Health Consultation

ROUTE 6-10 CONNECTOR RECONSTRUCTION SITE:
SOIL BACKFILL AND POLYCYCLIC AROMATIC HYDROCARBONS

PROVIDENCE COUNTY, RHODE ISLAND

Prepared by the
Rhode Island Department of Health

APRIL 27, 2021

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

Health Consultation: A Note of Explanation

A health consultation 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. 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 or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Providence, Providence County, Rhode Island

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SUMMARY

INTRODUCTION	The Rhode Island Department of Health (RIDOH) received a request from the Rhode Island Department of Environmental Management (RIDEM) to evaluate potential public health concerns related to the Route 6/10 Connector Reconstruction Project, located in Providence. RIDEM requested RIDOH to review levels of polycyclic aromatic hydrocarbons (PAHs) in soil samples and determine whether the levels pose a health hazard to workers or nearby residents. The site of concern is the Route 6/10 interchange, an east-west regional link for traffic between Interstates 295, 95 and 195, located west of downtown Providence. The project includes building the "missing connector" from Route 10 North to Route 6 West, just south of the Westminster Street bridge. In 2020, the contractor trucked in soil from other projects to be used as backfill. The soil was later found to have levels of two polycyclic aromatic hydrocarbons (PAHs), benzo(a)pyrene and dibenzo(a,h)anthracene, reported above RIDEM's Residential Direct Exposure Criteria (DEC). This health consultation addresses RIDEM's and the community's remaining concerns about PAH exposures at the 6/10 connection site.
CONCLUSION	RIDOH concluded that PAH exposures from backfill soil at the 6/10 connector site did not pose a public health hazard to workers or nearby residents.
BASIS FOR CONCLUSION	Conservative exposure dose calculations for occupational workers and nearby residents showed that PAH soil levels were below levels known to result in non-cancer health effects. The exposure time was no more than one year (365 days), so RIDOH did not expect a significant increase in cancer risk. Soils where PAH contamination were present have been removed and/or covered with clean fill, preventing people from coming into contact with contaminated soil.
NEXT STEPS	○ The PAH-contaminated soils were removed from the 6/10 construction site in December 2020. ○ Institutional controls (updated soil management plan), should be implemented to record the former location of the backfill soil piles for future reference. ○ RIDOH will distribute a frequently-asked-questions sheet describing this health evaluation and what the public can do to minimize PAH exposures.
FOR MORE INFORMATION	If you have concerns about your health, you should contact your local health care provider. You may also contact RIDOH at carolyn.poutasse@health.ri.gov and ask about PAH exposures.

BACKGROUND

History

The Rhode Island Department of Health (RIDOH) received a request from the Rhode Island Department of Environmental Management (RIDEM) to evaluate potential public health concerns related to the 6/10 Connector Reconstruction Project, located in Providence, Rhode Island (the site). RIDEM requested RIDOH to review the levels of polycyclic aromatic hydrocarbons (PAHs) in soil samples and determine whether the levels pose a health hazard to occupational workers or nearby residents. This health consultation is based on information provided to RIDOH by RIDEM, the Rhode Island Department of Transportation (RIDOT), and Alpha Analytical Laboratory.

The site is located in the Olneyville neighborhood, west of downtown Providence, at the intersection of westbound Route 6 and southbound Route 10 (Figure 1). Since the 1950s, the 6/10 interchange has served as an east-west regional link for traffic between Interstates 295, 95 and 195. An estimated 100,000 trips are made through the interchange each day. The five-year Route 6/10 Reconstruction Design-Build Project was intended to repair or replace seven of the nine interchange bridge structures. The project also includes building the "missing connector" from Route 10 North to Route 6 West, just south of the Westminster Street bridge (Figure 1).

Local neighborhood associations have opposed the 6/10 Connector Project due to concerns of pollution, noise, pedestrian safety, and historic environmental racism concerns. Nearby Olneyville residents have primarily self-identified as low-income people of color and have previously experienced environmental contamination incidents (Fix the 6/10 Coalition 2020). Neighborhood advocates supported eliminating the Route 6/10 connector in favor of developing a boulevard, with expected benefits for nearby businesses and schools.

In December 2017, the 6/10 Constructors Joint Venture (6/10 JV) was awarded the RIDOT reconstruction project, at an estimated $247 million (*GoLocal Prov News* 2020). The 6/10 JV team consisted of four companies: Barletta Heavy Division Inc. (lead), O&G Industries Inc., D.W. White Construction, and Aetna Bridge Company. RIDEM, RIDOT, and the 6/10 JV team agreed on a soil management plan to maximize construction site safety for occupational workers. The work officially began in September 2018, and Local 57 of the International Union of Operating Engineers were hired to drive bulldozers and other heavy machinery at the site.

In 2020, Barletta Heavy Division Inc. (Canton, MA) trucked in soil from other projects to be used as backfill. The backfill soil was later determined to be from the MBTA commuter rail station renovation in East Boston (Faulkner 2020). An estimated 2,500 cubic yards of soil were trucked into the site (Figure 2). Over the next few months, nearby residents issued multiple complaints about construction-related dust being blown into their yards.

Site Investigation

Union workers were concerned about exposure to hazardous contaminants in the fill, and the union sent samples to RI Analytical for testing. Levels of two PAHs, benzo(a)pyrene and dibenzo(a,h)anthracene, were reported above RIDEM's Residential Direct Exposure Criteria (DEC) for soil (*GoLocal Prov News* 2020). The union requested that the soil be removed and issued formal complaints to Barletta and RIDOT in July 2020 and to RIDEM in August 2020.

RIDOT and RIDEM sampled the soil in September 2020 to confirm the earlier laboratory results. The full environmental reports are available at http://www.dem.ri.gov/programs/wastemanagement/site-remediation/6-10-connector.php. On September 8, GEI Consultants (Woburn, MA) took three grab and three composite samples from the backfill soil piles of interest (Table 1). On September 13, GEI Consultants took an additional six grab and six composite samples from the backfill soil piles (Table 2). The samples were analyzed for over 190 chemicals, of which only 35 were detected (Table 1, Table 2).

