Letter Health Consultation

Bremerton Gasworks Superfund Site:
Time-Critical Removal Action of Sediments 2010 and 2013
Bremerton, Kitsap County, Washington

December 12, 2016

Prepared by

The Washington State Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Washington State Department of Health

DOH 334-406

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order 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 which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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LETTER HEALTH CONSULTATION

Time-Critical Removal Action of Sediments 2010 and 2013

BREMERTON GASWORKS SUPERFUND SITE:
BREMERTON, KITSAP COUNTY, WASHINGTON

Prepared By:

Washington State Department of Health
Under a cooperative agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

Foreword

The Washington State Department of Health (DOH) prepared this health consultation in accordance with the Agency for Toxic Substances and Disease Registry (ATSDR) methodologies and guidelines. Health consultations are initiated in response to health concerns raised by community members or agencies about exposure to hazardous substances released into the environment. The health consultation summarizes our health findings and if needed, provides steps or actions to protect public health.

The findings in this report are relevant to conditions at the site during the time the report was written. It should not be relied upon if site conditions or land use changes in the future.

This report was supported by funds provided through a cooperative agreement with the ATSDR, U.S. Department of Health and Human Services. ATSDR has reviewed this document and concurs with its findings based on the information presented.

Use of trade names is for identification only and does not imply endorsement by state or federal health agencies.

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June 27, 2016

William Ryan
Remedial Project Manager
EPA Region 10
Seattle, Washington 98001

Re: Bremerton Gasworks Superfund Site Health Evaluation - 2013 Surface Sediment Results

Dear Mr. Ryan:

As a follow up to the Public Health Action Plan for the February 2014 initial/public comment Public Health Assessment (PHA) [1], the Washington State Department of Health (DOH) evaluated levels of polycyclic aromatic hydrocarbons (PAH) in surface sediment collected post 2010 and during the 2013 (see Figure 1) time-critical removal actions at the Bremerton Gasworks Superfund Site. The purpose of evaluating the new sediment data was to determine whether carcinogenic polycyclic aromatic hydrocarbons (cPAH) remaining in surface sediment pose a public health threat. DOH found that the 2010 and 2013 time-critical removal actions have reduced the potential for exposure risk to the most contaminated sediments on the beach. This Letter Health Consultation (LHC) only reports on the evaluation of surface sediments and does not address other potential health hazards identified in the 2014 PHA such as physical hazards from ballast tanks and potential exposure to contaminants in soil and from consumption of biota (shellfish, fish, and blackberries). DOH will further evaluate potential hazards from soil and biota consumption in a future report if that data becomes available. DOH recommended the removal of the ballast tanks and further soil and biota sampling in the 2014 PHA. DOH conducts health consultations in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR).

The surface sediment samples (0 to 4 inches) were collected outside of the 2010 time-critical removal action areas and reflect conditions following implementation of both the 2010 and 2013 time-critical removal actions. The two time-critical removal actions were completed to reduce beachgoer's exposures to the most contaminated sediments and to prevent potential migration of hydrocarbon contamination before completing the Remedial Investigation/Feasibility Study (RI/FS).

BREMERTON-011547

Overall, DOH found that the 2010 and 2013 time-critical removal actions have reduced the potential for exposure risk to the most contaminated sediments. In addition, we evaluated four different exposure scenarios: Resident, visitor, trespasser, and short-term.

Summary of evaluation findings for each exposure scenario:

Scenario	**Example**	**Number of days**	**Age range**	**Conclusion**
Resident	A person accesses the site every day over their lifetime.	218 days/year	Child to adult	May harm health due to increased cancer risk.
Visitor	A person accesses the site every day during the summertime over their lifetime.	90 days/year	Child to adult	May harm health due to increased cancer risk.
Trespasser	A person accesses the site three days per week.	156 days/year	Older child to adult	Not expected to harm health.
Lifetime short-term	A person accesses the site 52 days per year over their lifetime.	52 days/year	Child to adult	May harm health due to increased cancer risk.
Short-term	A person accesses the site a total of 52 days OR A child accesses the site 52 days per year between the ages of 2 to 6.	52 days	Child to adult OR Child 2-6 years old	Not expected to harm health.

