PCB DETECTION DOG PILOT STUDY DATA REPORT
FINAL

Prepared for

City of Seattle:
Seattle Public Utilities
700 5th Avenue
Seattle, WA 98121

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Prepared by: Windward environmental LLC

200 West Mercer Street, Suite 401
Seattle, Washington ⬩ 98119

In Consultation with:
University of Washington
Center for Conservation Biology
Conservation Canine

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Acronyms

2LAET	second lowest apparent effects threshold
City	City of Seattle
CK9	University of Washington Conservation Canine
dw	dry weight
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
JTF	Joint Training Facility
LDW	Lower Duwamish Waterway
OCC	Operations Control Center
PCB	polychlorinated biphenyl
RCB	right-of-way catch basin
RL	reporting limit
SCIP	source control implementation plan
SMS	Washington State Sediment Management Standards
SPU	Seattle Public Utilities
TSCA	Toxic Substances Control Act
Windward	Windward Environmental LLC

Acknowledgements

Seattle Public Utilities, Windward Environmental LLC, and Conservation Canine wish to acknowledge the contributions of all of the businesses who graciously allowed the project team to access their properties, Laura Nokes at the City of Tacoma for sharing PCB concentration data and guiding the team to various sites in downtown Tacoma, and the Washington State Department of Ecology for providing the funding to conduct this study.

1 Introduction

Seattle Public Utilities (SPU) received a Stormwater Financial Assistance grant from the Washington State Department of Ecology (Ecology) to evaluate whether a specially trained detection dog can aid SPU in locating sources of polychlorinated biphenyls (PCBs) to the City of Seattle (City) storm drain system, which discharges to the Lower Duwamish Waterway (LDW). This grant was used to fund a pilot study, which was accomplished through a cooperative effort involving SPU, University of Washington Center for Conservation Biology's Conservation Canine program (CK9), and Windward Environmental LLC (Windward). This report presents the results of that study and potential future activities to continue the development of PCB detection dogs, as described further in Section 6.

1.1 Background

PCBs are a class of man-made chemicals that are commonly found in the environment due to their historical use. Although PCBs are generally considered to be odorless (e.g., ATSDR 2000), some people and the detection dog used in this study appear to be able to smell PCBs. Exposure to PCBs poses risks to human health and the environment; the US Environmental Protection Agency (EPA) banned the production of PCBs in the United States in 1977 (ATSDR 2000). Before that time, PCBs were commonly used in electrical equipment, such as transformers and capacitors, because of their chemical properties (e.g., chemical stability and high heat tolerance). PCBs have also historically been used as plasticizers; in hydraulic fluid, cutting oils, other lubricants, carbonless copy paper, wire insulation, inks, and dyes; and as petroleum additives (Leidos 2016). In the LDW, PCBs are one of the primary contaminants of concern, and specific sources of PCBs that have been identified in the LDW include transformer oil, exterior building paint, and caulk. In addition, the inadvertent production of PCBs in certain pigments and dyes is an ongoing source of certain PCBs (Ecology 2016b).

This pilot study was conducted to support SPU's ongoing source control efforts in the LDW, which EPA listed as a Superfund site in 1991 due to the presence of elevated levels of PCBs and other contaminants in LDW sediment. As part of the LDW cleanup and to reduce the potential for sediment recontamination after the Superfund cleanup is complete, SPU is responsible for identifying and controlling sources of pollution to and from the City-owned drainage and wastewater systems that discharge to the LDW.

PCBs have been commonly detected in solids samples collected from within City's drainage system, although rarely at concentrations greater than source tracing screening levels,[1] and are one of the contaminants identified as a risk driver for human and ecological health in the LDW. Storm drain solids tend to accumulate in low-energy areas of the drainage system (e.g., maintenance holes, vaults, and areas affected by tidal backwater from the waterway).

[1] The Lower Duwamish Source Control Group routinely uses the dry weight equivalent of the Washington State Sediment Management Standards (SMS) cleanup screening level—the second lowest apparent effects threshold (2LAET) (1,000 ug/kg)—to trigger source tracing activities in storm drain systems. Only 3 percent of the nearly 500 storm drain solids samples collected from the Seattle municipal storm drain system between 2003 and 2014 contained greater than 1,000 mg/kg total PCBs.

SPU has been sampling this material to evaluate potential contributions to the LDW, and to identify where source control actions are needed. In some cases, SPU has been able to identify specific sources of PCBs, such as exterior building paint that is peeling or otherwise leaching PCBs. However, it has often been difficult to associate a specific source with the concentrations detected in the City's drainage system.

Dogs (*Canis familiaris*) are widely known to be able to distinguish among a variety of scents, and this ability has allowed dogs to be used for a wide range of activities, including search and rescue, tracking, and biological applications (e.g., searching for animal scat or invasive weeds). Using dogs to identify sources of PCBs or confirm their absence would allow for a more efficient and thorough search of properties within the LDW drainage basin for potential sources of PCBs. This approach could prove to be highly cost-effective, as described in Section 6.

The City has recently completed a source control implementation plan (SCIP), which describes planned source control activities in the LDW for the 2015 to 2020 time period (City of Seattle 2016). This pilot test is included as an element of the SCIP. Ecology is regulating the SCIP as an adaptive management response under Special Condition S4.F.3 of the City's Phase 1 Municipal Stormwater Permit (Ecology 2016a).

1.2 Study Objectives

As was described in the test plan for this pilot study (Windward 2016b) (provided in Appendix D of this report), the primary objectives of this pilot study were to:

- Train a dog to detect PCBs.
- Determine the potential utility of a detection dog in identifying sources of PCBs in the LDW drainage basin.

The results of this pilot study will be used to evaluate whether the use of detection dogs could become an important part of source tracing efforts.

1.3 Detection Dog Team

Veteran CK9 handler-dog team Julianne Ubigau (handler) and Sampson (the detection dog) were instrumental in this pilot test. Julianne Ubigau has been a handler with the CK9 program since November of 2006, and Sampson is a 12-year-old black Labrador retriever who is an 8-year veteran of the CK9 detection dog program. Rescued from Seattle Humane in October of 2008, Sampson was selected for his high energy and insatiable drive to play ball. As with all of the program's dogs, this drive was used as the training mechanism to quickly teach Sampson to associate specific targets with the reward of play time. Sampson has been trained on more than 20 targets. Julianne and Sampson have undertaken various projects throughout North America since their first assignment in 2008, including locating wildlife scat for various species ranging from the tiny Pacific pocket mouse (*Perognathus longimembris pacificus*) to the giant grizzly bear (*Ursus arctos* spp.). Some other targets in Sampson's diverse repertoire include Jemez Mountains salamanders (*Plethodon neomexicanus*), sea turtle eggs (*Chelonioidea*), and garlic mustard (*Alliaria petiolata*).

Although Sampson was the only detection dog trained for PCB detection as part of this pilot study, CK9 handlers are confident that the lessons learned as part of this study will improve their ability to more quickly train future dogs for PCB detection. More information regarding the lessons learned from dog training are discussed in Sections 2 and 6.

1.4 STUDY OVERVIEW

As described in the test plan (see Appendix D), a phased testing approach was developed for this pilot study to evaluate Sampson's ability to identify PCBs in successively more realistic and difficult states of testing. The three phases were as follows:

- **Phase 1** – Controlled field tests at a "clean" industrial site with introduced media containing PCBs.
- **Phase 2** – Field tests at industrial sites where PCBs have been detected and the sources of PCBs are reasonably well-known.
- **Phase 3** – Field tests at uncharacterized industrial sites (i.e., without known sources of PCBs) where PCBs are suspected to be present.

In practice, Phases 2 and 3 were combined due to the variable nature of the available information regarding the industrial sites included in this study. Sites included in this combined Phase 2/3 ranged from well-characterized sites, where a significant amount of information regarding PCBs was available, to less-well-characterized sites, where only limited information was available suggesting that PCBs were likely present. The pilot study timeline, from May to December 2016, is shown in Figure 1-1.

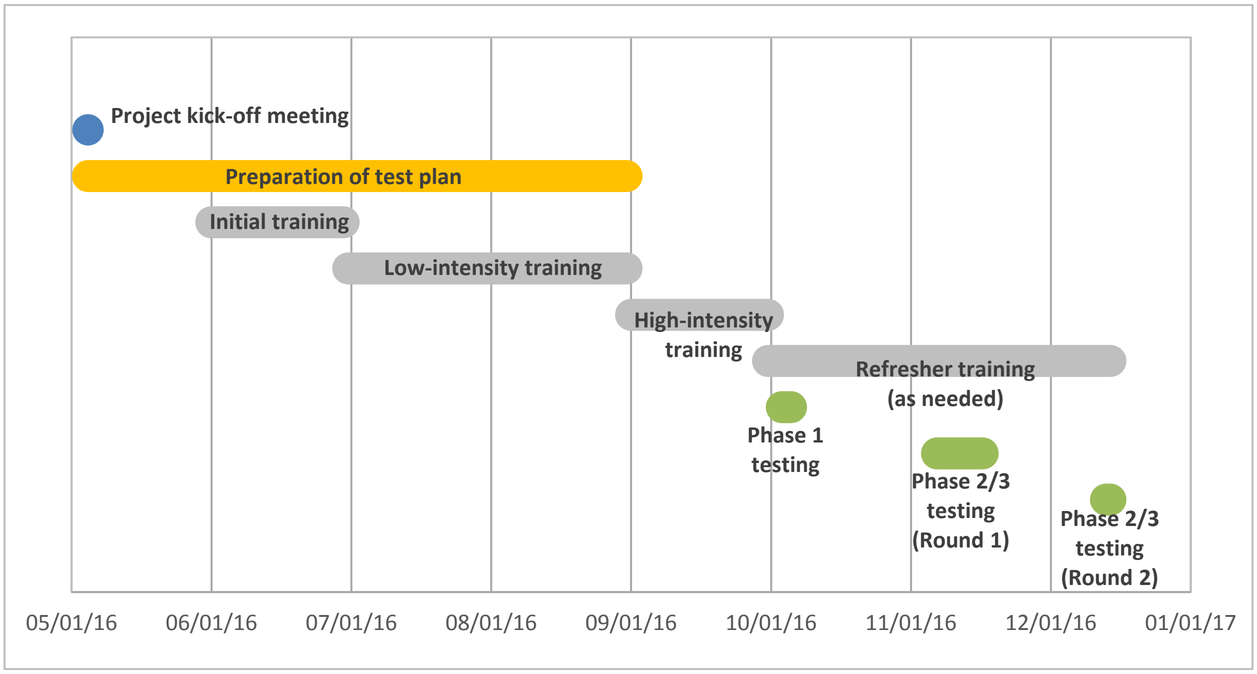

Figure 1-1. Project timeline

1.5 REPORT ORGANIZATION

This report provides an overview of the training procedures, the results of the phased testing, a discussion of the blood test results (to evaluate potential health effects on the dog), and a discussion of the results. The report is organized as follows:

- Section 2 – Detection Dog Training Procedures
- Section 3 – Controlled Tests (Phase 1)
- Section 4 – Field Tests at Industrial Sites (Phase 2/3)
- Section 5 – Detection Dog Blood Test Results
- Section 6 – Discussion and Conclusions
- Section 7 – References

In addition, this report contains the following appendices:

- Appendix A – Training Records
- Appendix B – Field Notes
- Appendix C – Summary of Analytical Results
- Appendix D – Test Plan for the PCB Detection Dog Pilot Study

2 Detection Dog Training Procedures

Training was conducted in three phases at the program training facility in Eatonville, Washington. These phases were as follows:

- **Low-intensity training** – Commenced in June 2016, and continued during the off-season period of July and August 2016 using sand/soil spiked with Aroclor 1254[2]
- **High-intensity training** – Occurred primarily in September 2016 using sand/soil spiked with either Aroclor 1254 or 1260, as well as other archived samples provided by SPU that were known to contain PCBs (e.g., catch basin solids, street dirt, and paint chips)[3]
- **Refresher training** – Conducted as needed during the course of the field testing (October to December 2016)

Using their expertise from training dogs for a variety of other targets, CK9 designed the training approach to focus on providing Sampson with a variety of PCB-contaminated materials and incorporating other variables (e.g., using different training techniques). The materials used for training are described in Section 2.1, and the techniques implemented at the various stages of the training process are described in Section 2.2. A complete record of training is provided in Appendix A.

2.1 Training Materials

To introduce Sampson to a variety of PCB-contaminated materials, a selection of samples was used for training purposes; such diversity was important to help ensure that Sampson did not inadvertently become trained to detect only one type of PCB-containing material. The materials used included both clean sand and forest soil spiked with Aroclor 1254 or 1260 (concentrations of approximately 0.1 and 1 mg/kg for each Aroclor). In addition, archived samples collected by SPU (e.g., catch basin solids, street dirt, and paint chips) that were known to contain PCBs were used during training to introduce Sampson to more varied types of PCB-containing materials. These archived samples were predominately mixtures of both Aroclor 1254 and 1260 but could contain additional Aroclor constituents. A summary of these samples is presented in Table 2-1; more details regarding the rationale for and development of these samples was provided in the study test plan (see Appendix D).

[2] As described in the test plan (Appendix D), Aroclors 1254 and 1260 were selected as the primary mixtures for training, both because they were dominant in total PCB sums in available SPU storm drain solids samples and had high detection frequencies, and because of the large number of congeners present in these two mixtures.

[3] The term "archived samples" is used throughout this report to refer to archived environmental samples provided by SPU that were known to be contaminated with PCBs. These archived samples included catch basin solids, street dirt, and paint chips.