This health consultation evaluated maximum PAH levels from the September 13 soil samples because only PAHs were detected above RIDEM Residential DEC values from these samples.

Response Actions

Following the September soil sampling, the backfill piles were covered with plastic tarps to prevent wind from blowing dust into residential yards. By December 10, 2020, Barletta removed the soil and disposed the piles at the Clinton Municipal Landfill in Massachusetts (RIDOT personal communications). Ongoing state and federal investigations related to the 6/10 connector soil contamination are not discussed in this report.

After the laboratory results were discussed in the news media, community members became very concerned about PAH exposures and negative health outcomes. RIDEM requested assistance from RIDOH on September 17, 2020 to answers questions about PAH toxicity specific to the 6/10 connector project. RIDOH developed a frequently asked questions (FAQ) document about PAH exposures at the site, which went through RIDOH communications review before being released to community members in November 2020 (Appendix A). As of February 2021, neighborhood advocates, RIDEM, and RIDOH have met virtually to discuss remaining questions about PAH exposures and prevention strategies for the future.

DISCUSSION

Potential for Human Exposure

Before negative health effects can occur, chemicals must be present and people have to come into contact with them. However, the level (i.e. concentration) of chemical and the amount of contact a human has with the chemical must also be high enough for harm to occur. The steps from pollutant to people is known as the exposure pathway, which has five parts: contaminant source, environmental media, exposure point, exposure route, and potentially exposed population. All five parts must be present for the exposure pathway to be complete.

For the 6/10 connector soil samples, RIDOH considered the exposure pathway to be complete, but at levels not expected to cause health effects: backfill soil piles (source), soil (media and exposure point), accidental ingestion or inhalation (exposure route), and occupational workers (population). A second complete exposure pathway was also considered: backfill soil piles (source), soil (media), dust blown into residential yards (exposure point), accidental ingestion or inhalation (exposure route), and nearby residents (population).

Polycyclic Aromatic Hydrocarbons

PAHs are a group of chemicals that commonly occur in the environment and are usually formed by burning materials, such as wood, coal, and gasoline. Dozens of different PAHs are regularly detected in soil, air, water, food, and animals. As a chemical group, PAHs are generally considered to be *semi-volatile organic chemicals*, meaning that PAH levels are often higher in soil than in air. Because PAHs are ubiquitous and found in lots of different environments (soil, air, etc.), it is not always possible to identify where PAHs came from (e.g. source) (Wang and Stout 2010).

Because burning coal and gasoline produce PAHs, cities often have soils containing many different PAHs (Bradley, Magee, and Allen 1994; Kim et al. 2019). These PAH levels are known as *background* and are often the result of human-related activities (e.g. anthropogenic sources). Interestingly, soil near busy highways do not always have higher PAH levels compared to soil near less busy roads (Kim et al. 2019; Lee and Dong 2010).

Humans can be exposed to PAHs through breathing (inhalation), eating (ingestion), and touching (dermal contact) different environmental media (e.g. air, water, food, soil). Most people are exposed by breathing air with PAHs (tobacco smoke) or eating foods with PAHs (grilling or charring). If a person breathes in PAHs from air for long periods of time (e.g. years), PAHs are known to cause heart attacks and lung diseases, such as emphysema and asthma, among other health effects (ATSDR 1995).

The US Environmental Protection Agency (EPA) has classified several PAHs as a "probable human carcinogens" (ATSDR 1995). Cancer health endpoints are only expected to happen after decades of PAH exposure. Long-term exposure to high levels of PAHs, especially in tobacco smoke and food, is known to cause lung cancer, colon cancer, bladder cancer, and a variety of other cancers.

To protect human health, scientists use non-cancer and cancer health endpoints to identify health-based regulations for PAH levels in soil. Higher PAH levels are needed for non-cancer health effects to happen compared to cancer health effects. To set conservative regulations, RIDEM used cancer as the main health endpoint so that the PAH soil criteria levels were stricter (Table 3). RIDEM DEC soil standards for individual PAHs were calculated from animal studies with cancer endpoints, where uncertainty factors accounted for animal-to-human differences and human-to-human differences (e.g. children versus adults) (ATSDR 1995). Because the RIDEM DEC soil standards are strict, cancer endpoints are only expected after 70 years (a lifetime) of exposures if the PAH levels are above the regulations.

Exposure to PAH levels above the RIDEM Industrial and Residential DEC soil values does not necessarily mean that adverse health effects will occur. However, such PAH levels indicated that remedial actions or further investigation to quantify actual exposures were necessary. At the 6/10 connector, the backfill soil piles were removed and properly disposed of in January 2021 (RIDOT personal communications).

PAHs in 6/10 Soil Samples

The soil sample with the highest PAH levels was used for the health evaluation (sample from 9/13/2020, SP-03 composite, Table 3). Several PAHs in the 6/10 soil samples were detected at higher levels than the RIDEM Residential and Industrial DEC soil standards, in milligrams of PAH per kilogram of soil (mg/kg)[1] (Table 3). However, these same PAHs were detected at similar levels in the New England city background soil samples, which included Providence and Boston (Bradley, Magee, and Allen 1994). Because the PAH levels between the 6/10 soil samples and background city soil were similar (e.g. within a factor of 10), it was likely that the backfill soil PAHs came from normal human activities, rather than a chemical spill or deliberate dumping. RIDOH does not currently consider the backfill soil piles to be highly contaminated hazardous waste.

Of the detected PAHs, benzo(a)pyrene (BaP) is the best studied. When studying adverse health endpoints, other PAHs are often compared to BaP for relative toxicity. Because multiple PAHs were detected in the 6/10 soil samples, RIDOH evaluated the overall toxicity of the PAH mixture. Each PAH concentration was multiplied by a BaP Toxic Equivalency Factor (Table 4), which determines what the equivalent PAH level would be if it were BaP. The sum of all BaP equivalent concentrations (7.66 mg/kg of soil) was used to assess the potential health risks of the PAH mixture at this site.

RIDOH quantitatively evaluated three exposure scenarios: occupational worker, nearby adult resident, and nearby child resident. Exposure time was assumed to be no more than 365 days. The most important exposure route at the 6/10 connector site was accidental soil ingestion (swallowing).