BREMERTON-011548

- Lifetime residential (218 days/year) and visitor (90 days/year) exposure to cPAH levels found outside of the time critical removal areas could harm children and adults due to an increased cancer risk.
- Lifetime short term exposure (52 days/year over a lifetime) to contaminated sediment may harm children and adults due to an increased cancer risk.
- Short-term or limited duration exposure (single exposure of 52 days or 52 days exposure per year in an age range – eg. Child 2 to <6 years old) to cPAHs in the sediment represent a low to very low cancer risk and is not expected result to result in harm.
- Adult or older child trespasser exposure (156 days/year) to contaminated sediment represent a low to very low cancer risk and is not expected to result in harm.

Based on the evaluation of surface sediments remaining at the beach, the 2010 and 2013 time-critical removal actions have reduced the exposure risk about seven fold. However, lifetime residential (218 days/year) and visitor (90 days/year) exposure to the upper limit of a 95% confidence interval (95% UCL) of the average concentration of the remaining cPAH could harm the health of children and adults. Lifetime short term (52 days/year) exposure to the average concentration of cPAH may harm the health of children and adults.

Short-term or limited duration (52 days or 52 days/year within a specific age group) exposure to the average concentration of cPAH remaining in the surface sediment is not expected to result in harmful health effects to children or adults. Similarly, adult or older child trespasser (156 days/year) exposure to the 95% upper confidence limit (UCL) concentration of cPAH remaining in the surface sediment is not expected to result in harmful health effects.

Background of 2010 and 2013 Time Critical Removal Actions

1) 2010 Time Critical Removal Action

In 2010, Kitsap Public Health District (KPHD) investigated reports of an oily sheen along the shoreline. The release was from an old pipe filled with what appeared to be tar-like hydrocarbons and contaminated sediment. KPHD reported the information to the U.S. Environmental Protection Agency (EPA). EPA contacted the Coast Guard, who installed a containment system and then cut and temporarily plugged the end of the pipe. The Coast Guard and EPA's Superfund Technical Assessment and Emergency Response Team (START) collected and analyzed 30 sediment samples. They identified high concentrations of polycyclic aromatic hydrocarbons (PAH) in sediment, and an area of visible hydrocarbon sheen was noted in sediments in the vicinity of the pipe [2]. The depth of contamination was not determined.

To stop the release, the Coast Guard issued an Administrative Order for a Pollution Incident (Order) to Cascade Natural Gas Corporation (Cascade), a company that acquired assets of a former owner and operator of a manufactured gas plant once located on the uplands near the area of impacted sediment. The release came from what appeared to be an abandoned stormwater outfall pipe, which was once connected to, or may still be connected to, an abandoned vault on Sesko property. Cascade removed approximately 60 feet of pipe and plugged the end with hydraulic cement. They excavated sediment (approximately 9 cubic yards) up to five feet deep and five feet around where the pipe was removed. The excavation area was filled with clean sandy materials. An organo-clay mat (approximately 2,600 square feet) was placed as a cap over

BREMERTON-011549

the sediments exhibiting visible hydrocarbon sheen [2]. The mat was covered with approximately 4,800 square feet of cobbles to prevent disturbance of the cap.

2) 2013 Time Critical Removal Action

In the summer of 2013, Cascade and its contractors, with the EPA's oversight, collected samples on the beach north of the old former manufactured gas plant (see Figure 1). In a localized portion of the western beach area, the sediments exhibited high PAH concentrations, patches of hardened hydrocarbon material were identified, and subsurface sediments contained both hydrocarbon sheen and elevated PAH concentrations. Upland inspections also identified a potential for water to infiltrate the vault believed to be connected to the pipe in the eastern beach area that was plugged during the 2010 time-critical removal action. A Removal Evaluation Work Plan was developed at EPA's direction to address these two areas with a preliminary human health risk screening values of 8 milligrams per kilogram (mg/kg) cPAH (based on Benzo(a)pyrene equivalents) at the lower end of their cancer target risk range [3]. The goals of the removal action were to minimize the risk that hydrocarbon contamination would migrate to Port Washington Narrows and impact surface water, and to minimize contact of beach users to contaminated sediments [3]. In the fall of 2013, Cascade removed the solid hydrocarbon deposits from the western beach area and then capped the area of subsurface sediments containing visible hydrocarbon sheen. The cap consisted of a layer of organo-clay mat and a 1-foot layer of cobbles, similar to the cap placed in the 2010 time-critical removal action. Warning signs were installed to alert beach users to the presence of contaminated sediments. In the uplands, actions were taken to prevent stormwater infiltration into the vault believed to be connected to the pipe that was the focus of the 2010 time-critical removal action [4].

