

OHA Assessment of Health Risk from Exposure to Soils around Bullseye Glass

March 8, 2016

Based on the soil data available, OHA concludes that levels of metals in soil around Bullseye Glass are *too low to harm the health of people in the surrounding community*. The following tables and text describe OHA's process in arriving at this conclusion.

DEQ collected 67 soil samples near the Bullseye Glass facility. DEQ had these samples analyzed for 12 metals including specific forms of chromium called chromium +6 or hexavalent chromium. Tables 1-3 show the complete list of metals tested. DEQ collected additional samples, but OHA focused on samples taken at shallow depth (0-6 inches) because they represent what people in the area would likely be exposed to. DEQ has maps that show where samples were collected ([link if available](#)).

DEQ divided the 67 samples into three areas, Powell City Park (30 samples), Fred Meyer Parking Lot (22 samples), and the KinderCare Children's Creative Learning Center (15 samples). Using area average¹ concentrations provided by DEQ, OHA assessed health risks in each area separately. Using child-protective screening levels, a few individual sample results exceeded these levels. However, given the possibility and duration of contact over any one area, the average¹ measured levels would not be great enough to harm health.

Steps for analyzing data:

1. **Identification of exposure scenarios:** This involves identifying what kinds of people come into contact with soil and with what intensity. We identified two exposure scenarios for this assessment:
 - a. Children at Children's Creative Learning Center daycare are the most sensitive exposure scenario because they are young children who daily come into more contact with soil than most adults.
 - b. Lifelong residents exposed to the soil represented by DEQ sampling.
2. **Calculation of average metal concentrations for each exposure area:** DEQ provided a calculated average (90th percentile upper confidence limit around the mean) for each metal for each of the areas. In some cases there were too few detections to reliably calculate an average. In these cases, we used the maximum detected value for the next step.
3. **Comparison to screening levels:** Through this step, we identify which data need to be looked at more closely. We compared measured levels to three [different screening levels](#). The section "Comparison to Screening Levels" describes how average measured metals levels for each area compared to screening levels. The screening step is also shown in Tables 1-3. When the average exceeds the ATSDR screening level or the DEQ residential screening level, we conducted an in-depth analysis.

- 4. *In-depth analysis:*** In this step, we consider what ways and how much people might come into contact with contamination. Children are sensitive to exposures to contaminants and also swallow more soil than most adults. For these calculations, OHA assumed that a 10 kilogram (22 pound) child would swallow 200 milligrams (1/5 of a paper clip) of soil per day, 5 days per week for 5 years for children at the daycare. Because cancer risk is estimated on a lifetime bases, the period of exposure is divided by the average lifespan. Following guidance from ATSDR, OHA assumed an 80-year lifespan. For lifelong residents, OHA assumed an 80 kilogram (176 pound) adult would swallow 100 milligrams of soil per day every day for 30 years. For more details about dose calculations and exposure assumptins, [see Attachment 2](#).

Comparison to Screening Levels

It is important to note that levels of arsenic in Oregon soils are often naturally higher than DEQ's Residential Screening Level for arsenic. Overall, cadmium levels were above expected background levels for the Portland Basin in each area, but average cadmium levels were below all health-based screening levels in all areas. See Tables 1-3 for details.

Screening level comparison for Powell Park

In Powell Park, the average¹ soil levels of arsenic and chromium +6 were higher than DEQ's residential screening levels, and none of the metals were measured at levels higher than ATSDR screening levels. Because of these exceedances, we took a closer look at arsenic and chromium +6 in the in-depth analysis section.

Screening levels comparison for daycare center

At the daycare, the average¹ soil levels of arsenic and chromium +6 levels were higher than DEQ's residential screening levels, and arsenic levels were higher than ATSDR's screening level. The section on in-depth analysis discusses risk from arsenic and chromium +6 in more detail. It is important to note that the samples with higher arsenic levels that fed into the average were collected from under sod outside the fence line of the daycare's outdoor play area.

Screening level comparison for the Fred Meyer parking lot

At the Fred Meyer parking lot, the average soil levels of arsenic, chromium +6, and cobalt levels were higher than DEQ's residential screening levels, and no metals were present at levels higher than ATSDR screening levels.

The section on in-depth analysis below discusses risk from arsenic, chromium +6, and cobalt in more detail, as these were the substance found at levels above the DEQ Residential Screening Level or the ATSDR Screening Level (see Tables 1-3).

¹ Upper 90th percentile confidence limit around the mean (UCL90) – Any calculation of a mean or average involves some uncertainty. The UCL90 is the measured soil level that we can say with 90 percent certainty that the actual mean does not exceed given the number of samples collected.