Exposure Scenario: Occupational Worker

This exposure scenario assumed that all workers (70 kg adult) followed all personal protective equipment requirements while on-site and ingested 330 milligrams soil per day (mg/day) for 5 days a week for 50 weeks (ATSDR 2005). With the 7.66 mg BaP_{eq}/kg soil, the estimated daily exposure dose of PAHs from ingestion was 0.000022 mg/kg/day.

For BaP ingestion, the reference dose was 0.0003 mg/kg/day, based on the non-cancer endpoint of developmental toxicity (ATSDR 1995). By comparison, the estimated ingestion exposure dose for an occupational worker was over 10 times smaller. Based on this exposure scenario, RIDOH did not expect ingestion of 6/10 connector soil to result in non-cancer adverse health effects from PAHs among occupational workers.

Soil ingestion was not a chronic exposure pathway at the 6/10 site (365 days per year over a 70-year lifetime). Because the exposure time was no more than one year, RIDOH did not expect a significant increase in cancer risk for occupational workers.

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[1] Milligram per kilogram (mg/kg) is equivalent to parts per million (example: one part per million is like one star in the Milky Way galaxy).

Exposure Scenario: Nearby Resident
This exposure scenario assumed that nearby adult residents (70 kg) ingested 10 mg soil per day for 7 days a week for 52 weeks (US EPA 2017a). The 10 mg/day was an overestimate because nearby residents would have accidentally ingested a combination of soil from the construction site and from their yards. The 6/10 soil ingestion may have been closer to 3-5 mg/day. However, based on guidance from the Agency for Toxic Substances and Disease Registry (ATSDR) and the Environmental Protection Agency (EPA), this health consultation used the 10 mg/day soil ingestion assumption as a conservative estimate.

With the 7.66 mg BaP_{eq}/kg soil, the estimated daily exposure dose of PAHs was 0.00000096 mg/kg/day. Similar to occupational workers, an adult resident's estimated dose was 300 times smaller than the reference dose of 0.0003 mg/kg/day. RIDOH did not expect ingestion of 6/10 connector soil to result in non-cancer adverse health effects from PAHs among adult residents.

Soil ingestion was not chronic exposure pathway at the 6/10 site (365 days per year over a 70-year lifetime). Because the exposure time was no more than one year, RIDOH did not expect a significant increase in cancer risk for nearby adult residents.

Childhood Health Considerations
RIDOH recognizes that infants and children are at greater risk than adults from certain exposures to contamination of their water, soil, air, or food. At the 6/10 connector site, children were more likely than adult residents to be exposed to higher doses: they play outdoors more frequently, have developing bodies, are smaller than adults (breathe closer to the ground), and weigh less (higher doses of chemical exposure per body weight). Children also depend on adults to identify risks, make housing decisions, and access medical care. RIDOH again used a reference dose of 0.0003 mg/kg/day for neurobehavioral effects and developmental changes (US EPA 2017b).

This exposure scenario assumed that nearby elementary-aged children (35.6 kg) ingested 30 mg soil per day for 7 days a week for 52 weeks (US EPA 2017a). The 30 mg/day was an overestimate because nearby children would have accidentally ingested a combination of soil from the construction site and from their yards. The 6/10 soil ingestion may have been closer to 10-15 mg/day for a child. However, based on ATSDR and EPA guidance, this health consultation used the 30 mg/day soil ingestion assumption as a conservative estimate.

With the 7.66 mg BaP_{eq}/kg soil, the estimated exposure dose of PAHs was 0.0000072 mg/kg/day. Here, a child's estimated daily exposure dose was about 40 times smaller than the lowest observed adverse effect level of 0.0003 mg/kg/day. RIDOH did not expect ingestion of 6/10 connector soil to result in non-cancer adverse health effects from PAHs among children.

Soil ingestion was not a chronic exposure pathway at the 6/10 site (365 days per year over a 70-year lifetime). Because the exposure time was no more than one year, RIDOH did not expect a significant increase in cancer risk for nearby children.

Community Health Concerns: Soil Inhalation
Due to community concerns, RIDOH also evaluated PAH exposures from soil inhalation. A person can be exposed by breathing in PAH-contaminated soils, but this is less likely than

breathing in tobacco smoke to lead to negative health effects (Ramírez et al. 2011). The soil inhalation health evaluation was qualitative, rather than quantitative, for several reasons: air samples were not taken at the 6/10 connector site, and ATSDR does not currently have guidance for calculating health risks from soil inhalation.

Because soil inhalation is not considered a major exposure route for PAHs, most US states do not have regulatory standards, known as Particulate Soil Inhalation Criteria (PSIC). For this qualitative assessment, RIDOH used PSIC values from Michigan as the references (Michigan Department of Community Health 2005).

With the Michigan BaP PSICs set at 1900 mg/kg for industrial sites and 1500 mg/kg for residential communities, the 6/10 connector site has BaP levels (7.66 mg/kg) about 200 times smaller. RIDOH did not expect inhalation of 6/10 connector soil to result in non-cancer adverse health effects from PAHs among occupational workers or nearby residents.

CONCLUSIONS

The incident at the Route 6/10 Connector Reconstruction Project was imported PAH-contaminated backfill soil with the potential for exposure to occupational workers and nearby residential communities. The combination of an indeterminate time frame for exposure and multiple exposure pathways put nearby populations at risk for health effects associated with soil ingestion of PAHs.

However, based on the soil samples and exposure scenarios evaluated, RIDOH concluded that exposure to PAHs in the backfill soil from the 6/10 connector site did not pose a public health hazard to occupational workers or nearby residents. PAH backfill soil levels were relatively low; future exposures to contaminated soil were mitigated by the removal of the backfill soil piles in December 2020.

RECOMMENDATIONS

Because the backfill soil of concern has been removed from the 6/10 connector site, RIDOH provided the following recommendations to RIDEM:

1. Institutional controls, such as an updated soil management plan, should be implemented to ensure that no similar incidents occur in the future.