2013 TCRA Surface Sediment Results and Discussion

Intertidal sediment was collected in July 2013 at 39 locations [3, 4]. A total of 42 surface sediment samples, including three duplicate samples, contained cPAH concentrations ranging from 0.043 mg TEQ/kg to 486 mg TEQ/kg (expressed as benzo(a)pyrene equivalents or TEQ using CalEPA toxicity equivalence factors) [3, 4]. The 2013 time-critical removal actions resulted in the removal of hardened hydrocarbon deposits from the western beach area, followed by capping of the sediment containing the highest cPAH concentrations (486 mg TEQ/kg). As described above, that area was covered by a cap consisting of an absorbent clay mat and a layer of cobbles similar to the 2010 cap.

The remaining 40 surface sediment samples including three duplicates samples contained cPAH ranging from 0.043 mg TEQ/kg to 63 mg TEQ/kg with a 95% UCL of 22.19 mg/kg and a mean of 15.59 mg/kg. All samples except one exceeded ATSDR's Cancer Risk Evaluation Guide (CREG) for Benzo(a)pyrene in soil of 0.096 mg/kg.

Lifetime residential (218 days/year) and visitor (90 days/year) exposure to the 95% UCL exceeds the EPA cancer risk range of 1×10^{-4} to 1×10^{-6} (see Attachment A, Table A2). Adult or older child trespasser (156 days/year) exposure to the 95% UCL falls within the EPA target cancer risk range of 1×10^{-4} to 1×10^{-6} (see Attachment A, Table A2). Lifetime short-term (52 days/year) exposure to the average concentration slightly exceeds the EPA target cancer risk range (see

BREMERTON-011550

Attachment A, Table A3). Short-term or limited duration exposure (single exposure of 52 days or 52 days exposure per year in an age range – eg. Child 2 to <6 years old) to the average concentration did not exceed the EPA cancer risk range of 1×10-4 to 1×10-6 (see Attachment A, Table A3).

Conclusion

1. DOH concludes that lifetime residential (218 days/year) and visitor (90 days/year) exposures (touching or accidentally eating sediment with cPAH) at the upper limit of a 95% confidence interval (95% UCL) of the average concentration could harm the health of children or adults.

2. DOH concludes that lifetime short-term (52 days/year) exposure (touching or accidentally eating sediment with cPAH) at the average concentration cPAH may harm the health of children or adults.

3. DOH concludes that adult or older child trespassers (156 days/year) exposure (touching or accidentally eating sediment with cPAH) at the average cPAH remaining concentration in the surface sediment represent a low to very low cancer risk and is not expected to result in harmful health effects to older children or adults.

4. DOH concludes that short-term or limited duration (52 days/year) exposure (touching or accidentally eating sediment with cPAH) at the average cPAH remaining concentration in the surface sediment represent a low to very low cancer risk and is not expected to result in harmful health effects to children or adults.

Recommendations/Actions

- DOH recommends maintenance of the capped areas on the shoreline.
- DOH recommends the current EPA beach warning signs remain in place.
- DOH recommends EPA determine a remedy to address the remaining contamination above the preliminary human health risk screening values.

DOH appreciates the opportunity to assist you with these technical issues. Please contact me at 360-236-3376 if you have any questions.

Sincerely,

Lenford O'Garro, MS., RS
Toxicologist, Health Assessor
Site Assessments and Toxicology Section

Enclosures (2)

cc: Joanne Snarski, Department of Health

BREMERTON-011551

References

1. Washington State Department of Health. Public Health Assessment (Initial/Public Comment Release) Evaluation of Exposures to Contaminants in soil, sediment, and groundwater, Bremerton Gasworks Superfund Site, Bremerton, Kitsap, County, Washington. February 26, 2014.