In-depth analysis for all three sampling areas by contaminant

Arsenic

OHA calculated estimated doses of arsenic to children at the daycare center because average¹ arsenic levels in that location were higher than all 3 screening levels. Literature suggests that less than 10 percent of total arsenic in ingested soil actually gets absorbed into the body. EPA typically uses 60 percent as the assumption when calculating arsenic doses from soil, and this is the assumption OHA used here². For these calculations, OHA used assumptions mentioned in item 4 of the list above. Given these assumptions, OHA estimated excess risk of lung and bladder cancers to children at the daycare center from arsenic exposure at 60 in 1 million over an 80-year lifespan. For a lifelong resident, the calculated cancer risk is 30 in 1 million over an 80-year lifespan. These are very low cancer risks that are indistinguishable from background cancer risk.

Using the same assumptions, we estimated risk for health effects other than cancer. For daycare children the calculated dose estimate was 0.2 micrograms of arsenic per kilogram body weight per day ($\mu\text{g}/\text{kg}\text{-day}$) which is less than the dose that ATSDR's minimal risk level dose (dose that ATSDR considers to be associated with insignificant risk) of 0.3 $\mu\text{g}/\text{kg}\text{-day}$. For lifelong residents, the calculated dose was 0.02 $\mu\text{g}/\text{kg}\text{-day}$, which is 15 times less than ATSDR's minimal risk level dose.

Considering all of this information, OHA concludes that soil concentrations of arsenic are too low to harm the health of children playing at the daycare center or the surrounding community. OHA used average soil levels from the daycare for both adults and children to be protective of health since the daycare had higher average levels of arsenic than either of the other two areas.

Chromium +6

Chromium +6 levels, when present, were often too low to be measured accurately in soil samples in all areas. The highest average¹ level of detected chromium +6 (1.63 mg/kg) across the three sampling areas was from the daycare center. All chromium +6 levels measured at the day care center were well below the ATSDR screening level for health effects other than cancer. Other than an insignificant increase in lifetime cancer risk, there is no risk of health effects related to chromium +6 from soil. In order to estimate cancer risk, OHA calculated estimated doses of chromium +6 to children at the daycare center and lifelong residents using the same assumptions about exposure as for arsenic. Given these assumptions, OHA calculated an estimated excess cancer risk to children at the daycare center from chromium +6 exposure at 0.7 in 1 million over an 80-year lifespan. For lifelong residents, the calculated cancer risk was 0.4 in 1 million. These are very low cancer risks that would not be detectable over baseline cancer rates.

Cobalt

Cobalt is not present at high enough concentrations to harm people's health. The DEQ residential screening level assumes daily ingestion of soil for 26 years, and it is very unlikely that anyone using the

² Email communication from EPA reviewers

Fred Meyer parking lot would come into contact with bare soil with the same level of intensity as a residential yard. It is important to note that while cobalt levels exceeded screening levels, the measured average levels are less than the expected background levels for the Portland Basin.

Combined cancer risk

OHA added the estimated cancer risks for arsenic and chromium +6 for children at the daycare center and lifelong residents found the combined cancer risk to be 60 in 1 million over an 80-year lifespan for daycare children and 30 in 1 million for lifelong residents. Even combined, these cancer risks would cause no detectable increase in cancer rates over baseline.

Note that estimated cancer risks are always presented to 1 significant digit to avoid implying a degree of precision that does not exist. However, all digits are used in all calculations. This rounding is the reason that the combined risk isn't a straight sum of 60 for arsenic and 0.7 for chromium +6.

Conclusions

Overall, OHA concludes that exposure to the levels of metal levels in soils around Bullseye Glass are too low to harm the health of the community, including children at the daycare center and lifelong residents. This conclusion is based on 67 surface soil samples collected by DEQ.

When additional soil data become available and DEQ verifies its reliability, OHA will evaluate it for public health significance.

Soil in individual yards and gardens is typically different from the soil in public spaces. See OHA's guidance on interpretation of self-collected soil data for information about how to understand the results of any soil testing you may have had done independently.