PUBLIC HEALTH ACTION PLAN

RIDEM endorsed all recommended actions following the 6/10 connector incident. At this time, RIDOH's public health action plan include the following items to protect the populations involved:

1. RIDOH will distribute a frequently-asked-questions sheet describing this health evaluation for the 6/10 connector site and what the public can do to minimize PAH exposures.

2. Upon request, RIDOH is available to assess additional exposure scenarios and health endpoints of interest beyond what is discussed in this health consultation.

Individuals with additional information or questions regarding this health consultation should contact the Environmental Health Risk Assessment Program, Division of Environmental Health, RIDOH at carolyn.poutasse@health.ri.gov.

Report Preparation

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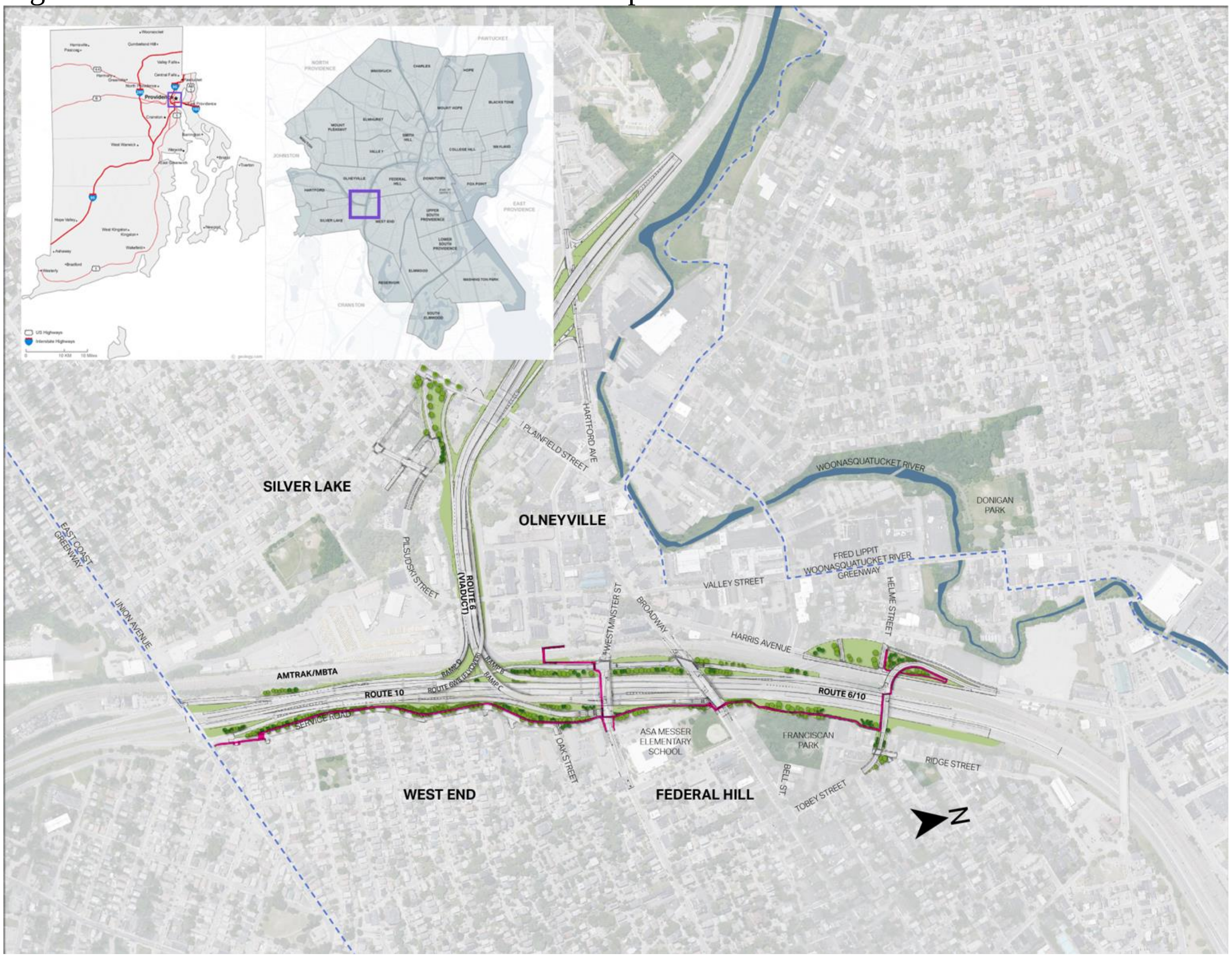
FIGURES

Figure 1. Route 6/10 Connector Site Location Map.



(“Route 6/10 Illustrative Plan,” n.d., 10)

Figure 2. Piles of backfill soil on Plainfield Street.

Source: (Faulkner 2020)

TABLES

Table 1. Summary of chemical detections from 6/10 soil samples (9/8/2020).