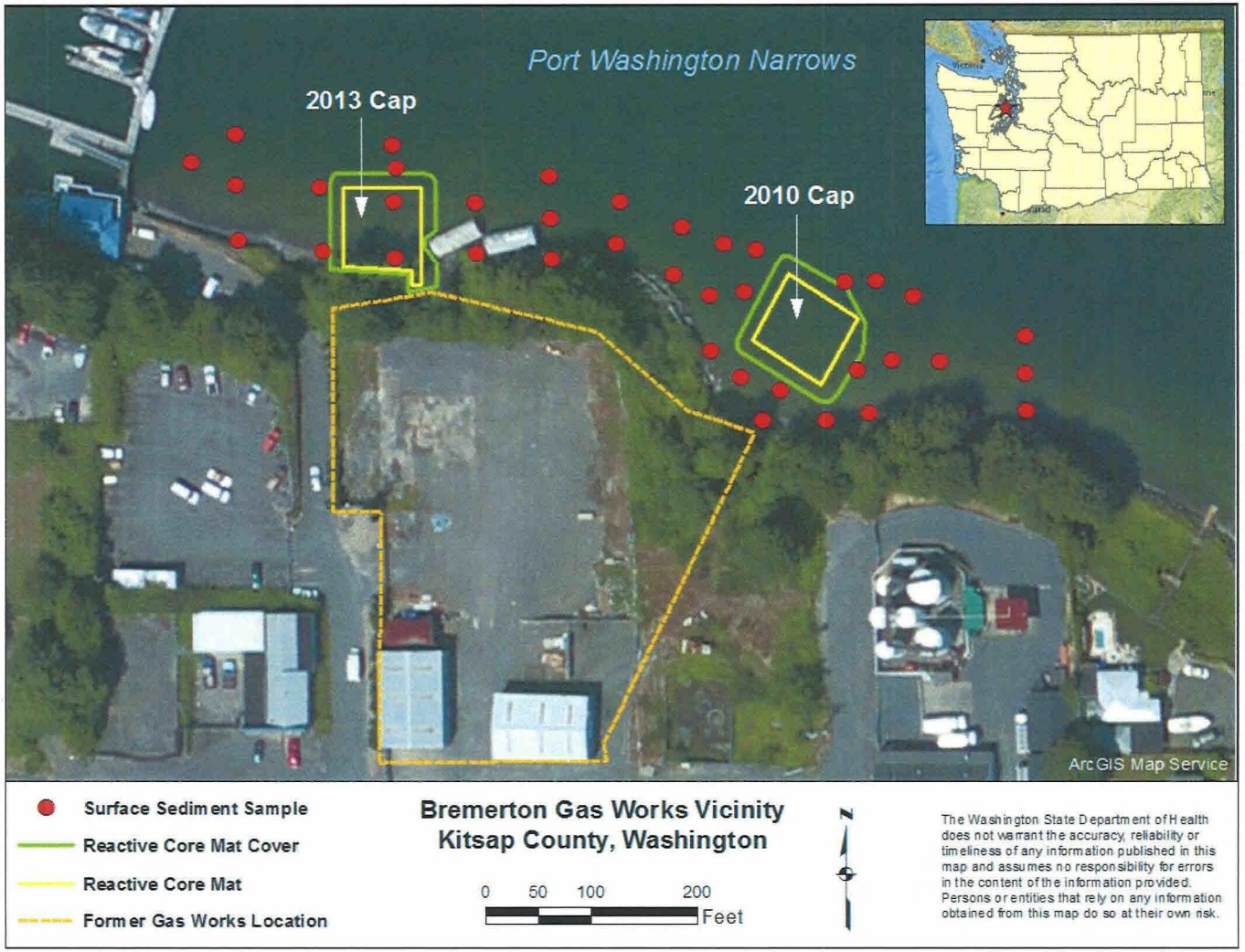
2. Anchor QEA, 2011. Completion Report Former Bremerton MGP Site Incident Action and Time-Critical Removal Action, Bremerton Gas Works Site. Prepared for U.S. Coast Guard Sector Puget Sound; January 2011.

3. Anchor QEA and Aspect, 2014. Time-Critical Removal Action Report, Bremerton Gas Works Site. Prepared for Cascade Natural Gas Corporation; April 2014.

4. Anchor QEA and Aspect, 2013. Final Removal Evaluation Report, Bremerton Gas Works Site. Prepared for Cascade Natural Gas Corporation; December 2013.

BREMERTON-011553

Figure 1: Bremerton Gasworks Superfund site – 2013Intertidal beach surface sediment sample locations, Bremerton, Kitsap, Washington.



BREMERTON-011555

Attachment A -Sediment Exposure Assumptions

This section provides the assumptions and calculations used to estimate daily intakes for exposure to chemicals in sediments at the site. Cancer exposure doses were calculated for incidental ingestion of sediment and dermal absorption of sediment adhered to skin. Inhalation of sediment particles was not considered as a route of exposure since inhalation of dust particles from wet sediments is not expected to occur. cPAH in sediments have been identified as a contaminant of concern.