Table 1.
POWELL PARK

METAL	Average* measured (mg/kg)	Portland Basin Background Estimate (mg/kg)	DEQ Residential Screening Level (mg/kg)	ATSDR [£] Screening Level (mg/kg)	Greater than Background?	Greater than DEQ Residential Screening Level?	Greater than ATSDR Screening Level?
Arsenic	5.1	8.8	0.43	15	No	Yes	No
Cadmium	4	0.63	78	5	Yes	No	No
Chromium (total)	16	76	120,000	75,000	No	No	No
Chromium +6	0.83	NA	0.3	45	NA	Yes	No
Cobalt	10	33	23	500	No	No	No
Lead	97	79	400	NA	Yes	No	NA
Nickel	14	47	1,500	1,000	No	No	No
Selenium	0.94	0.71	390	250	Yes	No	No
Mercury	0.09	0.23	23	15	No	No	No
Iron	18,912	36100	55,000	NA	No	No	NA
Manganese	641	1800	1,800	2,500	No	No	No
Aluminum	9,663	52300	77,000	50,000	No	No	No
Uranium	0.727 [¥]	3	230	150	No	No	No

*Upper 90th confidence limit around the mean, ¥Highest detection used instead of average because there were too few detections to calculate an average, £Agency for Toxic Substances and Disease Registry screening levels are either Environmental Media Evaluation Guidelines (EMEGs) or Reference Dose Media Evaluation Guidelines (RMEGs) for children. We chose levels in the following order of preference based on availability: chronic EMEGs, child RMEGs, intermediate child EMEGs. See soil screening table for more details about which ATSDR screening levels were used for each metal.

NA = no value available, or no comparison possible because no value available for this specific metal, or no estimate available by this specific agency.

Table 2. CCLC
Day Care

METAL	Average* measured (mg/kg)	Portland Basin Background Estimate (mg/kg)	DEQ Residential Screening Level (mg/kg)	ATSDR [£] Screening Level (mg/kg)	Greater than Background?	Greater than DEQ Residential Screening Level?	Greater than ATSDR Screening Level?
Arsenic	20	8.8	0.43	15	Yes	Yes	Yes
Cadmium	3.1	0.63	78	5	Yes	No	No
Chromium (total)	19	76	120000	75000	No	No	No
Chromium +6	1.63	NA	0.3	45	NA	Yes	No
Cobalt	11	33	23	500	No	No	No
Lead	60	79	400	NA	No	No	NA
Nickel	12	47	1500	1000	No	No	No
Selenium	0.94	0.71	390	250	Yes	No	No
Mercury	0.03	0.23	23	15	No	No	No
Iron	17560	36100	55000	NA	No	No	NA
Manganese	514	1800	1800	2500	No	No	No
Aluminum	9046	53300	77000	50000	No	No	No
Uranium	1.69 [¥]	3	230	150	No	No	No

*Upper 90th confidence limit around the mean, ¥Highest detection used instead of average because there were too few detections to calculate an average, £Agency for Toxic Substances and Disease Registry screening levels are either Environmental Media Evaluation Guidelines (EMEGs) or Reference Dose Media Evaluation Guidelines (RMEGs) for children. We chose levels in the following order of preference based on availability: chronic EMEGs, child RMEGs, intermediate child EMEGs. See soil screening table for more details about which ATSDR screening levels were used for each metal.

NA = no value available, or no comparison possible because no value available for this specific metal, or no estimate available by this specific agency.

Table 3. FRED
MEYER

METAL	Average* measured (mg/kg)	Portland Basin Background Estimate (mg/kg)	DEQ Residential Screening Level (mg/kg)	ATSDR [£] Screening Level (mg/kg)	Greater than Background?	Greater than DEQ Residential Screening Level?	Greater than ATSDR Screening Level?
Arsenic	5.7	8.8	0.43	15	No	Yes	No
Cadmium	5	0.63	78	5	Yes	No	No
Chromium (total)	19	76	120000	75000	No	No	No
Chromium +6	2.0 [¥]	NA	0.3	45	NA	Yes	No
Cobalt	30	33	23	500	No	Yes	No
Lead	30	79	400	NA	No	No	NA
Nickel	21	47	1500	1000	No	No	No
Selenium	4.42 [¥]	0.71	390	250	Yes	No	No
Mercury	0.04	0.23	23	15	No	No	No
Iron	25018	36100	55000	NA	No	No	NA
Manganese	938	1800	1800	2500	No	No	No
Aluminum	10120	53300	77000	50000	No	No	No
Uranium	0 [¥]	3	230	150	No	No	No

*Upper 90th confidence limit around the mean, ¥Highest detection used instead of average because there were too few detections to calculate an average, £Agency for Toxic Substances and Disease Registry screening levels are either Environmental Media Evaluation Guidelines (EMEGs) or Reference Dose Media Evaluation Guidelines (RMEGs) for children. We chose levels in the following order of preference based on availability: chronic EMEGs, child RMEGs, intermediate child EMEGs. See soil screening table for more details about which ATSDR screening levels were used for each metal.