Table 2-1. Summary of training materials

<table>
<tr><th rowspan="2">Material</th><th rowspan="2">PCB Aroclor</th><th colspan="2">Concentration (mg/kg)</th><th rowspan="2">Notes</th></tr>
<tr><th>Target</th><th>Actual</th></tr>
<tr><td rowspan="4">Ottawa sand (purchased from Fisher Scientific)</td><td>1254</td><td>0.1</td><td>0.096</td><td rowspan="4">Clean sand was also provided for training purposes.</td></tr>
<tr><td>1254</td><td>1</td><td>0.91</td></tr>
<tr><td>1260</td><td>0.1</td><td>0.10</td></tr>
<tr><td>1260</td><td>1</td><td>0.85</td></tr>
<tr><td rowspan="4">Forest soil (Bainbridge Island, Washington)</td><td>1254</td><td>0.1</td><td>0.13</td><td rowspan="4">Soil was collected from a residential area that has never been landscaped or otherwise cultivated in ways that would be expected to introduce PCBs.
Clean soil was also provided for training purposes.</td></tr>
<tr><td>1254</td><td>1</td><td>0.83</td></tr>
<tr><td>1260</td><td>0.1</td><td>0.085</td></tr>
<tr><td>1260</td><td>1</td><td>0.71</td></tr>
<tr><td>SPU archived samples</td><td>various</td><td>not applicable</td><td>various</td><td>Samples included catch basin solids, street dirt, and paint chips.</td></tr>
</table>

Note: Laboratory methods for the development of the training materials were presented in Appendix A of the test plan (Appendix D).

PCB – polychlorinated biphenyl

SPU – Seattle Public Utilities

2.2 TRAINING STAGES

Multiple training stages were used during the pilot study, as described in the test plan (Windward 2016b) (Appendix D). These stages included bench training, screen training, and wall training, as well as both basic and advanced field training.

2.2.1 Bench training

The bench training technique was used as the first stage of training to introduce Sampson to Aroclor 1254 training samples in June 2016. Each bench held six suspended jars: five control jars (i.e., containing clean material) and one target jar containing sand or soil spiked with PCBs (Figure 2-1). The bench training technique quickly established a positive association between the target odor and the reward. This same technique was used to introduce Sampson to Aroclor 1260 during training conducted in September 2016.

Figure 2-1. Sampson demonstrating the bench training method

2.2.2 Screen training

The screen apparatus technique was used as a training reinforcement method, and was designed to develop pinpointing skills on a horizontal, ground-level plane (Figure 2-2). For this method, the training apparatus included two layers of wood lattice material. The lower lattice layer was placed on the ground, container lids (some containing sample material and some empty) were placed in the spaces between the wood slats, and the top lattice layer (to which a sheet of screen mesh was attached) was placed over the first lattice layer and samples. The screen training method provides the dog a slightly different experience than the bench training method. This method was used during weekly training sessions from July to September 2016 to maintain and develop Sampson's familiarity with the PCB target. This technique was sustained throughout the project using a variety of materials (i.e., sand, soil, cotton, and wood) spiked with Aroclors 1254 or 1260 at high and low concentration levels. This was done to help Sampson become familiar with PCBs in various media (as would be encountered in the field), and to ensure that Sampson was not inadvertently trained to a specific media type (rather than to the PCBs).

Figure 2-2. Sampson demonstrating the screen training method (left) and the layers of the screen training apparatus (right)

2.2.3 Wall training

The wall training technique was used to further develop Sampson's scent detection skills by increasing the level of difficulty in PCB detection (Figure 2-3). The wall provided a vertical plane that contained holes leading to either 1) an open environment, 2) jars with control material, or 3) a jar containing the target chemical. A large wall (220 holes) and a portable wall (15 holes) were used between September 2016 and January 2017. All training samples (including Aroclor 1254, Aroclor 1260, and SPU archived samples) were utilized separately in this training method (i.e., only one type of training sample was used at a given time).

Figure 2-3. Sampson (left) and Pips (right) demonstrating the wall training method

2.2.4 Basic field training

Basic field training involved placing a variety of training samples in PCB-free natural and industrial sites. Similar to a game of hide-and-seek, this method acclimated Sampson to locating samples in realistic scenarios and under varying conditions. All samples (Aroclor 1254, Aroclor 1260, and SPU archived samples) were utilized during basic field training exercises.

2.2.5 Advanced field training

Advanced field training, also referred to as "hotspot training," introduced Sampson to the process of alerting to PCBs in the field, rather than to PCBs in materials used during training. This phase of training took place at sites with previously confirmed PCB contamination, and in actuality, overlapped with both Phase 1 testing (Section 3) and Phase 2/3 testing (Section 4). Advanced field training was the final and most important step in achieving a field-ready detection dog, meaning that the detection dog is able to successfully identify targets with confidence and is "locked-in" on the target in question.

During the pilot study, this training phase was also the most time-consuming, especially when high-quality hotspot training locations were initially not available. The first attempt at advanced field training occurred in September 2016, when Sampson was introduced to the Rainier Commons site, which has well-documented PCB contamination in the exterior building paint (NVL 2013). Training at this site was only moderately successful and did not result in the desired field readiness.

Ultimately, visits to several other sites where PCB contamination had been confirmed (e.g., downtown Tacoma [WSDOH 2014]) were essential to achieving field readiness. These site visits, which took place in November and December 2016 during the time between field testing events, were ultimately successful in helping Sampson become field ready because of the ability to provide Sampson with immediate rewards. After a series of field visits that produced low-confidence alerts (i.e., some change of behavior was obdserved, but no strong positive response that could be confidently rewarded; Sections 4.2.1 through 4.2.6), Sampson became field ready when the team visited sites with PCBs at levels detectable by a human's sense of smell (Sections 4.2.7 and 4.2.8).[4] In the presence of contaminated materials with sufficiently high concentrations of PCBs that they could be verified by human smell, immediate rewards could be given, and Sampson's ability to confidently detect PCB contamination improved dramatically. Better understanding what was needed to help Sampson achieve field readiness will make future efforts to train detection dogs significantly more efficient and effective. Advanced field training was also an important aspect of refresher training when preparing for the Phase 2/3 field tests conducted in December 2016.

[4] Although people can be exposed to PCBs by inhaling air contaminated with PCBs, the short exposure duration of these site visits and the thus limited exposure indicate that human health concerns are unlikely (ATSDR 2000).

3 Controlled Tests (Phase 1)

The first testing phase of the pilot study involved controlled tests conducted at the City's Joint Training Facility (JTF), which is located at 9401 Myers Way South in Seattle, Washington. This location was selected because it provided space for conducting the bench tests as well as outdoor areas for additional testing in a clean, industrial site-like setting (i.e., a site where PCBs were not expected to be present). This type of setting was intended to introduce Sampson to an industrial setting, which is different from the remote settings where he has typically worked.

As described in the September 27, 2016, memorandum documenting the details of the Phase 1 testing (Windward 2016a), two types of controlled tests were conducted: bench tests and outdoor hidden PCB tests. Details regarding the objectives, methods, deviations from the originally outlined methods, and results of these exercises are presented in Sections 3.1 and 3.2. An overall discussion of the results of the Phase 1 testing is presented in Section 3.3.

3.1 Bench Testing

The objectives of the bench testing portion of the Phase 1 field testing were to conduct trials that could be used to statistically evaluate Sampson's ability to correctly identify PCBs, and to test for both possible false negatives (i.e., when a PCB target item was not identified as such) and false positives (i.e., when a non-PCB item was signaled to contain PCBs).

3.1.1 Methods

The methods used in the bench testing were different from those described in the September 27, 2016, memorandum (Windward 2016a). Deviations from the original plan were necessary due to difficulties encountered with the original bench testing format (in which benches were arranged in a straight line [Figure 3-1] and three PCB targets were used). Although these initial tests indicated that Sampson could detect PCBs, his behavior denoted that the testing format was confusing to him. Accordingly, the methods were revised to optimize the flow of the trials and Sampson's ability to move through the bench tests.

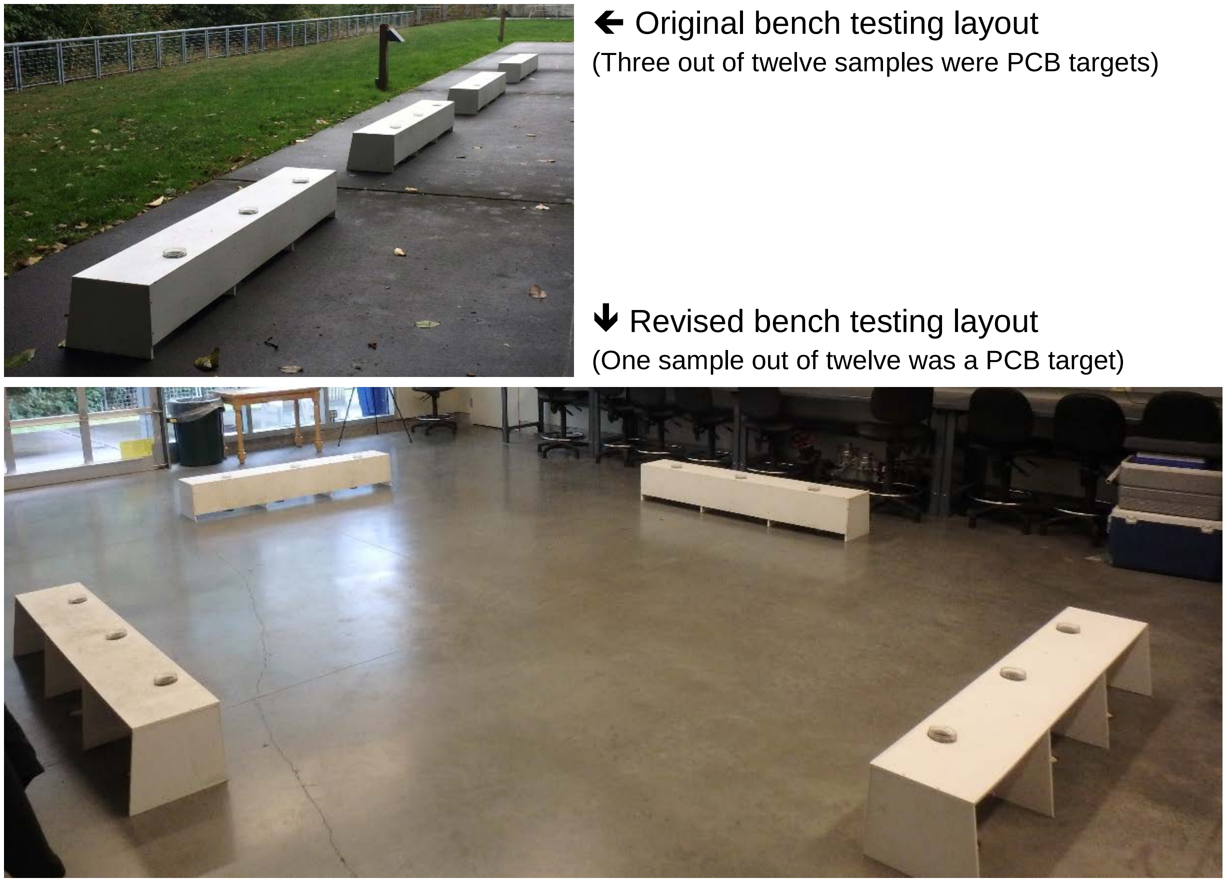

Figure 3-1. Bench test layout

Based on these initial findings, the project team developed revised methods for conducting the bench tests that would achieve the goal of the test (i.e., to conduct trials that could be used to statistically evaluate Sampson's ability to correctly identify PCBs) and would work for the dog-handler team. The revised bench test setup and the methods were as follows:

- Each trial was conducted using four benches (arranged in a square as shown in Figure 3-1). Due to the available space at the JTF, field trials were moved indoors, a change that was not anticipated to impact the trials. Each bench contained three holes for pint-sized Mason jars, for a total of 12 jars per trial. One jar per trial contained sand or soil that was spiked with PCBs, while the other 11 jars contained clean sand or soil (the same media as the target jar). Approximately 0.5 inches of sand or soil was placed in the bottom of each jar.
- Trials were conducted in groups of 16 (e.g., trials 1a-1d, 2a-2d, 3a-3d, and 4a-4d). In each group, the media (i.e., sand or soil) remained constant, and a different PCB target was used after every four trials. For example, trials 1a to 1d were all run using a PCB target of sand with a concentration of approximately 0.1 mg/kg Aroclor 1254. Trials 1a, 1b, 1c, and 1d differed by the location of the PCB target, which was varied randomly (locations were pre-determined using a random number generator). Each trial was

considered an independent replicate, meaning that sufficient time and/or space separated the trials so that they could each be considered a “restart” for Sampson.

- A total of 96 trials were conducted over two days, using a total of eight different PCB targets: sand and soil targets of Aroclor 1254 or 1260, each at concentrations of approximately 0.1 and 1 mg/kg.

3.1.2 Results

The results of the bench test trials are presented in Table 3-1. Overall, Sampson correctly alerted (without any false alerts) in 98 percent of the trials. During two trials, he first falsely alerted to jars that did not contain PCBs (one false alert during trial 2a and two false alerts during trial 5b). The PCB target was identified on the 1st pass in 58 trials (60 percent), on the 2nd pass in 30 trials (31 percent), on the 3rd pass in 6 trials (6 percent), and on the 4th pass in 2 trials (2 percent). The different factors evaluated—including different media (i.e., sand vs. soil), different PCB formulations (Aroclor 1254 or Aroclor 1260), and different PCB concentrations (0.1 or 1 mg/kg)—did not appear to cause significant differences in Sampson’s ability to detect PCBs (i.e., alert to the correct target and the number of passes required to identify the target).