			Sample ID:	SP01 (COMP)	SP01 (GRAB)	SP02 (COMP)	SP02 (GRAB)	SP03 (COMP)	SP03 (GRAB)
			Sampling Date:	9/8/2020	9/8/2020	9/8/2020	9/8/2020	9/8/2020	9/8/2020
			Lab Sample ID:	L2037130-01	L2037130-02	L2037130-03	L2037130-04	L2037130-05	L2037130-06
Analyte	**Method**	**Units**	**Rhode Island Industrial/Commercial Direct Exposure Criteria**						
Volatile Organic Compounds (VOCs)	5035	mg/kg	NS	NT	ND	NT	ND	NT	ND
Semivolatile Organic Compounds (SVOCs)	8270D	mg/kg			NT		NT		NT
Acenaphthylene			10000	<0.68		<0.14		0.39	
Anthracene			10000	<0.51		0.12		0.21	
Benzo(a)anthracene			7.8	1		0.5		0.92	
Benzo(a)pyrene			0.8	**0.93**		0.4		**0.83**	
Benzo(b)fluoranthene			7.8	1.4		0.61		1.1	
Benzo(ghi)perylene			10000	<0.68		0.25		0.54	
Benzo(k)fluoranthene			78	<0.51		0.18		0.41	
Chrysene			780	1		0.44		0.81	
Dibenzo(a,h)anthracene			0.8	0.16 J		0.067 J		0.13 J	
Fluoranthene			10000	2		0.67		1.4	
Indeno(1,2,3-cd)pyrene			7.8	<0.68		0.28		0.56	
Phenanthrene			10000	0.63		0.24		0.59	
Pyrene			10000	1.9		0.66		1.4	
Total Petroleum Hydrocarbons (TPH)	8015D	mg/kg			NT		NT		NT
TPH (C10-C36)			NS	112		90.2		91.6	
Polychlorinated Biphenyls (PCBs)	8082A	mg/kg			NT		NT		NT
Aroclor 1254			10	<0.0332		<0.0326		0.119	
Aroclor 1260			10	<0.0332		<0.0326		0.0468	
PCBs, Total			10	<0.0332		<0.0326		0.166	
Pesticides	8081B	mg/kg			NT		NT		NT
4,4'-DDT			NS	0.00999		0.00648		0.00644	
Herbicides	8151A	mg/kg		ND	NT	ND	NT	ND	NT
Metals		mg/kg			NT		NT		NT
Arsenic, Total	6010D		7	2.94		2.5		3.76	
Barium, Total	6010D		10000	34.4		22.1		25	
Cadmium, Total	6010D		1000	<0.404		<0.404		<0.402	
Chromium, Total	6010D		NS	6.19		5.76		6.96	
Copper, Total	6010D		10000	35.4		17.6		30.2	
Lead, Total	6010D		500	55.1		49.8		41.4	
Mercury, Total	7471B		610	0.117		0.104		0.102	
Nickel, Total	6010D		10000	5.83		5.07		6.23	
Selenium, Total	6010D		10000	<0.807		<0.808		<0.804	
Silver, Total	6010D		10000	<0.404		<0.404		<0.402	
Zinc, Total	6010D		10000	47.2		38		39.9	
General Chemistry									
Solids, Total	2540G	%	NS	96.8	96.8	96.6	96.6	97.8	97.8

General Notes (Alpha Analytical Laboratory Report)

1. In general, analytes detected in at least one sample are reported here. For a complete list of analytes, see Appendix B.
2. "<": the analyte was not detected at a concentration above the specified laboratory reporting limit.
3. Rhode Island Industrial/Commercial Direct Exposure Criteria are cited from Rules and Regulations for the investigation and Remediation of Hazardous Material Release, as amended February 2004.
4. NS: No standard or criteria has been established for this analyte.
5. NT: The sample was not tested for this analyte.
6. ND: The analyte was not detected in this sample.
7. mg/kg: milligrams per kilogram.
8. Values in bold exceed the Rhode Island Industrial/Commercial Direct Exposure Criteria.
9. J: The reported result is below the laboratory reporting limit and is estimated.

Table 2. Summary of chemical detections from 6/10 soil samples (9/13/2020).

Analyte	Method	Units	Rhode Island Residential Direct Exposure Criteria	Rhode Island Industrial/Commercial Direct Exposure Criteria	SP-01 (GRAB)	SP-01 (COMP)	SP-02 (GRAB)	SP-02 (COMP)	SP-03 (GRAB)	SP-03 (COMP)	SP-04 (GRAB)	SP-04 (COMP)	SP-05 (GRAB)	SP-05 (COMP)	SP-06 (GRAB)	SP-06 (COMP)
Sampling Date:					9/12/2020	9/12/2020	9/12/2020	9/12/2020	9/12/2020	9/12/2020	9/12/2020	9/12/2020	9/12/2020	9/12/2020	9/12/2020	9/12/2020
Lab Sample ID:					L2038032-01	L2038032-02	L2038032-03	L2038032-04	L2038032-05	L2038032-06	L2038032-07	L2038032-08	L2038032-09	L2038032-10	L2038032-11	L2038032-12
Volatile Organic Compounds (VOCs)	5035	mg/kg				NT		NT		NT		NT		NT		NT
Acetone			7800	10000	0.14		<0.018		0.075		<0.02		0.032		<0.02	
Tetrachloroethene			12	110	<0.00041		<0.00035		<0.00045		<0.00039		0.00062		<0.0004	
Semivolatile Organic Compounds (SVOCs)	8270D	mg/kg			NT		NT		NT		NT		NT		NT	
Acenaphthylene			23	10000		<0.14		<0.14		1.2		0.2		0.4		0.16
Anthracene			35	10000		<0.1		<0.1		0.77		0.22		0.3		0.15
Benzo(a)anthracene			0.9	7.8		0.14		0.22		3.6		1		1.7		0.56
Benzo(a)pyrene			0.4	0.8		<0.14		0.2		3.0		0.87		1.3		0.56
Benzo(b)fluoranthene			0.9	7.8		0.2		0.34		6.2		1.6		2.1		0.8
Benzo(ghi)perylene			0.8	10000		<0.14		0.16		2.2		0.66		0.75		0.38
Benzo(k)fluoranthene			0.9	78		<0.1		0.12		1.5		0.54		0.48		0.25
Carbazole			NS	NS		<0.17		<0.17		0.21		<0.16		<0.17		<0.17
Chrysene			0.4	780		0.14		0.24		3.6		1.1		1.6		0.61
Dibenzo(a,h)anthracene			0.4	0.8		<0.1		<0.1		0.64		0.16		0.21		<0.1
Fluoranthene			20	10000		0.21		0.37		4.5		1.5		2.8		0.89
Indeno(1,2,3-cd)pyrene			0.9	7.8		<0.14		0.17		2.5		0.71		0.8		0.38
Naphthalene			54	10000		<0.17		<0.17		0.28		<0.16		<0.17		<0.17
Phenanthrene			40	10000		<0.1		0.16		1.4		0.52		0.44		0.37
Pyrene			13	10000		0.2		0.35		4.8		1.5		2.6		0.9
Total Petroleum Hydrocarbons (TPH)	8015D	mg/kg			NT		NT		NT		NT		NT		NT	
TPH (C10-C36)			NS	NS		47 G		57 G		252 G		96.5 G		117 G		85.2 G
Polychlorinated Biphenyls (PCBs)	8082A	mg/kg			NT		NT		NT		NT		NT		NT	
Aroclor 1254			10	10		<0.0325		<0.0334		0.0366		<0.0335		<0.0342		<0.0334
Aroclor 1260			10	10		<0.0325		<0.0334		0.036		<0.0335		<0.0342		<0.0334
PCBs, Total			10	10		<0.0325		<0.0334		0.0726		<0.0335		<0.0342		<0.0334
Pesticides	8081B	mg/kg			NT		NT		NT		NT		NT		NT	
4,4'-DDE			NS	NS		<0.00158		<0.00163		0.00502 C+,G		0.00187 G		0.00236 G		<0.0016
4,4'-DDT			NS	NS		<0.00296		<0.00306		0.0188 C+		0.00856		0.0116		0.00785
cis-Chlordane			NS	NS		<0.00197		<0.00204		<0.00197		0.00247		<0.00202		<0.002
Herbicides	8151A	mg/kg	NS	NS	NT	ND	NT	ND	NT	ND	NT	ND	NT	ND	NT	ND
Metals		mg/kg			NT		NT		NT		NT		NT		NT	
Arsenic, Total	6010D		7	7		2.12		2.3		5.5		3.08		2.79		3.32
Barium, Total	6010D		5500	10000		12.4		17.1		66.6		25.5		26		23.7
Cadmium, Total	6010D		39	1000		<0.393		<0.403		1.12		<0.402		<0.41		<0.4
Chromium, Total	6010D		NS	NS		2.75		4.31		7.91		7.34		6.57		6.07
Copper, Total	6010D		3100	10000		6.95 G		10.4 G		49.9 G		58.8 G		2310 G		20.2 G
Lead, Total	6010D		150	500		13.9 G		29.5 G		57.4 G		87.6 G		50.1 G		38.5 G
Mercury, Total	7471B		23	610		<0.064		<0.065		0.157		0.101		0.082		<0.065
Nickel, Total	6010D		1000	10000		2.59		4.21		11		6.35		6.23		6.17
Selenium, Total	6010D		390	10000		<0.787		<0.806		<0.808		<0.804		2.43		<0.8
Silver, Total	6010D		200	10000		<0.393		<0.403		<0.404		<0.402		<0.41		<0.4
Zinc, Total	6010D		6000	10000		16.9		25.1		149		47.8		38.8		35.9
General Chemistry																
Solids, Total	2540G	%	NS	NS	97	97.3	95.6	96.4	95.6	96.6	96.8	97.6	94.9	95.9	96.3	97.1

