, 1998).

Several studies in humans have been performed evaluating 2,3,7,8-TCDD exposures and potential cancer effects. These studies suggest that exposure to 2,3,7,8-TCDD increases the risk of several types of cancer in humans. A major weakness in many of these studies is the lack of adequate exposure data. In many cases, body burdens of 2,3,7,8-TCDD were not measured, surrogates of exposure were used to identify subjects who were likely to have been exposed, and/or there was exposure to other carcinogenic compounds at the same time. Cancer health effects that are suspected (but not yet confirmed to be associated with dioxin exposures) include all cancers combined, rectal cancer, pleural cancer, lymphohemopoietic cancer, leukemia, respiratory cancers, prostate cancer, and multiple myeloma (a malignant tumor of plasma cells affecting the bone marrow) (ATSDR, 1998).

ATSDR and the National Toxicology Program (NTP) have determined that 2,3,7,8-TCDD may reasonably be anticipated to cause cancer in humans and thus have listed it as a Class 1 carcinogen (known human carcinogen). The International Agency for Research on Cancer (IARC) concluded that there is limited evidence in humans for the carcinogenicity of 2,3,7,8-TCDD; however, data from studies involving experimental animals provided sufficient evidence of carcinogenicity. Thus, IARC and the World Health Organization (WHO) currently list 2,3,7,8-TCDD as a Class 1 carcinogen (*i.e.*, there is sufficient human evidence). The US EPA concludes that there is sufficient evidence that 2,3,7,8-TCDD is an animal carcinogen but inadequate evidence that it is a human carcinogen and thus classifies it as a B2 carcinogen.

How Dioxin Exposure Affects Children

The developing fetus is most sensitive to dioxin exposure. Newborns, with rapidly developing organ systems, may also be more vulnerable to certain effects. Fetuses can be exposed in utero when the mother is exposed to dioxin. Since dioxin compounds are extremely lipophilic (*i.e.*, they bind easily to fat), infants can be exposed to dioxin through lactation.

Children can also be more susceptible to dioxin contamination in soil, because they spend more time playing outside than adults, are more likely to get their skin dirty with soil, and less likely to wash their hands and skin after getting dirty. All of these behaviors increase the chances that they will ingest soil through hand-to-mouth contact.

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