Table 3-1. Summary of bench testing results

Trial Number	PCB Target Description	Trial Results: Correctly Alerted? (Number of Passes to Correctly Identify Target)[a]			
		a	b	c	d
Group 1 (October 5, 2016)					
1a – 1d	sand, Aroclor 1254 (0.1 mg/kg)	yes (2)	yes (2)	yes (1)	yes (2)
2a – 2d	sand, Aroclor 1254 (1 mg/kg)	**no / yes (1)**	yes (1)	yes (2)	yes (2)
3a – 3d	sand, Aroclor 1260 (0.1 mg/kg)	yes (1)	yes (2)	yes (2)	yes (1)
4a – 4d	sand, Aroclor 1260 (1 mg/kg)	yes (1)	yes (2)	yes (3)	yes (1)
Group 2 (October 5, 2016)					
5a – 5d	soil, Aroclor 1260 (0.1 mg/kg)	yes (2)	**no / no / yes (2)**	yes (4)	yes (1)
6a – 6d	soil, Aroclor 1260 (1 mg/kg)	yes (2)	yes (1)	yes (1)	yes (2)
7a – 7d	soil, Aroclor 1254 (1 mg/kg)	yes (3)	yes (2)	yes (3)	yes (1)
8a – 8d	soil, Aroclor 1254 (0.1 mg/kg)	yes (1)	yes (1)	yes (2)	yes (3)
Group 3 (October 6, 2016)					
9a – 9d	soil, Aroclor 1254 (1 mg/kg)	yes (1)	yes (1)	yes (1)	yes (2)
10a – 10d	soil, Aroclor 1260 (1 mg/kg)	yes (2)	yes (1)	yes (1)	yes (2)
11a – 11d	soil, Aroclor 1260 (0.1 mg/kg)	yes (1)	yes (1)	yes (1)	yes (1)
12a – 12d	soil, Aroclor 1254 (0.1 mg/kg)	yes (2)	yes (2)	yes (1)	yes (1)
Group 4 (October 6, 2016)					
13a – 13d	sand, Aroclor 1260 (1 mg/kg)	yes (4th)	yes (2)	yes (1)	yes (1)
14a – 14d	sand, Aroclor 1254 (1 mg/kg)	yes (1)	yes (1)	yes (1)	yes (2)
15a – 15d	sand, Aroclor 1254 (0.1 mg/kg)	yes (1)	yes (1)	yes (1)	yes (1)
16a – 16d	sand, Aroclor 1260 (0.1 mg/kg)	yes (1)	yes (1)	yes (1)	yes (1)

Trial Number	PCB Target Description	Trial Results: Correctly Alerted? (Number of Passes to Correctly Identify Target)[a]			
		a	b	c	d
Group 5 (October 6, 2016)					
17a – 17d	soil, Aroclor 1254 (1 mg/kg)	yes (1)	yes (2)	yes (1)	yes (1)
18a – 18d	soil, Aroclor 1254 (0.1 mg/kg)	yes (1)	yes (1)	yes (1)	yes (1)
19a – 19d	soil, Aroclor 1260 (0.1 mg/kg)	yes (1)	yes (1)	yes (1)	yes (1)
20a – 20d	soil, Aroclor 1260 (1 mg/kg)	yes (1)	yes (2)	yes (1)	yes (1)
Group 6 (October 6, 2016)					
21a – 21d	sand, Aroclor 1260 (0.1 mg/kg)	yes (2)	yes (3)	yes (1)	yes (2)
22a – 22d	sand, Aroclor 1260 (1 mg/kg)	yes (3)	yes (2)	yes (2)	yes (2)
23a – 23d	sand, Aroclor 1254 (0.1 mg/kg)	yes (1)	yes (2)	yes (2)	yes (1)
24a – 24d	sand, Aroclor 1254 (1 mg/kg)	yes (1)	yes (1)	yes (1)	yes (1)

Note: Full results are presented in Appendix B.

[a] Results in this table are explained as follows: A "yes" in this table indicates that Sampson correctly identified the PCB target, while a "no" indicates an incorrect alert (i.e., Sampson alerted to a jar that did not contain PCBs). The number in parentheses indicates the number of passes for Sampson to correctly identify the PCB target. For example, a "no / yes (1)" entry in this table would indicate that Sampson first alerted to an incorrect jar that did not contain PCBs, but then alerted to the correct jar. The "(1)" in the table entry would indicate that Sampson identified the target the first time he passed that jar.

PCB – polychlorinated biphenyl

3.2 OUTDOOR HIDDEN PCB TESTS

The objective of the hidden-PCB tests was to create a transitional exercise that would help Sampson adjust to a more realistic type of scenario, similar to what would be encountered working at industrial sites. Although this part of the Phase 1 field testing did not allow for the same detailed statistical evaluation as the bench testing, it was useful as an anecdotal evaluation of Sampson's performance and provided information about what types of situations may be difficult for Sampson.

3.2.1 Methods

Hidden-PCB tests were conducted outside at the JTF facility, as described in the test plan and Phase 1 sampling memorandum (Windward 2016a, b) (Appendix D). A portion of the facility was designated for each test, and the project team placed one to three PCB targets (typically the SPU archived samples that were also used during training) in each area. Julianne and Sampson would then enter the test area and conduct their search for the PCB targets. Figure 3-2 presents an example of a test area at the JTF that was used for the hidden PCB tests, and shows an example of how archived samples were hidden at these sites.

Figure 3-2. Hidden PCB test area (left) and close-up of hidden sample (right)

3.2.2 Results

Six hidden-PCB test trials were conducted at the JTF between October 4 and 6, 2016. A total of 14 targets were placed during these trials, 12 of which were PCB-contaminated SPU archived samples (as well as a PCB-contaminated cooler), and 2 of which were not contaminated (Table 3-2). Sampson correctly alerted to 11 of the 12 PCB targets (92 percent correct). In addition, Sampson correctly did not alert to the two non-contaminated targets (see details regarding Trial 5 in Table 3-2). Details regarding each of the trials are presented in Table 3-2. Trials took between 5 and 17 minutes to complete and were successful in that they appeared to help Sampson adapt to more realistic scenarios for finding PCBs as compared to the bench testing.

Table 3-2. Summary of outdoor hidden PCB tests

Trial Number (Duration)	Description of Targets				Test Results
		Concentration (mg/kg)			
	Target Material	Aroclor 1248	Aroclor 1254	Aroclor 1260	
1 (12 min)	1 – paint chips	-	**1.0**	-	Sampson correctly alerted to both targets. First target was found quickly; second target was eventually found, but gusty wind conditions and placement of PCB sample in center of test area may have caused difficulties for Sampson.
	2 – paint chips	-	**8.65**	-	
2 (17 min)	1 – paint chips	-	**3.8**	**7.4**	Sampson correctly alerted to one of the two targets. The first target was found relatively easily. The second target was in a depression, and was not found by Sampson until a smaller area was identified.
	2 – paint chips	-	**30.1**	**18**	

Trial Number (Duration)	Description of Targets				Test Results
	Target Material	Concentration (mg/kg)			
		Aroclor 1248	Aroclor 1254	Aroclor 1260	
3 (7 min)	1 – catch basin solids (wet)	-	**64**	**96**	Sampson correctly alerted to both targets (first target found on initial pass; second target was found on the second pass).
	2 – catch basin solids (dry)	3.1 Y	**28**	**11**	
4 (5 min)	1 – catch basin solids (dry)	0.18 U	1.4 U	**10**	Sampson correctly alerted to both targets.
	2 – catch basin solids (wet)	0.86 U	4.3 U	**32**	
5 (5 min)	1 – cooler, PCB-contaminated[a]	na	na	na	Sampson correctly alerted to the PCB-contaminated cooler, even though it was placed about 4 feet off the ground and was mostly closed. He appeared interested in two other coolers (likely because they were placed objects), but did not alert to these items.
	2 – cooler, non-contaminated	na	na	na	
	3 – cooler, non-contaminated	na	na	na	
6 (13 min)	1 – catch basin solids (wet)	0.3 Y	**1.3**	**0.33**	Sampson correctly alerted to all three targets.
	2 – catch basin solids (wet)	**3.2**	**2.1**	**0.70**	
	3 – catch basin solids (dry)	2.2 Y	**21**	**7.9 J**	

[a] No analysis was conducted on the cooler, but it was known to be contaminated based on the ability of the human team members to smell PCBs when the cooler was opened.

Bold values indicate detected PCB concentrations.
J – estimated concentration
na – not analyzed
PCB – polychlorinated biphenyl
RL – reporting limit
U – not detected at the concentration shown
Y – not detected at the concentration shown and RL elevated (value shown is the RL)

3.3 Discussion of Controlled Testing Results

The results of the Phase 1 testing indicated that 1) Sampson was able to consistently detect PCBs, even at levels as low as 0.1 mg/kg and in various media, and 2) Sampson was ready to proceed from controlled Phase 1 testing to more realistic field testing and advanced field training. In addition, the controlled testing helped to verify that although Sampson was trained using primarily Aroclors 1254 and 1260, the SPU archived samples used during the hidden-PCB tests did not appear to be problematic, indicating that the specific PCB mixtures were not important.

Although Sampson appeared able to detect PCBs in a variety of media types, the primary challenge remaining after the conclusion of the Phase 1 testing was for Sampson to transition from detecting placed samples, including spiked PCB samples and SPU archived samples containing PCBs, to detecting non-placed PCBs that are already present at industrial sites. Although the hidden PCB tests were intended to help Sampson with this transition, the “placed” nature of these samples, although more realistic than bench testing, was still quite different from PCBs in real-world situations. As described in Section 2.2.5, the advanced field training portion of the pilot study was intended to help Sampson achieve field-readiness. In an attempt to achieve field readiness prior to the start of Phase 2/3 testing, CK9 took Sampson to several different sites where PCBs were known to be present (e.g., Rainier Commons and areas with transformer vaults where PCBs had previously been smelled) to help him work on this transition. However, as described in Section 2.2.5, field readiness was ultimately not achieved until partway through the Phase 2/3 field tests.

4 Field Tests at Industrial Sites (Phases 2 and 3)

After the completion of the Phase 1 testing at the JTF, the next step in the pilot study was to conduct field testing at industrial sites with various levels of information regarding the presence of PCBs. Although the test plan specified that there would be two distinct phases of testing (Phase 2 would include better-characterized sites and Phase 3 would include less-well-characterized sites), in reality, the two phases were combined because of a lack of a clear difference between these two types of sites. Instead, the sites represented a continuum ranging from those that were extremely well characterized to those where the presence of PCBs was known or suspected, but the source and magnitude of the PCB contamination was unknown. This section presents both an overview of the methods used for field testing at industrial sites (Section 4.1) and the results of these field tests (Section 4.2).

4.1 Methods

Field test sites were selected for inclusion in Phase 2/3 of the pilot study based on both information available to SPU regarding possible PCB contamination and the ability of the field team to access the site. This information is summarized for each site in Section 4.2. When arriving at a field test site, the general approach was as follows:

- **Initial site meeting** – The field team would begin the site visit by reviewing any site-specific safety precautions and (when applicable) meeting with relevant site personnel. In addition, the field team (excluding the dog-handler team) would review the available information regarding PCBs at the site. Depending on site conditions, the handler would determine whether the search would be conducted on- or off-leash and what safety equipment would be needed (e.g., dog booties).
- **Searching the site** – After the initial meeting, Sampson would begin searching the site. Depending on the site and on Sampson’s behavior, the handler would sometimes have Sampson take an initial pass to get acquainted with the site (or portions of the site); Sampson would then re-work the area. This approach allowed the handler to get a better sense of the confidence in Sampson’s alerts. For example, if Sampson alerted to an area during his initial pass, but on a second pass did not appear interested, this would indicate a lower level of confidence. If Sampson’s responses were similar during both passes, this would indicate a higher level of confidence.

- **Sample collection** – Samples were collected at the discretion of the field team to confirm the presence of PCBs and that PCBs were not present in areas to which Sampson did not alert. Types of samples collected as part of this pilot study included street dirt, catch basin solids, paint chips, surface wipes, rubberized paint material, moss, and soil. Details regarding collection methods, which were generally based on those outlined by SPU (Pyron Environmental 2009) and Ecology (SAIC 2011) in documents addressing source tracing work on the LDW, were presented in Appendix D of the test plan.

Detailed notes were taken at each site by the field team to document the site visit and any samples collected at the site (Appendix B).

4.2 Results of Field Tests

This section presents the results of the Phase 2/3 field tests, including a description of the sites, an overview of the site visits, and key results of the tests. Table 4-1 presents an overview of the 17 sites visited as part of this pilot study and the number of samples collected at each site, and full sample results are summarized in the supplemental information provided at the end of this report, and the laboratory reports are provided in Appendix C. Samples are identified by the assigned Site Number and Location ID (e.g., 6a) and the Station Identification assigned in SPU's EQuIS database (e.g., CB301, RCB175, MH18, or ODS4). Where samples were not collected, drainage infrastructure is identified by either 1) the six-digit SPU equipment numbers (e.g., 568845), or 2) the seven-digit feature key number (e.g., 1381836) when equipment numbers are not available.[5]

Table 4-1. Summary of field tests

Site No.	Site Description	Date	Mean Temperature (Range)	Section with Results	Samples Collected? (No. of Samples)
1	Commercial Site	11/07/16	58ºF (50-66ºF)	Section 4.2.1	yes (n = 9)
2	Commercial Site	11/10/16	54ºF (45-62ºF)	Section 4.2.2	yes (n = 4)
3	Commercial Site	11/15/16	50ºF (46-54ºF)	Section 4.2.3	yes (n = 4)
4	7th Avenue South between South Monroe Street and South Elmgrove Street			Section 4.2.4	yes (n = 5)
5	8th Avenue South and South Elmgrove Street[a]			Section 4.2.5	no
6	Commercial Site	11/16/16	47ºF (43-50ºF)	Section 4.2.6	yes (n = 5)
7	North Boeing Field			Section 4.2.7	no
8	Downtown Tacoma (various areas)	11/17/16	46ºF (41-51ºF)	Section 4.2.8	yes (n = 3)
9	SPU OCC site	12/14/16	35ºF (30-39ºF)	Section 4.2.9	yes (n = 1)
10	South Snoqualmie Street area			Section 4.2.10	yes (n = 2)
11	South Washington Street and 24th Avenue South			Section 4.2.11	yes (n = 2)
12	South Myrtle Street and Fox Avenue South			Section 4.2.12	yes (n = 4)

[5] SPU GIS assigns feature key numbers, but not equipment numbers, to private drainage structures.

Site No.	Site Description	Date	Mean Temperature (Range)	Section with Results	Samples Collected? (No. of Samples)
13	South Kenyon Street and 8th Avenue South	12/15/16	35ºF (32-38ºF)	Section 4.2.13	yes (n = 9)
14	South Elmgrove Street			Section 4.2.14	yes (n = 3)
15	South Austin Street			Section 4.2.15	yes (n = 8)
16	South Chicago Street			Section 4.2.16	yes (n = 1)
17	1960s-era building			Section 4.2.17	no

[a] Site was re-visited and evaluated more thoroughly on December 15, 2016.