General Notes (http://www.dem.ri.gov/programs/wastemanagement/site-remediation/6-10-connector.php)

1. In general, analytes detected in at least one sample are reported here. For a complete list of analytes, see Appendix B.
2. "<": the analyte was not detected at a concentration above the specified laboratory reporting limit.
3. Rhode Island Industrial/Commercial Direct Exposure Criteria are cited from Rules and Regulations for the investigation and Remediation of Hazardous Material Release, as amended February 2004.
4. NS: No standard or criteria has been established for this analyte.
5. NT: The sample was not tested for this analyte.
6. ND: The analyte was not detected in this sample.
7. mg/kg: milligrams per kilogram.
8. Values highlighted in blue exceed Rhode Island Residential Direct Exposure Criteria.
9. Values highlighted in pink exceed Rhode Island Industrial/Commercial Direct Exposure Criteria.
10. C+: The result has a high bias due to surrogate recovery above upper control limits.
11. G: The result is estimated due to duplicate precision outside control limits.

Table 3. PAH soil levels by RIDEM DEC, NE background, and 6/10 samples from 9/13/2020.

PAH	Units	RIDEM Residential Direct Exposure Criteria	6/10 Soil Samples# (maximum level detected)	New England Background Level* (upper 95% interval)
Acenaphthylene	mg/kg^	23	1.2	0.208
Anthracene	mg/kg	35	0.77	0.535
Benzo(a)anthracene	mg/kg	0.9	3.6	1.86
Benzo(a)pyrene	mg/kg	0.4	3.0	1.82
Benzo(b)fluoranthene	mg/kg	0.9	6.2	1.97
Benzo(ghi)perylene	mg/kg	0.8	2.2	1.20
Benzo(k)fluoranthene	mg/kg	0.9	1.5	2.52
Chrysene	mg/kg	0.4	3.6	2.69
Dibenzo(a,h)anthracene	mg/kg	0.4	0.64	0.521
Fluoranthene	mg/kg	20	4.5	4.44
Indeno(1,2,3-cd)pyrene	mg/kg	0.9	2.5	1.29
Naphthalene	mg/kg	54	0.28	0.149
Phenanthrene	mg/kg	40	1.4	2.98
Pyrene	mg/kg	13	4.8	2.95

#The 6/10 soil samples are composite samples, meaning that individual soil samples were mixed together into one. Compositing means that more samples can be taken while limiting costs. Shaded cells have 6/10 PAH soil levels above the RIDEM Residential DEC soil values.
*Bradley et al. 1994. Shaded cells have background PAH levels in New England cities above the RIDEM Residential DEC soil values.
^mg/kg=milligram PAH per kilogram soil, equivalent to one part per million (example: one star in the Milky Way galaxy).

Table 4. Benzo(a)pyrene toxic equivalency factors.