The following equations were used to calculate cancer exposures doses and risks:

Equation C1: Incidental Ingestion Route

$$Cancer\ Dose_{ing} = \frac{C_s \times IR \times EF \times CF}{BW} \quad \text{Where, } EF = \frac{F \times ED}{AT}$$

The exposure factor (EF) will vary depending on the scenario (see scenario-specific calculations for EF in Table C1).

Equation C2: Skin Contact Route

$$Cancer\ Dose_{der} = \frac{C_s \times AF \times ABS \times AD \times CF \times SA \times EF}{BW} \quad \text{Where, } EF = \frac{F \times ED}{AT}$$

Again, the exposure factor (EF) will vary depending on the scenario (see scenario-specific calculations for EF in Table C1).

Equation C3: Carcinogenic mutagenic risks (CMR) or (Carcinogenic risks)

$$CMR = Cancer\ Dose \times CSF \times ADAF$$

BREMERTON-011557

Table A1. Exposure assumptions used in exposure evaluation of people in contact with sediments at the former MGP in Bremerton, Washington.

Parameter and Abbreviation		Value	Units	Source
Cancer exposure dose for ingestion route	D(ing)	Calc.	mg/kg-day	D(ing) = C*IR*CF*EF/BW
Cancer exposure dose for dermal route	D(der)	Calc.	mg/kg-day	D(der) = (C*AF*ABS*AD*CF*EF*SA)/BW
Concentration in sediment	C_s	Calc.	mg/kg	Mean or the 95% UCL of the mean: chemical-specific concentration for sediment.
Conversion factor	CF	0.000001	kg/mg	Converts from kilograms soil to milligrams soil
Age-specific body weight	BW	9.2	kg	Body weight, Child 0.5 to < 1 year (EFH)
		11.4		Body weight, Child 1 to < 2 years (EFH)
		17.4		Body weight, Child 2 to < 6 years (EFH)
		31.8		Body weight, Child 6 to < 11 years (EFH)
		56.8		Body weight, Child 11 to < 16 years (EFH)
		71.6		Body weight, Child 16 to < 21 years (EFH)
		80		Body weight, Adult 21 to < 65 years (EFH)
		76		Body weight, Adult 65+ years (EFH)
Exposure factor (EF=F*ED/AT)	EF	Variable	unitless	Local resident (daily exposure at low tide)
				Visitor
				Trespasser
Frequency	F	218	days/year	Resident: low tides occur during the day for 60% of the year (218/365 based on NOAA 2011 data)
		~90		Visitor: summertime months (3 months a year)
		156		Trespasser: onsite 3 days a week
		52		1 days a week (short-term)
Age-specific exposure duration	ED	0.5	year	Child 0.5 to < 1 year
		1		Child 1 to < 2 years
		4		Child 2 to < 6 years
		5		Child 6 to < 11 years
		5		Child 11 to <16 years
		5		Child 16 to <21 years
		44		Adult 21 to < 65 years
		14		Adult 65+
Averaging time	AT	28470	day	Tribal averaging time, number of days in lifetime (78 years*365 days per year)
Age-dependent adjustment factor for mutagenicity	ADAF	10	unitless	Children < 2 years
		3		Children 2 to < 16 years
		1		Young adults and adults 16 years and older
Cancer risk	CMR	Calc.	$(mg/kg\text{-}day)^{-1}$	Increased risk of getting cancer CMR=D*CSF*ADAF
Cancer slope factor	CSF	7.3	unitless	For BaP used as a reference chemical for cPAHs, published by EPA

BREMERTON-011558

Table A1 (continued).

Parameter and Abbreviation		Value	Units	Source
Ingestion Parameters				
Incidental ingestion rate (central tendency)	IR	60	mg/day	Child 0.5 to < 1 year
		100		Child 1 to < 21 years
		50		Adult
Dermal Parameters				
Absorption duration	AD	1	day	Fraction of day sediment is in contact with the skin (worst-case) RAGS E
Skin-sediment adherence factor	AF	0.2	mg/cm^2	Amount of sediment that adheres to skin, child 1-6 years (RAGS E)
		0.07		Amount of sediment that adheres to skin, child and adult (7-31 years) (RAGS E)
Dermal absorption factor	ABS	PAH 0.13	unitless	Chemical-specific, fraction of chemical that absorbs through the skin in 24-hours (EPA RSL; EPA RAGS E)
Surface area	SA	2900	cm^2	Surface area exposed, child 1-6 years (RAGS E)
		5700		Surface area exposed, child and adult 7-31 years (RAGS E)