NA = no value available, or no comparison possible because no value available for this specific metal, or no estimate available by this specific agency.

Attachment 1: Soil Screening Levels

Health risks were evaluated by comparing soil sample results against accepted screening levels. Data was evaluated for three areas: the day care, Powell City Park, and the Fred Meyer parking lot.

Three screening levels were used for each contaminant.

- **DEQ's estimate of the background level for the Portland Basin.** This comparison provides context for what we would expect to find in soil anywhere in the Portland area. For more information: <http://www.deq.state.or.us/lq/pubs/docs/cu/FSbackgroundmetals.pdf>
- **DEQ's Residential Screening Level.** These screening numbers establish soil cleanup levels based on proposed reuse for contaminated sites. Residential reuse requires the most stringent cleanup as it assumes children and families will live on the property. For more information: <http://www.epa.gov/risk/regional-screening-levels-rsls-users-guide-november-2015>
- **Environmental Media Evaluation Guides [EMEGs] and Reference Dose Media Evaluation Guides [RMEGs]** from the Agency for Toxic Substances and Disease Registry (ATSDR), which is a part of the Centers for Disease Control and Prevention (CDC). These screening levels are calculated to assess human health risks. For more information: ATSDR's website (section 3 of [Appendix F](#) of ATSDR's Public Health Assessment Guidance Manual)

The toxicity-based screening levels from both DEQ and ATSDR were added to give more perspective for both cancer and non-cancer risks. When the screening level numbers vary widely, it is because the level of a substance that causes a non-cancer health effect may be much higher than the amount that would pose a cancer risk. Depending on the metal in question, non-cancer health effects could include kidney damage for cadmium, skin problems or nerve damage for arsenic, and learning deficits for lead.

The screening levels established by both DEQ assume that a 33 pound child will consume 200 milligrams of the contaminated soil per day for a year or more and that it will all be absorbed into their body. 200 milligrams is about one fifth of the weight of a paper clip. ATSDR uses the same assumptions except that the child is 22 pounds instead of 33. These assumptions are designed to protect health, because metals in swallowed soil are absorbed at much lower rates (often as low as 1% or less), especially when soil is mixed with organic matter. These assumptions are also very protective of adults because an adult is larger and so would have smaller dose than a child if the same amount were swallowed.

In summary, substances measured at levels below screening levels are not expected to harm health for children or adults. Substances measured at levels above screening levels require further evaluation before making a conclusion on how health could be affected.

Metal	DEQ Portland Basin Background¹	DEQ Residential Screening Levels²	ATSDR Screening Levels³
Aluminum	52,300 ^b	77,000 ^a	50,000
Arsenic	8.8	0.43	15
Cadmium	0.63	78	5
Total Chromium ^e	76	120,000	75,000
Chromium +6	NA	0.3	45
Cobalt	33 ^c	23 ^a	500
Iron	36,100 ^b	55,000 ^a	NA
Lead	79	400	NA
Manganese	1,800	1,800	2,500
Mercury	0.23	23	15
Nickel	47	1,500	1,000
Selenium	0.71	390 ^a	250
Uranium	3 ^d	230 ^a	150

1- Source DEQ background metals fact sheet,

<http://www.deq.state.or.us/lq/pubs/docs/cu/FSbackgroundmetals.pdf>

2 - Residential Levels are DEQ soil screening levels, where available, or EPA regional screening levels (RSLs) When no DEQ residential level is published.

3 - Agency for Toxic Substances and Disease Registry (ATSDR) Screening Levels. ATSDR levels are environmental media evaluation guides (EMEGs), or reference dose media evaluation guides (RMEGs).

a - Residential levels for these metals are the US EPA Regional Screening Levels (RSLs) for residential use.

b - Background levels shown are from Washington Department of Ecology Pub. No. 94-115

c - No background estimate for cobalt has been published by DEQ. Level shown is average of Willamette Valley soil from DEQ database.

d- Background estimate from Toxicological Profile for Uranium, US ATSDR, February 2013.

e- Background level is based on total chromium. Screening Levels are based on trivalent chromium.

NA - Not Available - No estimate of background soil concentration or screening levels are available for these metals and agencies.

Attachment 2. Dose and Risk Calculation

This attachment describes the formulas, methods, and assumptions used to calculate estimated doses and risk for arsenic and chromium +6 for children at the CCLC Daycare and 30 year residents. For soil samples, the upper 90th percent confidence limit (UCL90) around the average concentration was used to calculate dose (Tables 1-3). 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 arsenic and chromium +6.