PAH	TEF	6/10 Soil Samples[#] (maximum level detected)	6/10 BaP toxic equivalent (mg/kg) (BaP_{eq})
Benzo(a)pyrene (index compound)	1.0	3.0	3.0
Acenaphthylene	0.001	1.2	0.0012
Anthracene	0.01	0.77	0.0077
Benzo(a)anthracene	0.1	3.6	0.36
Benzo(b)fluoranthene	0.1	6.2	0.62
Benzo(ghi)perylene	0.01	2.2	0.022
Benzo(k)fluoranthene	0.1	1.5	0.15
Chrysene	0.01	3.6	0.036
Dibenzo(a,h)anthracene	5.0	0.64	3.2
Fluoranthene	0.001	4.5	0.0045
Indeno(1,2,3-cd)pyrene	0.1	2.5	0.25
Naphthalene	0.001	0.28	0.00028
Phenanthrene	0.001	1.4	0.0014
Pyrene	0.001	4.8	0.0048
BaP-TEQ			7.66

Source: (Nisbet and Lagoy 1992)

APPENDIX A: PAHs – FREQUENTLY ASKED QUESTIONS

Department of Health

Three Capitol Hill
Providence, RI 02908-5097

TTY: 711
www.health.ri.gov

Frequently Asked Questions
Polycyclic Aromatic Hydrocarbons (PAH) and the 6-10 Interchange Construction Project

Last updated 11/10/2020

What was found in samples from fill used for the 6-10 interchange construction project?
When the Rhode Island Department of Environmental Management (RIDEM) studied samples from fill brought in for the construction project, they found levels of benzo[a]pyrene (B[a]P) and several other polycyclic aromatic hydrocarbons (PAHs) that required a cleanup according to Rhode Island's environmental regulations. That fill had only been used in a few locations that were later covered and was not used after the tests were performed.

What are polycyclic aromatic hydrocarbons (PAHs)?
PAHs are a group of chemicals that are most commonly formed by burning materials. They are found in the particles that make up smoke and exhaust from burning wood, coal, gasoline, and diesel. These particles are also sometimes known as soot or tar.

What are potential health effects from the PAHs at this site?
The overall risk of health effects from this project is very low given the limited exposure people had to PAHs at this site. Soil with the levels of PAHs found at this site would require decades of exposure to pose a significant risk.

What are the health concerns with exposure to PAHs at higher levels and/or for longer periods of time?
The amount of PAH exposure expected from this contaminated fill is not anticipated to cause health effects, particularly with the implementation of the site's soil management plan.

Longer-term exposure to much higher levels of PAHs in the environment, especially in tobacco smoke and food, is known to cause lung cancer, colon cancer, bladder cancer, and a variety of other cancers. Breathing in PAHs (for example, from smoking) is also known to cause heart attacks and lung diseases, such as emphysema and asthma, among other health effects.

Are the levels of PAHs found at this site unusual?
No. The levels of PAHs found at this site in the fill were typical of soils found in urban areas. The levels of B[a]P and other PAHs found in these samples were lower than the levels found in soil samples from sites without known contamination around Providence, Boston, and Springfield, MA during the 1990s, before recent steps to limit their pollution from electrical generation and motor vehicles, and are similar to levels found more recently in other cities.

How did PAHs get into this soil?
The widespread use of fossil fuels other than natural gas, including in vehicles and for generating electricity, pollutes the air with PAHs that fall from the air onto soil and other parts of urban environments. You can often see this as a blackish residue on urban windows.

PAHs are also formed as tires break down and are a major component of sealants used on hard surfaces like roofs and pavement. For example, coal tar pitch, a common component of sealants, is 50% or more PAHs, by weight. The widespread use of fossil fuels and their byproducts has led to potentially unsafe levels of PAHs in many urban soils. The soil used in this project was originally removed from another urban construction project, where it had likely been contaminated through air pollution and/or runoff from contaminated surfaces.

How are people normally exposed to PAHs?
Although there is very little potential for exposure to the PAHs found in this fill, PAH exposure through other sources is very common. According to the Agency for Toxic Substances and Disease Registry, a federal public health agency, the most important ways most Americans are exposed to PAHs are by inhaling tobacco and wood smoke (e.g. forest fires), and through eating foods that have PAHs in them (especially those that are dried, smoked, or charred). Eating contaminated food is the most common way non-smokers are exposed to PAHs.

Are children at higher risk from PAH exposure?
Children should not have any increased risk of health effects due to the PAHs in this fill. However, Children are at increased risk from PAHs from more common sources of exposure both because of the way that it causes cancer and because they are often exposed to higher levels than adults.

PAHs can permanently damage DNA, which starts a process that requires more steps before it can cause cancer. This process takes decades in adults but can occur more quickly in children because their bodies are still developing. Children, particularly infants and toddlers, are also more likely to accidentally or intentionally consume PAH-contaminated soils or dusts. Children breathe much more air, relative to their body weight, than adults and experience higher levels of exposure to PAHs and other chemicals in the air.

How can I avoid exposure to PAHs?
Although it is not necessary to avoid exposure to the PAHs found in this fill, there are a number of steps you can take to reduce PAH exposure in the general environment. For smokers, quitting smoking will be the best way to reduce exposure. Everyone can eat more foods that are prepared in ways that limit the production of PAHs. Boiling and microwaving do not produce PAHs, while drying, smoking, cooking over an open flame or frying produce higher levels.

Plants grown in soils with PAHs will absorb the chemicals, so avoid growing food in areas that have high levels of air pollution or near sealed parking lots or driveways. PAHs can also be absorbed through the skin. Since small children often put things in their mouth, limit their play in potentially contaminated soil or on sealed driveways and frequently clean their toys and play areas. You can also limit your exposure of PAHs by avoiding secondhand tobacco smoke, staying inside during poor air quality days, limiting the amount of time you spend in traffic, and by making sure you have proper ventilation when you are cooking.

APPENDIX B: PAHs – FREQUENTLY ASKED QUESTIONS (Spanish)

Department of Health

Three Capitol Hill
Providence, RI 02908-5097

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Preguntas Frecuentes

Hidrocarburos Aromáticos Policíclicos (HAPs) y el proyecto de construcción del distribuidor vial 6-10

Última actualización 11/10/2020

¿Qué se encontró en las muestras de asfalto usadas en el proyecto de construcción del distribuidor vial 6-10?
Cuando el Departamento de Administración Ambiental de Rhode Island estudió muestras provenientes del asfalto usado en el proyecto, ellos encontraron niveles de benzo [a]pireno (B[a]P) y otros cuantos hidrocarburos aromáticos policíclicos (HAPs**, por sus siglas**) que debían ser limpiados conforme a las regulaciones ambientales de Rhode Island. Este asfalto solo fue usado en pocas áreas que fueron cubiertas posteriormente y no se volvieron a usar después de las pruebas realizadas.