OCC – Operations Control Center

SPU – Seattle Public Utilities

Detailed information for each site is presented in the sections referenced in Table 4-1. For each site, a table is provided that documents the following:

- Total PCB concentrations (when available), either from samples collected during this study, or from samples collected during past sampling efforts
- Indication of whether the human team members were able to smell PCBs
- Notes regarding the sample location and/or characteristics, including (when applicable) the representativeness of the sample relative to the target identified by Sampson (i.e., the extent to which the sample collected by the project team matches the target to which Sampson alerted). For example, in some cases, the project team sampled moss/dirt at the base of a wall where Sampson appeared to alert to the caulking (low representativeness), while in other cases, the project team was able to sample paint chips that were the actual target to which Sampson alerted (high representativeness).
- Sampson's response at the specified location (classified as none, low positive, moderate positive, or strong positive)
- Handler gestalt (meaning the handler's interpretation of Sampson's response relative to observations and other potentially complicating factors; confidence levels were classified as high, medium, or low)

Sites are presented in chronological order, and information regarding Sampson's progress over the course of the pilot study is discussed. The subsections that follow present a detailed discussion of each site visit, while Section 6 provides a broader discussion of the results and conclusions of the study.

4.2.1 Site 1

The field team visited Site 1, a commercial property in Seattle, on November 7, 2016. This site was selected for inclusion in the pilot study because PCBs were previously detected in a solids sample collected from a right-of-way catch basin (RCB) adjacent to this property (1.4 mg/kg in RCB353) and an onsite catch basin (3.7 mg/kg in CB175), which triggered continued investigation. At issue was whether the PCBs on the property were impacting the roadway surface and public drainage through track-out[6] as materials were moved between adjacent properties. During previous visits to the site, SPU inspectors were able to smell PCBs in the south yard, but the source of this smell was unknown.

During the site visit, the field team walked Sampson around the publicly accessible areas of the site several times. Sampson showed strong positive responses at three locations and moderate positive responses at two locations (Table 4-2). Surface dirt samples were collected at each of these five positive response locations, as well as at a sixth location where Sampson did not show any change of behavior (i.e., no response). The sample results matched Sampson's behavior. Samples from the three locations where strong positive responses were observed had the highest PCB concentrations (1.17 to 2.30 mg/kg), while the concentrations in samples from the two locations where moderate positive responses were observed were lower (0.48 and 0.68 mg/kg). Concentrations at the location where Sampson did not show any change of behavior were the lowest (0.060 mg/kg).

Table 4-2. Site 1 summary

Location ID	Total PCBs (mg/kg)	Team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
1a	1.173 J	no[a]	Dirt around dumpster containing shredded electronics waste (ODS31). Relative to target,[b] sample representativeness is high.	strong positive	medium confidence PCBs are present
1b	2.304	no[a]	Dirt along fence line behind particle board dumpster (ODS33). Relative to target,[b] sample representativeness is high.	strong positive	high confidence PCBs are present
1c	0.484	no	Dirt along east edge of building (ODS34). Relative to target,[b] sample representativeness is moderate.	moderate positive	medium confidence PCBs are present
1d	0.683	no	Granular material along fence line east of building, possibly from roof or pressure washing (ODS35). Relative to target,[b] sample representativeness is moderate.	moderate positive	medium confidence PCBs are present
1e	1.179	no	Dirt adjacent to loading dock on north side of site (ODS36). Relative to target, sample representativeness is high.	moderate positive	high confidence PCBs are present
1f	0.060	no	Dirt from around concrete blocks on east side of yard area (ODS32).	none	medium confidence PCBs are <u>NOT</u> present
1g	5.20–5.42[c]	no	Catch basin on the northeast corner of the street (RCB353)	na	na
1h	1.52	no	Catch basin on the southeast corner of the street (RCB352)	na	na

[a] Field team members were intermittently able to smell PCBs at low levels in the vicinity of these two locations.
[b] The target is the item/area to which Sampson alerted.
[c] Results for field and duplicate samples

ID – identification
J – estimated concentration
na – not applicable (Sampson did not investigate)
PCB – polychlorinated biphenyl

[6] Track-out refers to mud, dirt, or other debris tracked onto a public roadway by a vehicle leaving the site.

4.2.2 Site 2

The field team visited Site 2, a commercial property in Seattle, on November 10, 2016. This site was selected for inclusion in the pilot study because catch basin solids samples collected there in 2008 and 2010 contained concentrations of total PCBs of 8.3 and 3.7 mg/kg respectively.[7]

During the site visit, the field team walked Sampson around the building at the site several times to better evaluate his reactions at various locations. Sampson showed a strong positive response at one location and a moderate positive response at two locations (Table 4-3). Samples were collected at these three locations, as well as at one location where Sampson did not show any change of behavior (i.e., no response). PCBs were detected at the highest concentration in the sample from the location where Sampson showed a strong response (5.95 mg/kg). In samples from the two locations where Sampson showed a moderate positive response, PCBs were either not detected or were detected at a lower concentration (0.31 mg/kg). In both of these cases, the target to which Sampson appeared to alert could not be directly sampled because it was part of a building or wall, so the representativeness of the sampled material may be low (i.e., a higher concentration of PCBs may be present in the actual target). Lastly, PCBs were detected at a concentration of 0.55 mg/kg in the sample collected from the area where Sampson did not show any change of behavior.

Table 4-3. Site 2 summary

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
2a	5.95	no	Dirt along base of south building wall in storage area at northwest corner of property (ODS27). Relative to the target,[a] sample representativeness is moderate to low.	strong positive	medium confidence PCBs are present
2b	0.545	no	Dirt at base of north side of building wall near roof downspout (ODS28).	none	high confidence PCBs are <u>NOT</u> present
2c	0.02 U	no	Seam in wall. Sampled moss (and some dirt) near southeast corner of building along edge of the stone/mortar wall (ODS29). Relative to the target,[a] sample representativeness is low.	moderate positive	low confidence PCBs are present
2d	0.312	no	Corner seam of building where caulk was present (ODS30). Sampled dirt at base of this building corner (east side of building near roof downspout). Relative to the target,[a] sample representativeness is low.	moderate positive	medium confidence PCBs are present

[a] The target is the item/area to which Sampson alerted.

ID – identification

PCB – polychlorinated biphenyl

U – not detected at the concentration shown

[7] The catch basin was resampled as part of this study and contained 5.62 mg/kg PCBs.

4.2.3 Site 3

The field team visited Site 3, a commercial property in Seattle, on November 15, 2016. This site was selected for inclusion in the pilot study based on catch basin samples collected in October 2016. During this sample collection effort, two composite catch basin samples were collected: one comprised of solids from two catch basins in the east parking lot, and the other comprised of solids from two catch basins in the west storage lot. Total PCB concentrations detected in these samples were 0.084 and 3.0, respectively.

During the site visit, Sampson did not alert or show any change of behavior in the east parking lot area, indicating that a source of PCBs is not present in this area. Sampson strongly alerted near a flammables storage cabinet in the northern area of the west storage lot, as well as moderately alerted near a metal I-beam storage area just south of the flammables storage cabinet. At both locations, no surface dirt was available to collect, so a standard sampling method could not be utilized. Instead, the field team implemented an improvised sampling protocol. Using individually packaged gauze from a first aid kit as sampling swabs, the field team saturated the swabs in lacquer thinner found in the flammables cabinet to facilitate lifting a sample off of the painted surface of the cabinet where PCB odors were most prevalent to human team members. In this manner, wipe samples were collected in the two locations where Sampson's behavior had indicated that PCBs might be present, and in a third location where Sampson's behavior had not changed. In addition, to confirm that the lacquer thinner was not a source of PCBs, a field blank sample of gauze saturated with lacquer thinner was submitted to the lab along with the wipe samples.

The smell of PCBs was strong enough in the vicinity of the flammables cabinet that the human team members were able to confirm the presence of PCBs at this location. However, all four samples (three field wipe samples and one field blank) came back with no detectable PCBs (Table 4-4). There are several possible explanations for why PCBs were not detected in the wipe samples:

- **Issues associated with sample methodology** –The method used to collect the samples (paint thinner applied to gauze wipes and rubbed across the item to be sampled) may not have been effective.
- **Incorrect sample placement** – It is possible that the sampling area did not correspond to the PCB contamination in this vicinity because only a small portion of each item was sampled.
- **Incorrect target** – It is possible that Sampson alerted to the general area where the PCB smell was present, and that although both the flammables storage cabinet and steel I-beam storage area were located near the contamination, they were not the actual targets. As this was one of the early sites visited in the Phase 2/3 testing, Sampson was not yet accustomed to the possibility of the target being part of the building (e.g., caulk or paint). Both locations were near a vertical seam in the building containing caulk.

This site was revisited on March 28, 2017 and Sampson again alerted in the area of the flammables storage cabinet. Windy conditions and inconsistent wind direction resulted in swirling wind patterns in the yard areas between the buildings. The team members sporadically detected PCB odors in the vicinity of the cabinet, as well as in front of the building, but given the wind conditions, it was not possible to determine the source of these odors. This site visit emphasized the difficulty of these conditions for a detection dog when attempting to conduct source tracing work, and thus it may be worthwhile to revisit this site on a less windy day.

Table 4-4. Site 3 summary

Location ID	Total PCBs	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
3a	0.001 U	yes	Wipe sample of flammables storage cabinet. Sampson alerted to area near the cabinet. Relative to target,[a] sample representativeness is uncertain.	strong positive	high confidence PCBs are present
3b	0.001 U	no	Wipe sample of coating on I-beam. Sampson alerted to several things in this general area (e.g., I-beam, wall, and faucet on wall). Relative to target,[a] sample representativeness is uncertain.	moderate positive	medium confidence PCBs are present
3c	0.001 U	no	Wipe sample of metal railing.	none	high confidence PCBs are NOT present
3d	0.001 U	na	Blank wipe.	na	na

Note: Wipe samples were collecting using paint thinner and gauze.

[a] The target is the item/area to which Sampson alerted.

ID – identification

na – not applicable

PCB – polychlorinated biphenyl

U – not detected at the concentration shown

4.2.4 Site 4

The field team visited Site 4, a commercial property, on November 15, 2016. This site was selected for inclusion in the pilot study based on PCB contamination discovered at the site during an inspection conducted in 2012. The surface of the site has since been regraded with dirt piled in berms along the east/south sides of the site, which has moved and thoroughly disturbed the original distribution of PCBs in the site soil. This site is currently unoccupied.

During the site visit, the field team walked Sampson around the site, focusing primarily on the site edges (particularly the berms located along the south and east sides of the site). Overall, Sampson's interest at this site was relatively low, but he showed a moderate positive response at three locations and a slight change of behavior at another location (i.e., a low-level positive or a negative response). A total of five samples were collected: one at each of the four locations described above, and another at a location where Sampson did not show any change of behavior (Table 4-5).

The sample results appeared to indicate that Sampson was generally not successful in detecting PCBs at this site (concentrations were either non-detect or quite low). However, a key uncertainty is that the three locations where Sampson showed a moderate positive reaction (i.e., indicated that PCBs were present) were along soil berms that were created when the site was regraded, meaning that PCB-contaminated material could be present below the surface layer where samples were collected (approximately 0–10 cm collected sample depth). Further work could be done to collect samples at various depths to determine if Sampson was detecting buried PCBs within the berm. Another possibility is that PCBs were not present at this site, but that the field team over-searched the area, causing Sampson to alert in frustration. This site visit was relatively early in the pilot study when dog and handler confidence was still relatively low.

Table 4-5. Site 4 summary

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
4a	0.0229	no	Soil sample from berm at south edge of site (ODS 23). Relative to target,[a] sample representativeness is uncertain.	moderate positive	medium confidence PCBs present
4b	0.018 U	no	Soil sample from berm at south edge of site (ODS 24). Relative to target,[a] sample representativeness is uncertain.	moderate positive	medium confidence PCBs present
4c	0.019 U	no	Soil sample from berm at east edge of site (ODS 25). Relative to target,[a] sample representativeness is uncertain.	low positive	low confidence PCBs present
4d	0.077	no	Soil sample from berm at northeast corner of site (ODS 26).	none	medium confidence PCBs NOT present
4e	0.019 U	no	Soil sample away from edge of site (ODS 22).	none	high confidence PCBs NOT present

a The target is the item/area to which Sampson alerted.

ID – identification

PCB – polychlorinated biphenyl

U – not detected at the concentration shown

4.2.5 Site 5

The field team made a brief visit to Site 5 on November 15, 2016. This site was selected for inclusion in the pilot study based on known past contamination associated with the site. No samples were collected during the relatively quick walkthrough of the area although Sampson appeared interested in two locations: along 8th Avenue South and along South Elmgrove Street. Human team members were able to confirm the scent of PCBs at the second location, although the origin of the smell was not determined. The field team returned to this site in December for a more thorough investigation (see Section 4.2.14).

4.2.6 Site 6

The field team visited Site 6, a commercial property in Seattle, on November 16, 2016. This site was selected for inclusion in the pilot study based on results from a 2014 source control inspection. Catch basin solids samples collected at that time contained 0.27 to 32 mg/kg PCBs and loose paint chips collected from one of the catch basins contained 45 mg/kg PCBs. The entire onsite drainage system was cleaned in 2014 after these samples were collected.

During the site visit, the field team walked Sampson around the site parking lot and around the back of the building (southwest part of the property). Sampson showed a strong positive response at two locations and a moderate or low positive response at two other locations (Table 4-6). A total of five samples were collected at the site: four from the locations described above, and one additional sample in an area where Sampson's behavior did not change.