Sources: Guidance for developing soil screening levels for Superfund sites Abbreviations not defined in the table:

BaP	Benzo(a)Pyrene used as the reference compound for PAHs with carcinogenic effects (cPAH)
Calc.	Calculated
cm	centimeters
EFH	EPA Exposure Factors Handbook 2011
EPA	U.S. Environmental Protection Agency
mg	milligram
NOAA	National Oceanic Atmospheric Administration
kg	kilogram
cPAH	polycyclic aromatic hydrocarbons with carcinogenic effects
RAGS E	EPA Risk Assessment Guidance for Superfund Part E, Volume 1: Human Health Evaluation Manual (Part E - Supplemental Guidance for Dermal Risk Assessment)
RSL	EPA Regional Screening Levels
UCL	upper confidence limit of the mean

BREMERTON-011559

BREMERTON-011560

Results

Table A2. Estimated cancer risks resulting from exposures to carcinogenic polycyclic aromatic hydrocarbons (cPAH)[a] in intertidal sediments near the former MGP from Bremerton, Kitsap County, Washington.

Exposure Pathway	Age	Concentration (mg/kg) [b]	Estimated Cancer Dose			Cancer Slope Factor	ADAF	Increased Cancer Risk			Age [c]	Total Cancer Risk
			Incidental Ingestion	Dermal Contact	Total Dose			Incidental Ingestion	Dermal Contact	Total Cancer Risk		
Resident (daily during low tides)	Child 0.5 to < 1 year	22.19	5.54E-7	6.96E-7	1.25E-6	7.3[a]	10	4.04E-5	5.08E-5	9.13E-5	Young Child	4.3E-4
	Child 1 to < 2 years		1.49E-6	1.12E-6	2.61E-6		10	1.09E-4	8.20E-5	1.91E-4		
	Child 2 to < 6 years		3.91E-6	2.95E-6	6.85E-6		3	8.55E-5	6.45E-5	1.50E-4		
	Child 6 to < 11 years		2.67E-6	3.96E-6	6.63E-6		3	5.85E-5	8.67E-5	1.45E-4	Older Child	2.3E-4
	Child 11 to <16 years		1.50E-6	2.22E-6	3.71E-6		3	3.28E-5	4.85E-5	8.13E-5		
	Child 16 to <21 years		1.19E-6	1.76E-6	2.94E-6		1	8.66E-6	1.28E-5	2.15E-5	Young Adult to Adult	1.1E-4
	Adult 21 to < 65 years		4.67E-6	4.85E-6	9.52E-6		1	3.41E-5	3.54E-5	6.95E-5		
	Adult 65+		1.56E-6	1.62E-6	3.19E-6		1	1.14E-5	1.19E-5	2.33E-5		
	Lifetime		**1.75E-5**	**1.92E-5**	**3.67E-5**			**3.80E-4**	**3.93E-4**	**7.73E-4**		**7.73E-4**
Visitor (daily during summertime only)	Child 0.5 to < 1 year	22.19	2.29E-7	2.87E-7	5.16E-7		10	1.67E-5	2.10E-5	3.77E-5	Young Child	1.78E-4
	Child 1 to < 2 years		6.15E-7	4.64E-7	1.08E-6		10	4.49E-5	3.39E-5	7.88E-5		
	Child 2 to < 6 years		1.61E-6	1.22E-6	2.83E-6		3	3.53E-5	2.66E-5	6.19E-5		
	Child 6 to < 11 years		1.10E-6	1.63E-6	2.74E-6		3	2.42E-5	3.58E-5	6.00E-5	Older Child	9.35E-5
	Child 11 to <16 years		6.17E-7	9.15E-7	1.53E-6		3	1.35E-5	2.00E-5	3.36E-5		
	Child 16 to <21 years		4.90E-7	7.26E-7	1.22E-6		1	3.58E-6	5.30E-6	8.88E-6	Young Adult to Adult	4.72E-5
	Adult 21 to < 65 years		1.93E-6	2.00E-6	3.93E-6		1	1.41E-5	1.46E-5	2.87E-5		
	Adult 65+		6.46E-7	6.70E-7	1.32E-6		1	4.72E-6	4.89E-6	9.61E-6		
	Lifetime		**7.24E-6**	**7.91E-6**	**1.52E-5**			**1.57E-4**	**1.62E-3**	**3.19E-4**		**3.19E-4**
Trespasser (3 days per week)	Child 16 to <21 years	22.19	8.49E-7	1.26E-6	2.11E-6		1	6.20E-6	9.19E-6	1.54E-5	Young Adult to Adult	8.18E-5
	Adult 21 to < 65 years		3.34E-6	3.47E-6	6.81E-6		1	2.44E-5	2.53E-5	4.97E-5		
	Adult 65+		1.12E-6	1.16E-6	2.28E-6		1	8.18E-6	8.48E-6	1.67E-5		