¿Qué son los hidrocarburos aromáticos policíclicos (HAPs)?
Los HAPs son un grupo de químicos que comúnmente se forman al quemar ciertos materiales. Pueden ser encontrados en las partículas de humo y gases de escape al quemar madera, carbón, gasolina y diésel. Estas partículas también son conocidas como el hollín o el alquitrán.

¿Cuáles son los posibles problemas de salud relacionados con los HAPs en este sitio?
El riesgo de presentar problemas de salud por este proyecto es muy bajo ya que las personas estuvieron en contacto muy limitado con estos químicos. Se necesitarían décadas de exposición prolongada a los niveles de HAPs encontrados en el suelo de esta área, para que pudiera presentarse un mayor riesgo.

¿Cuáles son los riesgos de exponerse a cantidades grandes de HAPs y/o por periodos prolongados?
Se sabe que la exposición por periodos prolongados a niveles mucho más altos de HAPs en el medio ambiente, especialmente a esos encontrados en tabaco y en alimentos, puede causar cáncer de pulmón, de vejiga, de colon, entre otros tipos de cáncer. Asimismo, se sabe que inhalar HAPs (por ejemplo, al fumar) también puede causar ataques al corazón y enfermedades pulmonares, por ejemplo, enfisema y asma, entre otros.

No se espera que el grado de exposición a HAPs en este asfalto sea suficiente para causar problemas de salud, particularmente gracias a la implementación del plan de manejo de los suelos en este sitio.

¿Son inusuales los niveles de HAPs encontrados en este sitio?

No. Los niveles de HAPs en este sitio son similares a los niveles comúnmente observados en suelos de otras áreas urbanas. Los niveles de B[a]P y de otros HAPs que se encontraron en las muestras que se tomaron, fueron menores a los niveles observados en muestras tomadas en los años noventa del suelo en sitios de los que no se conocía contaminación, como, por ejemplo, en las áreas alrededor de Providence, Boston, y Springfield, MA, antes de que se tomaran medidas para limitar la contaminación generada por la industria eléctrica y por vehículos motorizados. Ahora bien, los niveles de HAPs en el proyecto del distribuidor vial son similares a los niveles observados más recientemente en otras ciudades.

¿Cómo llegaron los HAPs a este suelo?
El uso extenso de combustibles fósiles (a excepción del gas natural) en los vehículos y para generar electricidad, contamina el aire con HAPs, los cuales tienden a caer del aire hacia el suelo y hacia otras áreas urbanas. Normalmente se puede observar este fenómeno en las ventanas, donde puede estar presente un residuo de color negro.

Los HAPs también se forman con el desgaste de las llantas y se pueden percibir en sellantes de superficies duras como techos y pavimento, ya que los HAPs son notables compuestos de estos materiales. Por ejemplo, los HAPs constituyen al 50% o más del peso de la brea de alquitrán de hulla, un componente de los sellantes. El uso extenso de combustibles fósiles y sus productos secundarios ha causado niveles peligrosos de HAPs en muchos suelos urbanos. El material usado en esta construcción fue originalmente recobrado de otra construcción, donde probablemente haya sido contaminado mediante la polución del aire y/o el agua de lluvia de superficies contaminadas.

¿Cómo suelen exponerse las personas a los HAPs?
Aunque es muy poco probable que las personas se expongan a los HAPs encontrados en este sitio, si es muy común que se expongan mediante otras procedencias. Según la Agencia para Sustancias Tóxicas y Registro de Enfermedades, una agencia federal de salud pública, las fuentes más importantes de HAPs son la inhalación de tabaco y humo de leña (por ejemplo, a causa de incendios forestales), y mediante alimentos que contengan HAPs (especialmente comida seca, ahumada, o carbonizada). La manera más común de exponerse a los HAPs para aquellos que no fuman es consumiendo alimentos contaminados.

¿Los niños están en mayor riesgo de exponerse a los HAPs?
Los niños no tendrían porque correr un mayor riesgo de exponerse a los HAPs en este asfalto. Sin embargo, para ellos el riesgo si es mayor cuando estos químicos provienen de fuentes más comunes, ya que estos pueden ocasionar distintos canceres y porque normalmente los niños están expuestos a niveles más altos que los adultos.

Los HAPs pueden dañar el ADN permanentemente, lo cual conlleva a un largo proceso biológico que podría terminar en cáncer. Este proceso suele tomar décadas en adultos, pero puede ocurrir más rápidamente en niños, ya que sus cuerpos aún están en desarrollo. Los niños, particularmente los más pequeños, son más propensos a ingerir tierra o polvo contaminado con HAPs accidental o intencionalmente. Asimismo, los niños de acuerdo con su peso, respiran mucho más aire que los adultos y son más susceptibles a los HAPs y a otros químicos en el aire.

¿Cómo puedo evitar exponerme a los HAPs?
Aunque no es necesario tratar de evitar exponerse a los HAPs encontrados en este sitio en particular, hay muchas maneras de evitar estos químicos en el ambiente general. Para los fumadores, tratar de dejar el cigarro es la mejor opción y para la población en general, evitar consumir comidas preparadas de las maneras discutidas a continuación. Hervir o calentar comida en el microondas no produce HAPs, mientras que secarla, ahumarla, cocinarla a llama abierta o freírla si produce niveles más altos.

Las plantas cultivadas en suelos contaminados con HAPs absorben estos químicos, así que se debe evitar cultivar comida en áreas donde el aire esté muy contaminado o en áreas cercanas a estacionamientos cerrados, a entradas de coches, o a automóviles en general. Adicionalmente, la piel puede absorber HAPs. Ya que los niños suelen meterse las cosas a la boca, es recomendable evitar que jueguen en tierra o suelos que podrían estar contaminados o en entradas de automóviles, y también limpiar sus juguetes y sus áreas de juego frecuentemente. Finalmente, los HAPs se pueden evitar previniendo el humo de segunda mano, quedándose en casa durante días con mala calidad de aire, no quedándose mucho tiempo en el tráfico y asegurando la ventilación adecuada al cocinar.