Doses were calculated as follows:

$$\text{Dose} = \frac{C \times IR \times C_1 \times \text{BAF} \times \text{EF} \times \text{ED}}{\text{AT} \times \text{BW}}$$

$$\text{Cancer Risk} = \text{Dose} \times \text{CSF}$$

$$\text{Hazard Quotient (non - cancer risk)} = \frac{\text{Dose}}{\text{MRL}}$$

Where¹:

C = Concentration of chemical measured in soil (chemical specific)

IR = Intake rate of soil

C₁ = Conversion factor 1

BAF = Bioavailability Factor (chemical specific)

EF = Exposure frequency

ED = Exposure duration

AT = Averaging time

BW = Body weight

CSF = Cancer slope factor (chemical specific)

MRL = Minimal Risk Level (chemical specific and defined by [ATSDR](#))

Hazard quotient greater than 1 indicates potential risk for non-cancer health effects

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:

$$\text{AT} = \text{ED} \times 365 \text{ days}$$

Where:

AT = Averaging time

ED = Exposure duration (years)

Cancer:

$$\text{AT} = 29200 \text{ days (80 year lifetime} \times 365 \text{ days/year)}$$

¹See Table 2-1 for more details about terms in the formula and the values used for each with their rationale.

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 (80 years) for agents that cause cancer [[Public Health Assessment Guidance Manual](#)].

Table 2-1. Exposure Factors for Dose Calculations

Term	Description			Units	Notes
		Child at daycare	Adult 30-year resident		
C	Concentration	Arsenic: 20 Chromium +6: 1.63	Arsenic: 20 Chromium +6: 1.63	mg/kg	Chemical specific from Tables 1-3. UCL90
IR	Intake rate for soil/tailings ingestion	200	100	mg/day	ATSDR Guidance [Public Health Assessment Guidance Manual]
C ₁	Conversion Factor 1	0.000001	0.000001	kg/mg	Converts kilograms of soil to milligrams of soil
BAF	Oral bioavailability factor	Arsenic: 0.6 Chromium +6: 1	Arsenic: 0.6 Chromium +6: 1	No units	Chemical specific
EF	Exposure frequency for ingestion of soil	260	365	days/year	Assumed 5 days per week for daycare children and 7 days per week for 30-year resident
ED	Exposure Duration	5	30	years	
BW	Body weight	10	80	kg	ATSDR guidance for adults [Public Health Assessment Guidance Manual]; Conservative assumption for very young children
AT _{nc}	Averaging time for non-cancer health effects	1825	10950	days	Exposure duration x 365 days
AT _c	Averaging time for cancer health effects	29200	29200	days	80 year lifetime x 365 days
CSF	Cancer Slope Factor	Arsenic: 5.7 Chromium +6: 0.5	Arsenic: 5.7 Chromium +6: 0.5	Mg/kg-day ⁻¹	EPA
MRL	Minimal Risk Level	Arsenic: 0.0003	Arsenic: 0.0003	Mg/kg-day	ATSDR (MRL Table) MRL for Chromium +6 is not listed because measured levels of chromium +6 in soil were below ATSDR's screening level for non-cancer health effects, so no calculation of non-cancer health risk was indicated.

Abbreviations: ATSDR – Agency for Toxic Substances and Disease Registry; EPA – Environmental Protection Agency; mg – milligrams; kg – kilograms; w/ - with

Table 2-2 Dose and risk calculation results (non-cancer) for arsenic

Exposed Group	Dose (mg/kg-day)	Hazard Quotient	Health Hazard?
Daycare child	0.00017	0.6	No
Adult 30-year resident	0.000015	0.05	No

Table 2-3 Dose and risk calculation results (cancer) for arsenic and chromium +6

Exposed Group	Chemical	Dose (mg/kg-day)	Excess cancer risk (rounded to 1 significant digit)	Health Hazard?
Daycare child	Arsenic	1.1×10^{-5}	6×10^{-5} (60 in 1 million)	No
	Chromium +6	1.5×10^{-6}	7×10^{-7} (0.7 in 1 million)	No
	Combined cancer risk		6×10^{-5} (60 in 1 million)	No
Adult 30-year resident	Arsenic	5.6×10^{-6}	3×10^{-5} (30 in 1 million)	No
	Chromium +6	7.6×10^{-7}	4×10^{-7} (0.4 in 1 million)	No
	Combined cancer risk		3×10^{-5} (30 in 1 million)	No