Notes:
a – Carcinogenic polycyclic aromatic hydrocarbons (cPAHs) classified by EPA as Group B2 Probable Human Carcinogens; calculations performed with EPA's slope factor 7.3 $(mg/kg\text{-}day)^{-1}$.
Concentrations of each PAHs multiplied by carcinogenic potency factors relative to Benzo(a)pyrene (BaP) according to CalEPA and summed/expressed as BaP equivalents (BEQ).
b – Concentration represents 95% upper confidence limit of the mean sediment samples
c – Age groupings are young (0.5 to < 6 years), older (6 to < 16 years old) and young adult/adult (16 years and older)
Abbreviations: EPA – Environmental Protection Agency; mg/kg – milligrams chemical per kilogram sediment
ADAF - Age-dependent adjustment factor for mutagenicity
$(mg/kg\text{-}day)^{-1}$ – milligrams per kilograms per day

Table A3. Estimated cancer risks resulting from short-term exposures to carcinogenic polycyclic aromatic hydrocarbons (cPAH)[a] in intertidal sediments near the former MGP from Bremerton, Kitsap County, Washington.

Exposure Pathway	Age	Concentration (mg/kg) [b]	Estimated Cancer Dose			Cancer Slope Factor	ADAF	Increased Cancer Risk			Age [c]	Total Cancer Risk
			Incidental Ingestion	Dermal Contact	Total Dose			Incidental Ingestion	Dermal Contact	Total Cancer Risk		
Short-term	Child 0.5 to < 1 year	15.59	9.29E-8	1.17E-7	2.10E-7	7.3[a]	10	6.78E-6	8.52E-6	1.53E-5	Young Child	7.2E-5
	Child 1 to < 2 years		2.50E-7	1.88E-7	4.38E-7		10	1.82E-5	1.37E-5	3.20E-5		
	Child 2 to < 6 years		6.55E-7	4.94E-7	1.15E-6		3	1.43E-5	1.08E-5	2.51E-5		
	Child 6 to < 11 years		4.48E-7	6.64E-7	1.11E-6		3	9.81E-6	1.45E-5	2.43E-5	Older Child	3.8E-5
	Child 11 to <16 years		2.51E-7	3.71E-7	6.22E-7		3	5.49E-6	8.14E-6	1.36E-5		
	Child 16 to <21 years		1.99E-7	2.95E-7	4.94E-7		1	1.45E-6	2.15E-6	3.60E-6	Young Adult to Adult	1.9E-5
	Adult 21 to < 65 years		7.83E-7	8.12E-7	1.60E-6		1	5.72E-6	5.93E-6	1.16E-5		
	Adult 65+		2.62E-7	2.72E-7	5.34E-7		1	1.91E-6	1.99E-6	3.90E-6		
	Lifetime		**2.94E-6**	**3.21E-6**	**6.15E-6**			**6.37E-05**	**6.58E-05**	**1.30E-4**		**1.30E-4**

Notes:
a – Carcinogenic polycyclic aromatic hydrocarbons (cPAHs) classified by EPA as Group B2 Probable Human Carcinogens; calculations performed with EPA's slope factor 7.3 $(mg/kg\text{-}day)^{-1}$.
Concentrations of each PAHs multiplied by carcinogenic potency factors relative to Benzo(a)pyrene (BaP) according to CalEPA and summed/expressed as BaP equivalents (BEQ).
b – Concentration the mean sediment samples
c – Age groupings are young (0.5 to < 6 years), older (6 to < 16 years old) and young adult/adult (16 years and older)
Abbreviations: EPA – Environmental Protection Agency; mg/kg – milligrams chemical per kilogram sediment
ADAF - Age-dependent adjustment factor for mutagenicity
$(mg/kg\text{-}day)^{-1}$ – milligrams per kilograms per day

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