Sample results indicated that the strong positive alerts from Sampson (on multiple passes of these locations) correlated with PCB concentrations of 130 and 31.5 mg/kg. The sample with the higher concentration (6b) was comprised completely of paint chips, while the sample with the somewhat lower concentration (6c) was comprised of both dirt and paint chips. The other three locations where samples were collected included:

- **Location 6a** – Sampson showed a moderate positive reaction to the catch basin where sample 6a (0.609 mg/kg PCBs) was collected. In April 2014 (prior to being cleaned), catch basins solids from this catch basin and one immediately south (CB246) were collected and composited for analysis, and the composite sample contained 10 mg/kg PCBs. CB246 was sampled separately in May 2014 (also prior to cleaning) and contained 32 mg/kg PCBs.
- **Location 6d** – Sampson initially showed some interest in this location, but did not appear to be interested on later passes. There were some paint chips on the ground in this area, which may have contributed to a low-level PCB smell; after locating areas with much higher PCB concentrations, Sampson perhaps did not find this area as interesting.
- **Location 6e** – Sampson did not show any interest in this area. A sample of moss/dirt was collected from along the site fence line to provide confirmation that PCBs were not present. PCBs were detected in this sample at a concentration of 1.01 mg/kg.

Overall, the sample results indicated that Sampson's strong responses correctly indicated areas with high levels of PCBs (31.5 and 130 mg/kg), although the lower concentrations of PCBs (1 mg/kg or lower) may have been more difficult for Sampson to distinguish, particularly when nearby smells from higher concentrations caused difficulties.

Table 4-6. Site 6 summary

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
6a	0.609	no	Catch basin along west wall of building (CB321). Relative to target,[a] sample representativeness is uncertain.	moderate positive	medium/low confidence PCBs present
6b	130	yes	Paint chips found in steel I-beam laying in a pile on the ground (ODS15). Relative to target,[a] sample representativeness is high.	strong positive	high confidence PCBs present

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
6c	31.5	yes	Dirt/paint chips from box that appeared to contain sweepings from the area (ODS16). Relative to target,[a] sample representativeness is high.	strong positive	medium confidence PCBs present
6d	0.328	no	Dirt/paint chips from behind transformer (ODS17). Relative to target,[a] sample representativeness is high.	moderate/low positive (showed initial interest, but no response when revisiting this area)	low confidence PCBs present
6e	1.006 J	no	Moss/dirt sample along fence (ODS18).	none	low/medium confidence PCBs NOT present

[a] The target is the item/area to which Sampson alerted.

ID – identification

PCB – polychlorinated biphenyl

4.2.7 Site 7 – North Boeing Field

The field team visited North Boeing Field on November 16, 2016. This site was selected for inclusion in the pilot study based on past sampling at the site that indicated the presence of PCBs at concentrations up to 10,000 mg/kg in building materials (e.g., paint and caulk in windows, doors, and pavement joints (Landau 2010)).

During the site visit, the field team walked Sampson around locations where PCBs had been previously detected, including: building 3-369; the open paved area among buildings 3-369, 3-380, and 3-390; and the northernmost part of the site (e.g., buildings 3-626, 3-332, and 3-368). No samples were collected, because the area had been well characterized and PCB-contaminated areas were known. Thus, this site visit provided an excellent opportunity for Sampson to detect PCBs in a variety of types of media (e.g., caulk, paint, and paving joints), and for the field team to be able to reward him for these detections based on the results of past sampling and/or the ability of the human team members to smell PCBs.

Sampson alerted to a large number of targets during this site visit (Table 4-7). Strong positive responses and moderate-to-strong positive responses were observed at numerous locations, at nearly all of which the human team members were also able to smell PCBs and immediately provide rewards. This was also the case at many of the locations where Sampson showed a moderate or moderate-to-low positive response. Although a large amount of data has been collected from this site, data were not available at many of the locations to which Sampson alerted, and thus the ability of the human team members to smell PCBs was useful at this site. In addition, at two locations where Sampson did not show a response (both doors in Building 3-369), Boeing representatives confirmed that the doors in question were newer, and thus the caulk surrounding the doors was unlikely to contain PCBs. This information was useful in confirming that Sampson was not alerting to all doorways and caulk, but rather was accurately detecting PCBs where they were present. North Boeing Field represented a turning point in the pilot study, because it provided an opportunity to give Sampson immediate rewards, which resulted in improved dog and handler confidence.

Table 4-7. Site 7 summary – North Boeing Field

Location ID	Total PCBs[s] (mg/kg)	Human team members able to smell PCBs?	Notes Regarding Sample or Area of Interest	Sampson Response	Handler Gestalt
Building 3-369					
7a	no data	no	Door W5 caulk (newer door – unlikely to have PCBs).	none	high confidence PCBs NOT present
7b	no data	yes	Caulk along steel beam to left of W5 door.	strong positive	high/medium confidence PCBs present
7c	no data	yes	Caulk around S9 door (right/bottom side of door).	strong positive	high/medium confidence PCBs present
7d	no data	no	5x5-ft cardboard receptacle along south side of building.	moderate positive	medium confidence PCBs present
7e	no data	yes	Caulk along I-beam just to left of door S4 (same brown/white caulk as around S9 door).	strong positive	high/medium confidence PCBs present
7f	no data	no	Maintenance hole between S4 and S6 doors.	moderate/ low positive	high/medium confidence PCBs present
7g	no data	no	Caulk along left and right sides of door S3.	moderate/ low positive	high/medium confidence PCBs present
7h	no data	no	Showed some interest in caulk between concrete pads at southeast corner of building.	moderate/ low positive	medium confidence PCBs present
7i	no data	no	Behavior change around paint chips near southeast corner of building (just south of door E7 – flaking paint near chemical storage area).	moderate/ low positive	medium confidence PCBs present
7j	2 – 250,000[b]	yes	Caulk on right side of door E7.	strong positive	high/medium confidence PCBs present
7k	no data	yes	Left side of I-beam between doors E6 and E7.	strong positive	high/medium confidence PCBs present
7l	2 – 250,000[b]	yes	Caulk along I-beam to right of door E4 (around side opposite from door).	strong positive	high/medium confidence PCBs present
7m	2 – 250,000[b]	yes	Caulk around door E3; generally strong PCB smell in air in breezeway near this door.	strong positive	high/medium confidence PCBs present
7o	2 – 250,000[b]	yes	Caulk along I-beam to left of door E1 (side of beam towards door).	strong positive	high/medium confidence PCBs present
7p	no data	no	Door E1 (likely newer door and thus unlikely to have PCBs).	none	high confidence PCBs NOT present

Location ID	Total PCBs[s] (mg/kg)	Human team members able to smell PCBs?	Notes Regarding Sample or Area of Interest	Sampson Response	Handler Gestalt
7q	no data	yes	Caulk along I-beam to right of door E2.	strong positive	high/medium confidence PCBs present
7r	no data	yes	Base of east wall of building in area of previous sample.	strong positive	high/medium confidence PCBs present
7s	no data	yes	Caulk along I-beam at northeast corner of building near door N8.	strong positive	high/medium confidence PCBs present
7t	no data	no	Joint material at bottom of door N7; vertical join material seems to have stronger PCB smell.	moderate/ low positive	high/medium confidence PCBs present
7u	1,000–10,000[b]	yes	Vertical joints and horizontal caulk at bases of doors N8, N7, N6, N5, N4, N3, N2, N1.	strong positive	high confidence PCBs present
Building 3-374					
7n	no data	yes	Area north of this building but seemed unsure where to alert. He seemed to be most interested in area under tank that was attached to the wall of the building.	moderate positive	high/medium confidence PCBs present
Building 3-380					
7v	no data	no	Base of door E2. Building is newer, so if PCBs are present, it will be at lower levels.	moderate/ low positive	medium confidence PCBs present
7w	no data	no	Seam between doors E1 and E2.	moderate/ low positive	medium confidence PCBs present
7x	no data	no	Caulk at northeast corner between sidewalk and pavement pad.	moderate/ low positive	medium confidence PCBs present
Parking area					
7y	< 1– > 10,000[b]	yes	Caulk in area where previous samples had been collected (e.g., CJM-23). Joints in area near parking strip to north of Building 3-390 appear to have the highest levels of PCBs based on Sampson's behavior (concrete here appears older than in surrounding areas).	strong positive	high confidence PCBs present
Building 3-626					
7z	no data	no	Area south of building.	moderate/ low positive	medium/low confidence PCBs present
7aa	no data	yes	Corner to right of door S5 and in caulk joints in pavement in this area.	moderate positive	medium confidence PCBs present
7bb	20 (paint)[b]	yes	Wall to right of door S6.	strong positive	high confidence PCBs present
7cc	no data	yes	Southeast building corner.	strong positive	high confidence PCBs present
7dd	no data	no	Base of chiller.	moderate/ low positive	medium/low confidence PCBs present

Location ID	Total PCBs[s] (mg/kg)	Human team members able to smell PCBs?	Notes Regarding Sample or Area of Interest	Sampson Response	Handler Gestalt
Building 3-323					
7ee	20 (paint)[b]	no	Air tanks near building.	strong positive	high confidence PCBs present
Building 3-368					
7ff	120,000	yes	Caulk in area near door W2 (directly opposite side of door in alcove). Building material is known to have PCBs greater than 10,000 mg/kg.	strong positive	high confidence PCBs present
7gg	no data	yes	Vertical joint to left of door W1.	moderate/ strong positive	high confidence PCBs present.
7hh	no data	yes	Vertical joint to right of and below door 2W1.	moderate/ strong positive	high confidence PCBs present
7ii	no data	no	Rounded wall at west side of building (left side of wind tunnel opening).	moderate positive	medium/low confidence PCBs present

a Although a large number of samples have been analyzed from the North Boeing Field site, many of the locations to which Sampson alerted were not co-located with sampling locations, and thus “no data” was entered in the table because the exact concentrations of PCBs are not known.

b Data based on past sampling conducted at this location.

ID – identification

PCB – polychlorinated biphenyl

4.2.8 Site 8 – Downtown Tacoma

The field team visited various locations in the downtown Tacoma area on November 17, 2016. These areas were selected for inclusion in the pilot study based on the considerable past sampling (e.g., from catch basins) that had been conducted by the City of Tacoma, which indicated the presence of PCBs. A total of three samples were collected as part of this study.

Locations where Sampson showed interest are summarized in Table 4-8, and a brief overview of each of the six areas visited by the field team is provided below:

- **8A: Sound Physicians Building** – Past sampling of this building had found elevated levels of PCBs in the building caulk. Sampson was quickly able to identify this target, and strongly alerted along both the south and east sides of the building. The PCB smell along the south side of the building (which was in the sun) was strong enough to be detected by the human team members; no PCB smell was detected by the human team members along the east side of the building. Although past sampling had been conducted only along the south side, the visual similarity of the two building sides and Sampson’s response indicate that PCBs are likely present on exterior caulk overlay of mortar joints.
- **8B: Pacific Plaza Parking Garage** – PCBs had been detected in catch basins at the base of the Pacific Plaza parking garage in 2013 (3.2 mg/kg) and 2016 (1.6 mg/kg). Past sampling of the parking garage itself had detected PCBs at concentrations of 0.7 to

6 mg/kg in the sealant paint on the top level of the garage. Sampson strongly alerted to the rubberized material along the railing of the parking garage and to the rubberized material along the base of the walls in the elevator entry room. Samples collected at both of these locations confirmed that PCBs were present at elevated concentrations (164,100 and 69.5 mg/kg). The human team members were also able to smell PCBs at both of these locations.

- **8C: Century Link Building** – PCBs had been detected in a catch basin at the corner of Fawcett Avenue and South 9th Street in 2013 (2.7 mg/kg) and 2016 (4.8 mg/kg). Upon arrival at this site, Sampson strongly alerted to the vertical caulk in the nearby Century Link building; the human team members were also able to smell PCBs at this location. A sample of moss collected from the base of the building was found to contain elevated levels of PCBs (763 mg/kg). Sampson also alerted to the catch basin that the City of Tacoma had previously sampled.
- **8D: Market Street between South 9th and South 11th Streets** – PCBs had been detected in a catch basin along Market Street in 2013 (2.1 mg/kg) and 2016 (0.85 mg/kg). Sampson strongly alerted to the caulk along the side of the parking garage at this location. No sample was collected, but the human team members were also able to smell PCBs at this location. Sampson also showed moderate interest in the building on the northeast corner of Market and South 11th Streets, but the presence of PCBs could not be confirmed.
- **8E: Commerce Street between South 11th and South 13th Streets** – PCBs had been detected in two catch basins along Market Street in 2013 and 2016 at concentrations ranging from 0.89 to 2.9 mg/kg. Sampson strongly alerted to the areas around the windows (possibly the caulk) in two buildings (both on the east side of the street) toward the north end of the block. Sampson also showed interest in the area around a grate just north of the parking garage driveway on the east side of the street (moderate positive response to the grate, and low positive response to the nearby wall). Human team members were later able to smell PCBs near the grate, although smells from the grate (possibly with a PCB-containing transformer) may have caused confusion for Sampson, because of their apparently intermittent release and the way they may have pooled around the general area.
- **8F: Wells Fargo Building** – Samples previously collected at this site had concentrations of PCBs up to 53,000 mg/kg in building and sidewalk caulk. The sidewalk along the north side of this building has been remediated, so the field team walked along the south side of the building (i.e., along South 13th Street) where high concentrations of PCBs in sidewalk caulk remain. Sampson appeared to be unfocused and was not able to correctly detect the high concentrations of PCBs until after taking a break to calm down. Ultimately, Sampson did show a strong positive reaction to the PCBs in the sidewalk caulk and to caulk in one of the building pillars.

Overall, the various sites visited in downtown Tacoma were useful in improving Sampson's confidence in alerting to PCB targets of different types.

Table 4-8. Site 8 summary – Downtown Tacoma

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
8A: Sound Physicians Building					
8A-a	13,000–17,000[a]	yes	Caulk along south side of building.	strong positive	high confidence PCBs present
8A-b	no data	no	Caulk along west side of building (likely same as 8A-a).	strong positive	medium confidence PCBs present
8B: Pacific Plaza Parking Garage					
8B-a	164,100 (16.4% PCBs)	yes	Sample of rubberized paint was collected near parking garage railing. Relative to target,[b] sample representativeness is high.	strong positive	high confidence PCBs present.
8B-b	69.5	yes	Sample of rubberized paint was collected in elevator entrance. Relative to target,[b] sample representativeness is high.	strong positive	high confidence PCBs present
8B-c	0.7–2.5[a]	no	Center of drive area; previously collected paint samples had concentrations of 0.7 to 2.5 mg/kg (depending on paint layer).	low positive (some change of behavior, but not clear alert)	medium confidence PCBs present (may be at lower concentrations)
8C: Century Link Building					
8C-a	763	Yes	Vertical building caulk. Sample of moss/dirt at base of building wall collected. Relative to target,[b] sample representativeness is low.	strong positive	high confidence PCBs present
8C-b	4.8[a]	No	Two catch basins near building.	moderate positive	medium confidence PCBs present
8D: Market Street (South 9th to South 11th Streets)					
8D-a	no data	yes	Parking garage building caulk.	strong positive	high confidence PCBs present
8D-b	no data	no	Caulk along window of building at corner of South 11th and Market Streets.	moderate positive	low confidence PCBs present
8E: Commerce Street (South 9th to South 11th Streets)					
8E-a	no data	yes	Caulk/paint around windows of Chase Bank building on South 11th and Market Streets.	strong positive	high confidence PCBs present
8E-b	no data	yes	Base of windows (possibly caulk) of 1120 Commerce Street building.	strong positive	high confidence PCBs present
8E-c	no data	yes	Grate just north of parking garage entrance on east side of Commerce Street.	moderate positive	high confidence PCBs present
8E-d	no data	no	Base of wall near grate (location 8E-c), possibly caulk or related to odors from grate.	low positive	low confidence PCBs present
8F: Wells Fargo Building					
8F-a	no data	no	Caulk at base of parking garage wall along South 13th Street.	moderate positive	low confidence PCBs present

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
8F-b	16,000–24,000[a]	yes	Sidewalk joint material along South 13th Street.	strong positive	high confidence PCBs present
8F-c	no data	yes	Caulk in building pillars.	strong positive	high confidence PCBs present

[a] Source: Tacoma (2017)

[b] The target is the item/area to which Sampson alerted.

ID – identification

PCB – polychlorinated biphenyl

4.2.9 Site 9 – SPU Operations Control Center site

The field team visited the SPU Operations Control Center (OCC) on December 14, 2016. This site was selected for inclusion in the pilot study based on a 2011 Ecology study of building materials as potential sources of PCBs in the LDW in which this site was tested (SAIC 2011). SAIC (2011) composited samples of building materials (i.e., caulk and paint) from 16 areas in the Lower Duwamish basin; sampling areas were selected based on location, building type, and construction date. Caulk from buildings at the OCC were included in one of the composite samples comprised of material collected from three different buildings constructed during the 1960s; this composite sample contained 920 mg/kg PCBs. As part of this site visit, SPU wanted to both confirm whether PCBs are present in the building caulk and determine whether there are other sources of PCBs at the OCC.

During the site visit, the field team walked Sampson around the buildings at the site. Sampson showed a moderate positive reaction at three locations and a moderate-to-low positive reaction at one other location (Table 4-9). Sampson's reactions at the three locations where he showed a moderate positive reaction could not be confirmed (either through smell by the human team members or by sample collection). At location 9b, where Sampson showed a moderate-to-low positive reaction, the sample collected showed that PCBs were present in the moss at a concentration of 0.48 mg/kg. However, the representativeness of this moss sample is likely low relative to the building wall/base of the building wall where Sampson alerted (i.e., Sampson alerted to the building, but the sampled material was the moss at the base of the building wall).

Table 4-9. Site 9 summary – SPU OCC

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location / Sample Notes	Sampson Response	Handler Gestalt
9a	no data	no	Fluorescent light ballast storage cabinet and vicinity where PCB-containing materials are known to have been stored in the past.	moderate positive	medium confidence PCBs present
9b	0.479	no	Base or caulk of building. Sample of moss collected at base of wall (ODS37). Relative to target,[a] sample representativeness is low.	moderate/ low positive	low confidence PCBs present

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location / Sample Notes	Sampson Response	Handler Gestalt
9c	no data	no	Oil-stained area in Bay 14 along loading dock.	moderate positive	low confidence PCBs present
9d	no data	no	Oil-stained area in Bay 17 along loading dock.	moderate positive	low confidence PCBs present

[a] The target is the item/area to which Sampson alerted.
ID – identification
OCC – Operations Control Center
PCB – polychlorinated biphenyl
SPU – Seattle Public Utilities

4.2.10 Site 10 – South Snoqualmie Street area

The field team visited the South Snoqualmie Street area in Seattle on December 14, 2016. This site was selected for inclusion in the pilot study based on past source tracing efforts. This area underwent extensive source tracing in 2013 to identify the source of elevated levels of PCBs found in a maintenance hole on South Snoqualmie St near 6th Avenue South (MH18). PCBs ranged from 3.1 to 45.9 mg/kg in three samples collected between 2012 and 2014. SPU identified several sources of PCBs during the investigation and lines in the vicinity were cleaned; however elevated levels of PCBs continue to occur in MH18. SPU wanted to see whether Sampson could identify any additional sources in this area.

During the site visit, the field team walked Sampson around the area: along both South Snoqualmie Street and South Alaska Street between 6th Avenue South and Airport Way, and along parts of both 7th Avenue South and Airport Way. Sampson showed only one strong positive response, which was to caulk under window flashing at a building along 7th Avenue South. PCBs at this location were present at a sufficiently high concentration that the human team members could also smell the PCBs. Various other moderate-to-low positive reactions indicated the possible presence of PCBs at lower levels (e.g., less than 1 mg/kg) in these areas (e.g., in catch basins where samples collected as part of this study detected PCBs at concentrations of 0.15 to 0.79 mg/kg). In addition, it was useful to note that Sampson had no change of behavior when walking past a distribution building, where a previously-collected catch basin composite sample (CB244) in this parking lot area found only low levels of PCBs (0.123 mg/kg).

Table 4-10. Site 10 summary – South Snoqualmie Street area

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
10a	3.1 – 45.9 (2012/2014)	no	MH18 (did not alert to other nearby manholes).	moderate positive	medium confidence PCBs present
10b	no data	no	Catch basins along South Snoqualmie Street (north side of street)[a]	low positive	low confidence PCBs present

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
10c	no data	no	Entry door and the bottom of the bay door on the south side of building on South Snoqualmie Street.	moderate positive	low confidence PCBs present
10d	no data	yes	Caulk under window flashing in a building on 7th Avenue South.	strong positive	high confidence PCBs present
10e	no data	no	Caulk in building on north side of South Alaska Street, especially around air conditioner.	Moderate positive	medium/high confidence PCBs present
10f	0.791 – 1.57[b]	no	Catch basin in parking lot on South Alaska Street (CB237). Relative to target,[c] sample representativeness is uncertain.	Moderate/ low positive	medium/low confidence PCBs present
10g	0.149	no	Catch basin on northeast corner of 6th Avenue South and South Alaska Street (RCB72). Relative to target,[c] sample representativeness is uncertain.	Moderate/ low positive	medium/low confidence PCBs present
10h	0.123[d]	no	Sampson did not alert to the distribution building; composite sample of catch basins (CB244) in this area contained low levels of PCBs	None	high confidence PCBs NOT present

[a] Equipment numbers 572695, 572666, 572664, and 572694.

[b] Sample collected December 21, 2016 contained 0.791 mg/kg PCBs (CB237). A composite sample comprised of solids from this catch basin and one located in same parking lot about 40 feet to the east (CB177) contained 1.57 mg/kg PCBs.

[c] The target is the item/area to which Sampson alerted.

[d] A composite sample of catch basin solids (CB244) collected by SPU on April 10, 2014 in the east parking lot of the distribution building (the area where Sampson walked through) was found to contain PCBs at a concentration of 0.123 mg/kg.

ID – identification

PCB – polychlorinated biphenyl

SPU – Seattle Public Utilities

4.2.11 Site 11 – 24th Avenue South and South Washington Street

The field team visited the 24th Avenue South and South Washington Street site in Seattle on December 14, 2016. This site was selected for inclusion in the pilot study based on a 2011 catch basin solids sample (RCB251) that contained elevated levels of PCBs. RCB251 has been sampled three times the past 5 years. PCB results are listed below:

- 2011 – 9.2 mg/kg
- 2012 – 0.1 mg/kg
- 2016 – 0.035 mg/kg

The change in PCB concentrations between 2011 and 2012 is unusual since this catch basin was not cleaned during the intervening period (it was cleaned in 2009 and 2015). It may be related to heterogeneity of PCBs within the catch basin, but without field duplicates, it is not possible to know whether this was a factor.

During this site visit, the field team walked Sampson from 24th Avenue South and South Washington Street north on 24th Avenue South for about half a block. Sampson showed a moderate positive reaction at two locations (Table 4-11), both at the northeast corner of 24th Avenue South and South Washington Street (11ab). SPU wanted to determine whether there are ongoing sources of PCBs in this area.

Although very low levels of PCBs were found in the sample collected from this catch basin during this study (0.035 mg/kg), it is unknown whether residual PCBs present in or around this drain could have impacted Sampson's response. No previous data were available from the inlet connected to catch basin RCB251 (11a) where Sampson showed a moderate positive reaction; the PCB concentration there is likely similar to that at location 11b, because these two structures are connected.

Table 4-11. Site 11 summary – 24th Avenue South and South Washington Street

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
11a	no data	no	Inlet connected to catch basin RCB251.	moderate positive	medium confidence PCBs present
11b	0.0354[a]	no	Catch basin at northeast corner of South Washington Street and 24th Avenue South (RCB251). Relative to target,[b] sample representativeness is uncertain.	moderate positive	medium confidence PCBs present
11c	0.052	no	Catch basin at northwest corner of 24th Avenue South and South Washington Street (RCB67).	none	medium confidence PCBs <u>NOT</u> present

a PCBs in previous samples collected at this location in 2011 and 2012 were 9.2 and 0.1 mg/kg, respectively

b The target is the item/area to which Sampson alerted.

ID – identification

PCB – polychlorinated biphenyl

4.2.12 Site 12 – South Myrtle Street and Fox Avenue South

The field team visited South Myrtle Street and Fox Avenue South site in Seattle on December 14, 2016. This site was selected for inclusion in the pilot study because elevated levels of PCBs have been and continue to be found in this area in association with a nearby metals recycling facility as documented in Seattle's SCIP (City of Seattle 2016). The entire drainage system in this area was cleaned in 2009, but PCBs were detected at concentrations ranging from 1.93 to 4.87 mg/kg in samples collected after cleaning. Given the history of this area, it was considered a prime test area for Sampson. In addition, SPU wanted to have Sampson screen the area for other potential PCB sources.

During the site visit, the team walked Sampson along South Myrtle Street and down Fox Avenue South (to South Brighton Street). Sampson had a strong positive reaction to a plastic crate located along South Fox Avenue; PCBs were detected at a concentration of 74.5 mg/kg in the solids removed from the crate.[8] Later, after the crate had been removed, Sampson still had a moderate positive reaction to the area where the crate had been located; a sample of surface soil collected at this location 0.36 mg/kg PCBs.[9]

Sampson also showed a moderate to strong positive reaction to material on the ground (possibly from the nearby building roof) along the west side of South Fox Avenue; however, no sample was collected at this location. In addition, Sampson showed moderate and low positive reactions to several other areas during the site walk, but no other samples were collected. This site walk indicated that there may be several sources of PCBs in this general area, but that other than the plastic crate, the primary sources were not identified and may not have been accessible to the field team.

Table 4-12. Site 12 summary – South Myrtle Street and Fox Avenue South

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
12a	8.23[b]	no	Street dirt (under Filterra® tree box units) and catch basins in the vicinity of the metal recycling facility.	moderate positive	medium confidence PCBs present
12b	74.5	yes	Plastic crate found along Fox Avenue South. Crate was collected for analysis by methanol wash. Note that Sampson's reaction to crate was confirmed by moving it across the street and walking him past the crate again. Relative to target,[a] sample representativeness is moderate.	strong positive	high confidence PCBs present
12c	0.360	no	Soil adjacent to location 12b where crate was found (ODS38). Relative to target,[a] sample representativeness is moderate.	moderate positive	medium confidence PCBs present
12d	no data	no	Material on ground along west side of Fox Avenue South (possibly from building roof), across street from 6900 Fox Avenue building.	moderate/ strong positive	medium/low confidence PCBs present
12e	0.562[c]	no	Catch basin located on the east side of Fox Avenue South (RCB179); location near where Sampson identified possible PCB source (location 12b).	na	na
12f	no data	no	Corner of building across from 6701 Fox Avenue South, close to red door.	low positive	low confidence PCBs present

[8] The crate was washed with methanol to remove the adhered soil and rinsate was submitted to lab for analysis. The lab decanted off the excess methanol and the resulting sampling was approximately half solids and half methanol.

[9] Note that handler gestalt was medium in this case because of Sampson's tendency to return to a location where he had previously been rewarded.

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
12g	no data	no	Base of bay door at 525 South Brighton Street and along east side of driveway where sweepings from driveway appear to have accumulated.	moderate positive	low/medium confidence PCBs present
12h	no data	no	Ecology block along the east side Fox Avenue South.	moderate positive	low confidence PCBs present

[a] The target is the item/area to which Sampson alerted.
[b] Results from most recent sample collected in February 2011 from catch basin in this area (RCB189/RCB225).
[c] Sample collected in 2009, prior to cleaning, contained 1.74 mg/kg PCBs.
ID – identification
na – not applicable
PCB – polychlorinated biphenyl

4.2.13 Site 13 – South Kenyon Street and 8th Avenue South

The field team visited South Kenyon Street and 8th Avenue South on December 15, 2016. These streets border a former metals recycling facility, which ceased operations in 2014. This site was selected for inclusion in the pilot study because solids samples collected from RCBs (0.71 to 5.3 mg/kg PCBs) and an onsite catch basin (3.38 mg/kg PCBs) contained elevated levels of PCBs.[10] SPU wanted to confirm the presence of PCBs in the right-of-way and locate possible hotspots and/or sources of PCBs.

During the site visit, the team walked Sampson along the streets bordering the former metal recycling site. Sampson did not show a strong positive reaction at any area during this site visit, but did show moderate positive reactions at three locations (13b, 13c, and 13j) and low-to-moderate positive reactions at four locations (13f to 13i). Samples collected at six of these seven locations were shown to have PCBs at concentrations ranging from 0.093 to 0.5 mg/kg, although the representativeness of the samples is uncertain in many cases.

In addition, samples were collected at two catch basins on the west side of 8th Avenue South at South Chicago Street (RCB279 and RCB311), across the street from the former metals recycling facility driveway (13d and 13e), where Sampson did not appear to have any reaction; PCBs were detected in these samples at concentrations ranging from 0.06 to 0.52 mg/kg. Overall, the lower PCBs concentrations detected in samples taken along 8th Avenue South and South Kenyon Street are consistent with Sampson's lack of strong responses in this area, as well as the corresponding handler gestalt indicating low-to-medium confidence in the presence of PCBs at this site.

[10] Samples were collected between 2011 and 2013.

Table 4-13. Site 13 summary – South Kenyon Street and 8th Avenue South

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
13a	no data	no	Inlet on northeast corner of 8th Avenue South and South Kenyon Street (577174). Not interested in inlet on northwest or southwest corner of 8th Avenue South and South Kenyon Street.	moderate positive	low/medium confidence PCBs present
13b-c	0.164–0.373[b]	no	Inlets on east side of 8th Avenue South at South Chicago Street (RCB229 and RCB310). Relative to target,[a] sample representativeness is uncertain.	moderate positive	medium confidence PCBs present
13d-e	0.058–0.519[c]	no	Catch basins on west side of 8th Avenue South at South Chicago Street, across street from locations 13b and 13c (RCB279 and RCB311).	none	medium confidence PCBs NOT present
13f	0.491	no	Cracks in concrete panels in middle of street near 836 and 837 South Kenyon Street (ODS50). Relative to target,[a] sample representativeness is uncertain.	moderate/ low positive	low/medium confidence PCBs present
13g	no data	no	Sewer maintenance hole (071-301) near 823 South Kenyon Street.	moderate/ low positive	low/medium confidence PCBs present
13h	0.302	no	Catch basin on north side of South Kenyon Street (RCB278). Relative to target,[a] sample representativeness is uncertain.	moderate/ low positive	low/medium confidence PCBs present
13i	0.093	no	Catch basin on south side of South Kenyon Street across the street from location 13h (RCB74). Relative to target,[a] sample representativeness is uncertain.	moderate/ low positive	low/medium confidence PCBs present
13j	0.503	no	Dirt on north side of South Kenyon Street opposite door (ODS39). Relative to target,[a] sample representativeness is moderate.	moderate positive	Medium confidence that PCBs are present.

a The target is the item/area to which Sampson alerted.

b A composite sample collected in 2011 from the two catch basins on the east side of 8th Avenue South contained 0.71 mg/kg PCBs (RCB229).

c A composite sample collected in 2011 from the two catch basins on the west side of 8th Avenue South contained 0.37 mg/kg PCBs (RCB279).

ID – identification

PCB – polychlorinated biphenyl

4.2.14 Site 14 – South Elmgrove Street and 8th Avenue South

The field team visited 8th Avenue South and South Elmgrove Street in Seattle's South Park neighborhood on December 15, 2016. These streets border a former metals recycling facility that ceased operations in 2014. This area was selected for inclusion in the pilot study because King County Industrial Waste found elevated levels of PCBs in solids samples collected from onsite catch basins in 2011 (0.73 to 2.7 mg/kg) (King County 2011). SPU wanted to determine whether PCBs had migrated offsite during the years of plant operations.

During the site visit, the team walked Sampson along 8th Avenue South and South Elmgrove Street. Sampson had a strong positive reaction to location 14b; PCBs were detected at a concentration of 63.8 mg/kg in the soil sample collected in a planting strip located between the fence line and the street. PCBs were also detected at 46.9 mg/kg in a soil sample collected directly under the property fence (location 14c). During collection of samples at these two locations, PCB odors were unmistakable to the human team members.

Sampson showed moderate positive reactions to two other locations (14a and 14d), providing medium-to-high confidence that PCBs are present at these locations, although no samples were collected for confirmation. In addition, one sample was collected in an area where Sampson's behavior did not change (location 14e); PCBs were detected at a concentration of 0.92 mg/kg in this sample.

Table 4-14. Site 14 summary – South Elmgrove Street and 8th Avenue South

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
14a	no data	no	Dirt along fence line on 8th Avenue South just north of facility gate (same area where he had showed interest in November).	moderate positive	medium confidence PCBs present
14b	63.81	yes	Dirt in tree bed (between the two trees) toward fence along north side of South Elmgrove Street (ODS40). Relative to target,[a] sample representativeness is high.	strong positive	high confidence PCBs present
14c	46.91	yes	Dirt at base of fence directly towards property from 14b (ODS41). Sampson did not alert in this location; sample collected for comparison.	na	na
14d	no data	no	Area next to gate and in dirt to west of gate (and to west of locations 14b and 14c).	moderate positive	medium/high confidence PCBs present
14e	0.924	no	Catch basin located at northwest corner of South Elmgrove Street and 8th Avenue South (RCB73).	none	medium confidence PCBs NOT present

[a] The target is the item/area to which Sampson alerted.

ID – identification

na – not applicable

PCB – polychlorinated biphenyl

4.2.15 Site 15 – South Austin Street

The field team visited South Austin Street near 2nd Avenue South in Seattle's South Park neighborhood on December 15, 2016. This area was selected for inclusion in the pilot study because a solids sample collected in 2008 from a catch basin on the north side of South Austin Street contained 3.19 mg/kg PCBs. PCBs in other catch basins sampled in this area were generally lower, ranging from 0.202 to 0.250 mg/kg. Until 2013, a small scrap metal recycling business operated on the property on the south side of S Austin St. In 2008, SPU inspectors found three drums of lamp ballasts on this property that had a distinct PCB odor. Catch basins in this area were last cleaned in 2014 after the closure of the scrap metal business. SPU wanted to have Sampson screen this area for PCBs.

During the site visit, the team walked Sampson along South Austin Street from 2nd Avenue South most of the way to 5th Avenue South. Sampson showed a moderate positive response at several locations along South Austin Street (15a to 15c). Samples collected at these locations had PCB concentrations ranging from 0.096 to 2.65 mg/kg; however, the representativeness of the samples relative to the targets is somewhat uncertain because samplers could not identify the specific location to which Sampson showed some interest. Consequently, because the target was a general area (rather than a specific point on the ground), the sample representativeness was defined as being low to moderate.

Sampson showed a moderate-to-low positive response at three of the four catch basins sampled (15d to 15g). PCB concentrations were actually highest in the one catch basin where he showed minimal interest (15g), although concentrations in samples collected from all of these catch basins were less than 1 mg/kg. In addition, as is the case with all catch basin samples, the representativeness of the sampled catch basin solids is uncertain relative to the material that Sampson may have smelled.

Table 4-15. Site 15 summary – South Austin Street

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location / Sample Notes	Sampson Response	Handler Gestalt
15a	2.651	no	Ground near power pole at northeast corner of 2nd Avenue South and South Austin Street (ODS42). After the field team moved a board in this area, Sampson again showed interest in ground previously covered by the board. Relative to target,[a] sample representativeness is moderate to low.	moderate positive	Low/medium confidence PCBs present
15b	0.096	no (may have smelled PCBs in nearby electrical boxes)	Ground near electrical boxes on north side of South Austin Street approximately 75 feet east of 2nd Avenue S (ODS43). Sampson alerted to electrical boxes again when field team returned to this area. Relative to target,[a] sample representativeness is moderate to low.	moderate positive	High confidence PCBs present
15c	0.504	no	Red dirt on north side of South Austin Street and area near gate in fence between 1st and 2nd buildings on north side of South Austin Street (ODS44). Relative to target,[a] sample representativeness is moderate to low.	moderate positive	Medium/high confidence PCBs present
15d-15f	0.149–0.301	no	3 catch basins/junction boxes along north side of South Austin Street[c] (Sampson alerted on multiple passes, first when walking away from 2nd Avenue South and again when returning). Relative to target,[a] sample representativeness is uncertain.	moderate/ low positive	Medium confidence PCBs present[b]
15g	0.866	no	Catch basin on the south side of South Austin Street (1st catch basin east of 2nd Avenue South, RCB71).	none	Medium confidence PCBs NOT present

Location ID	Total PCBs (mg/kg)	Human team members able to smell PCBs?	Location / Sample Notes	Sampson Response	Handler Gestalt
15h	no data	no	Area east of former recycling facility. Sampson seemed interested and had animated search, but did not zero in on anything.	low positive	Low confidence PCBs present

[a] The target is the item/area to which Sampson alerted.

[b] Confidence that PCBs are present in these locations is somewhat lower because Sampson was guided to these catch basins (i.e., rather than discovering them on his own).

[c] RCB139, RCB203, and RCB70. Sampson showed only slight interest in the catch basin across the street from the 2nd catch basin in the series (956180).

ID – identification

PCB – polychlorinated biphenyl

4.2.16 Site 16 – South Chicago Street

The field team visited South Chicago Street (near 7th Avenue South) in Seattle's South Park neighborhood on December 15, 2016. This area was mistakenly selected for inclusion in the pilot study due to an error in the location description of a sample (RCB165-061314) collected in 2014. The location of this sample, which contained 3.2 mg/kg PCBs, was incorrectly assigned to the S Chicago Street area. Unfortunately, the error was not discovered until after Sampson investigated this location. SPU's database has since been revised.

During the site visit, the field team walked Sampson along South Chicago Street from 7th Avenue South approximately halfway to 5th Avenue South. Sampson did not show any change in behavior in any locations along this street, indicating that PCBs are likely not present in this area. One catch basin sample was collected along South Chicago Street to help confirm this finding (Table 4-16). PCBs were not detected in this sample, helping to validate Sampson's lack of a reaction at this site.

Table 4-16. Site 16 summary – South Chicago Street

Location ID	Total PCBs	Human team members able to smell PCBs?	Location / Sample Notes	Sampson Response	Handler Gestalt
16a	0.0197 U	no	Catch basin sample collected from South Chicago Street between 7th Avenue South and approximately half way to 5th Avenue South (RCB165).	none	Medium/high confidence PCBs NOT present

ID – identification

PCB – polychlorinated biphenyl

U – not detected at the concentration shown

4.2.17 Site 17 – 1960s-era building

The field team visited a 1960s-era building located in Seattle on December 15, 2016. This site was selected for inclusion in the pilot study based on a 2011 Ecology study of building materials as potential sources of PCBs in the LDW that included this site (SAIC 2011). The composite caulk sample that included caulk from this building (along with caulk from two other buildings) contained 920 mg/kg PCBs. During the site visit, the field team walked Sampson along the building, and he strongly alerted several times to the building caulk. Confirmatory samples could not be collected, but Sampson's response and the human team members' ability to smell PCBs indicate that concentrations in this caulk are likely high (Table 4-17).

Table 4-17. Site 17 summary – 1960s-era building

Location ID	Total PCBs	Human team members able to smell PCBs?	Location/Sample Notes	Sampson Response	Handler Gestalt
17a	no data	yes	building caulk	strong positive	high confidence PCBs present

ID – identification
PCB – polychlorinated biphenyl

4.3 Summary of Phase 2/3 Field Test Results

A summary of PCB concentrations in samples collected during Phase 2/3 field tests is presented in Table 4-18, organized by Sampson's response category. These data provide a sense of Sampson's ability to detect various concentrations of PCBs in field testing environments. As shown in Table 4-18, strong positive responses were associated with PCB concentrations ranging from approximately 1 to 164,000 mg/kg dry weight (dw), or with locations where PCBs were present at sufficiently high levels that they could be detected (i.e., smelled) by the human team members. Concentrations at locations where Sampson showed a low/moderate or moderate response ranged from 0.023 to 2.65 mg/kg dw. Results are similar when looking at handler gestalt, which was generally comparable to Sampson's response at most locations. A more detailed discussion of these results and conclusions from this pilot study are presented in Section 6.

Table 4-18. Summary of Phase 2/3 field test results where study samples were collected

Sampson's Response	Number of Targets	Number of Targets Sampled	Detection Frequency	Total PCBs (mg/kg dw)[a]		
				Average	Minimum	Maximum
None	15	12	9/12	0.46	0.052	1.001
Low	6	1	0/1	na	na	na
Moderate/low	21	10	10/10	0.39	0.093	0.968
Moderate	38	17	14/17	0.57	0.023	2.65
Strong	37	11	10/11	16,500	1.17	164,100

[a] Summary statistics for detected values only.
dw – dry weight
na – not applicable
PCB – polychlorinated biphenyl

5 Detection Dog Blood Tests

To monitor for any potential negative health impacts associated with Sampson's exposure to PCBs, the University of Washington veterinary services collected samples of his blood and analyzed them for a subset of PCB congeners[11] prior to the start of the study (i.e., baseline testing), midway through the study, and toward the end of the study. Two PCB congeners (PCB 28 and PCB 52) were detected in both the midway and final blood samples at concentrations just above the reporting limit (RL) (Table 5-1) (NMS 2016a, b, c). None of the other congeners were detected.

Table 5-1. Blood test results

PCB Congener	Blood Test Results (µg/L)		
	Baseline Sample (May 11, 2016)	**Mid-study Sample (October 18, 2016)**	**Final Sample (November 18, 2016)**
PCB 28	0.020 U	**0.021**	**0.022**
PCB 44	0.010 U	0.010 U	0.010 U
PCB 52	0.010 U	**0.011**	**0.011**
PCB 66	0.010 U	0.010 U	0.010 U
PCB 74	0.020 U	0.020 U	0.020 U
PCB 101	0.010 U	0.010 U	0.010 U
PCB 118	0.020 U	0.020 U	0.020 U
PCB 138	0.040 U	0.040 U	0.040 U
PCB 153	0.080 U	0.080 U	0.080 U
PCB 156	0.010 U	0.010 U	0.010 U
PCB 180	0.080 U	0.080 U	0.080 U

Note: Sample results in **bold** indicate detected values.
U – not detected at the concentration shown
PCB – polychlorinated biphenyl

5.1 Interpreting Sampson's Blood Test Results

5.1.1 Blood concentrations relative to human populations

Along with the test results shown in Table 5-1, the University of Washington veterinary services provided information regarding the 95th percentile of PCB concentrations in human blood for the populations in both the United States and Canada (NMS 2016a, b, c). Concentrations detected in Sampson's blood and/or the RLs for the congeners were lower in all cases relative to these 95th percentile PCB concentrations reported for the general population in the United States and Canada (Table 5-2).

[11] The subset of PCB congeners analyzed in Sampson's blood samples was selected based on previous testing done by the University of Washington veterinary services.

Table 5-2. Blood level concentrations in general population

PCB Congener	Maximum Values from Sampson's Blood Test Samples (µg/L)	Blood Level Concentrations in the Human Population (µg/L)	
		95th Percentile in the US Population (NHANES 2003-2004)[a]	95th Percentile in the Canadian Population (Health Canada 2007-2009)[a]
PCB 28	**0.022**	0.068	0.05
PCB 44	0.010 U	0.032	not available
PCB 52	**0.011**	0.044	not available
PCB 66	0.010 U	0.025	0.03
PCB 74	0.020 U	0.15	0.10
PCB 101	0.010 U	0.033	0.03
PCB 118	0.020 U	0.22	0.12
PCB 138	0.040 U	0.48[b]	0.28
PCB 153	0.080 U	0.63	0.54
PCB 156	0.010 U	0.10	0.07
PCB 180	0.080 U	0.54	0.49

Note: Sample results in **bold** indicate detected values.

[a] Values as provided in blood test analytical reports from the University of Washington veterinary services (NMS 2016a, b, c) and as reported by the CDC (2009) and Health Canada (2010).

[b] Value reported is for a combination of PCB 138 and PCB 158.

NHANES – National Health and Nutrition Examination Survey

PCB – polychlorinated biphenyl

U – not detected at the concentration shown

5.1.2 Literature search

To further evaluate any potential health effects associated with Sampson's exposure to PCBs, a literature search was conducted to find additional information regarding 1) PCB concentrations in blood associated with effects, 2) toxicity of PCBs via inhalation, and 3) other information regarding PCB toxicity to dogs. The information collected as part of this search is summarized in the following bullets:

- **PCB concentrations in blood and effects** – Toxicity reference values (i.e., thresholds above which adverse health effects are expected) were not available for PCBs in blood samples, so the link between the PCB concentrations in the blood tests and potential toxicity could not be directly evaluated.
- **PCB toxicity via inhalation** – Limited data are available regarding the effects of exposure to PCBs via inhalation (Lehmann et al. 2015), particularly exposures similar to those experienced by Sampson in this pilot study. Results from a few relevant studies are as follows:
  - Although diet is generally assumed to be the primary route of PCB exposure, several studies have assessed overall PCB exposure in humans and have concluded that exposure via indoor inhalation may be an important source of PCBs (Ampleman et al. 2015; Lehmann et al. 2015). This finding indicates that given sufficient duration of exposure or concentration of PCBs, inhalation may be an important exposure

pathway for PCBs. However, insufficient information was available to link these exposure studies with the results of Sampson's blood tests from this pilot study.

- Studies of rats exposed to PCBs through "nose-only" inhalation found that health effects were minimal, both for shorter-term exposure to higher concentrations (Hu et al. 2010) and intermediate-term exposure to lower concentrations (Hu et al. 2012). Details are described as follows:
  - Shorter-term exposure (Hu et al. 2010) – Rats were exposed via inhalation to either acutely (total of 2 hours at a concentration of 2.4 mg/m^3) or sub-acutely (2 hours per day for 10 days at a concentration of 8.2 mg/m^3).
  - Intermediate-duration exposure (Hu et al. 2012) – Rats were exposed for 1.6 hours/day for four weeks at a concentration of 520 $\mu g/m^3$ (± 10 $\mu g/m^3$).

  Although air concentrations were not measured as part of the pilot study, it is anticipated that Sampson's exposure in this pilot study would likely be more similar to the 2012 study (i.e., intermediate duration exposure to lower concentrations.

- **Other information regarding dogs and PCB exposure** – Schilling et al. (1988) evaluated PCB concentrations in dogs in both contaminated and uncontaminated areas. For dogs living in the contaminated area of Indiana where the average concentration of PCBs in soil was 9,000 mg/kg, the authors found the median blood concentration of Aroclor 1260 PCBs in dogs to be 3.0 parts per billion (ppb) (approximately 3.0 µg/L).[12] For dogs living in an uncontaminated location (Atlanta, Georgia; average soil concentration not reported), dogs were found to have median blood concentration of Aroclor 1260 PCB of 1.7 ppb (approximately 1.7 µg/L). PCB contamination was present in the soil in Indiana in this study, so exposure was expected to have occurred through several exposure routes (i.e., inhalation, dermal exposure, and incidental ingestion).

5.2 SUMMARY

During this pilot study, Sampson's exposure to PCBs can be characterized as follows:

- Exposure was short-term (the pilot study duration was approximately six months) and occurred only periodically (i.e., during training and site visits).
- Concentrations were generally less than 1 mg/kg; exposure to higher concentrations (e.g., more than 10 mg/kg) was limited to select site visits and some training materials.
- Exposure occurred primarily via inhalation. Limited dermal exposure and incidental ingestion may have occurred also, although these pathways were minimized to the extent possible (e.g., through bathing, wiping off Sampson's face, and use of protective gear such as booties in the field).

[12] When referring to PCB concentrations in blood, concentrations in ppb are approximately equal to those in µg/L, such as those presented in Table 5-1 and 5-2.

Based on the results of Sampson's blood tests, the type of exposure, and the available literature summarized in Section 5.1, the overall risk associated with Sampson's exposure to PCBs is low. However, additional research is needed regarding exposure to PCBs via inhalation to fully understand the potential for risks associated with using detection dogs to find sources of PCBs.

6 Discussion and Conclusions

This section presents a discussion of the study conclusions (Section 6.1) and considerations for future work (Section 6.2).

6.1 Key Conclusions

Overall, the pilot study was a success, and both objectives identified as study goals were achieved (Table 6-1). More details regarding the capabilities of the detection dog team and the key lessons learned are presented in the subsections that follow.

Table 6-1. Summary of results relative to study objectives

Objective	Outcome
Objective 1: Train a dog to detect PCBs.	Sampson was able to detect PCBs successfully, both in controlled tests (Phase 1) and in field testing (Phase 2/3).
Objective 2: Determine the potential utility of a detection dog to identify sources of PCBs in the LDW drainage basin.	Sampson's success at detecting PCBs at industrial sites in Phase 2/3 indicates that the use of a detection dog can be incorporated as an important tool in future SPU source control work.

LDW – Lower Duwamish Waterway
PCB – polychlorinated biphenyl
SPU – Seattle Public Utilities

6.1.1 Detection dog team capabilities

The following bullets summarize information learned during the pilot study related to the capabilities of the detection dog team:

- **Low detection limits** – During controlled field testing, Sampson was able to detect PCBs at concentrations as low as 0.1 mg/kg dw (Section 3). Sampson detected PCBs at similarly low levels during field testing (Table 4-18).
- **Highly efficient search ability** – The detection dog team was able to quickly and effectively screen large areas on industrial sites for PCBs, and was successful at both finding sources of PCBs and showing a lack of interest in their absence. For example, at one site, Sampson quickly identified a hotspot in soil with Toxic Substances Control Act (TSCA)-level PCB contamination (63.81 mg/kg) that would have not have been found by SPU investigators without extensive investigation and sampling (Section 4.2.14).
- **Ability to detect PCBs in a variety of media** – Sampson was able to detect PCBs in a variety of media types during field testing. He was particularly effective at identifying PCB-contaminated caulk/paint on buildings, and was able to locate more unusual contaminated objects. For example, at one site, Sampson alerted to a plastic milk crate

on the side of the road; solids were removed from the crate, and PCBs in those solids were detected at a concentration of 74.5 mg/kg (Section 4.2.12).

6.1.2 Lessons learned

The following bullets summarize key lessons learned during the pilot study about the process of using a detection dog to locate PCBs:

- **Detection dog team confidence is important.** – The development of confidence for both the detection dog and the handler is key to the success of the detection team in identifying PCBs. As described in Section 2.2.5, the necessary confidence was achieved when the team visited sites where immediate rewards could be given to the detection dog (because of either previous site characterization or PCBs were present at levels sufficiently high to be smelled by humans). The ability of the detection team to visit these types of sites independently (i.e., without outside observers that can unintentionally put pressure on the dog and handler) will be an important component of future training.
- **PCBs have a recognizable odor that can be smelled by humans.** – Human team members were generally able to smell PCBs at concentrations above 50 mg/kg, and were sometimes able to smell PCBs at concentrations below this level. In spiked samples used for training and the Phase 1 testing, some human individuals were able to smell PCBs at concentrations as low was 0.1 mg/kg, although concentrations at such levels could not be detected by humans during field testing.
- **The detection of an invisible target such as PCBs has unique challenges.** – Compared with the typical detection work performed by CK9 (e.g., scat detection), PCBs are unique in that no visual confirmation is available to confirm that the detection dog is alerting correctly (i.e., PCBs are an “invisible target”). The ability of human team members to smell PCBs was useful in many cases; at times, however, it also resulted in conflicting feelings of confidence from the handler when Sampson alerted, but human team members could not smell PCBs. In these cases, it is likely that PCBs were present, but were below levels that could be detected by humans.
- **Advanced field training incorporating immediate rewards is key to achieving field readiness.** – As described in Section 2.2.5, field readiness (i.e., the detection dog is able to successfully identify targets with confidence and is “locked-in” on the target in question) was not achieved until the team was able to visit industrial sites where immediate rewards could be provided. This occurred both at sites where sufficient characterization had been conducted to identify sources of PCB, and at sites where PCBs were present at levels sufficiently high to be smelled by the human team members. In the future, the ability to visit field sites where immediate rewards can be provided will be an essential component in 1) training additional detection dogs to find PCBs or other chemicals, and 2) refresher training to maintain field readiness and boost the confidence of the detection dog team. Applying this information to training future detection dogs will significantly shorten the timeline necessary to achieve field readiness.

- **Identification of sources/hotspots is the best use of detection dogs.** – The results of this pilot study indicate that detection dogs are best suited to screening areas to eliminate those that do not require further investigation (i.e., PCBs not present), or to locating specific PCB sources (i.e., hotspots), rather than to defining the extent of PCB contamination. This conclusion is not surprising, since Sampson is trained to seek out the strongest PCB smell (i.e., highest concentration), and would thus bypass areas with lower concentrations, even though the results of this study indicate that he is able to smell PCBs at lower concentrations.
- **Differing representativeness of study samples makes interpretation of results difficult.** – The study team was not always able to collect samples that were representative of the target to which Sampson alerted. For example, in some cases, the project team sampled moss/dirt at the base of a wall where Sampson appeared to alert to the caulking (i.e., low sample representativeness), because of the desire to avoid sampling building materials that could trigger TSCA remediation for building owners who generously allowed access to their site for this pilot study. In addition, if PCB contamination was present at depth (i.e., buried below the surface layer where the samples were collected), then samples collected from surface soil (e.g., 0–10 cm) may not have been representative of what Sampson was smelling. Such samples of low representativeness, documented throughout Section 4, were not always useful in confirming Sampson's response.
- **Detection work during windy conditions should be avoided.** – Attempts to conduct site visits during windy conditions proved challenging for the detection dog. This was particularly evident when working in and around buildings (as often occurs at industrial sites), because of the way buildings complicate wind patterns. Efforts should be made to avoid windy conditions during future work.
- **The detection dog team was highly motivated to find PCBs.** – The desire of the detection dog team (particularly the handler) to be successful in identifying sources of PCBs may have resulted in an area where PCBs were not present being overworked, which caused frustration for both the dog and handler. Care should be taken during future work to minimize the number of outside observers, and to emphasize to the handler that not finding PCBs at a site is also a useful conclusion.

6.2 NEXT STEPS

Based on the results of the pilot study, the following step should be considered as part of future work to better understand the abilities of a detection dog to detect PCBs, and to determine how dogs could be incorporated into source control work:

- **Conduct additional testing to better understand the effects of weather on detection dog searches.**
  - Revisit sites where source tracing was conducted during windy weather. Wind is a particularly difficult condition for detection dogs to contend with when buildings are present (as was the case at most of the industrial sites visited during Phase 2/3 of

this study). Buildings complicate wind patterns, which impacts the detection dog's ability to trace odors.

- Conduct site visits during warmer weather to test whether this improves Sampson's ability to locate PCBs (the majority of the Phase 2/3 tests were conducted on relatively cool days when temperatures ranged from 30ºF to 60ºF; Table 4-1), or whether cooler days are preferable.

- **Compare site characterization methods**. Evaluate whether using the detection dog results in better and more cost-effective characterization of a site and identification of hotspots than standard SPU practices (e.g., random sampling and/or sampling determined based on site characteristics/historical information).
- **Incorporate detection dogs into source tracing.** Based on the success of this pilot study, SPU will work to develop a plan for how to best incorporate a detection dog into its standard source tracing program.

7 Supplemental Information: Summary of Sample Results

Site Information				Sample Information							Study Results		Sample Results (mg/kg)								
Date of Site Visit	Site Description	Site No.	Loc ID	Sample ID	Station ID[a]	Sample Date	SDG	Sample Location Description	Material	Representative-ness of Sample Relative to Target	Sampson Response	Handler Gestalt	TOC (%)	Aroclor 1016	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260	Total PCBs
11/07/16	Commercial site	1	1a	MJ-110716-4	ODS31	11/07/16	16K0103	Around orange Bloch Steel dumpster	Dirt	High	Strong positive	Medium	4.82	0.0178 U	0.0178 U	0.0178 U	**0.658**	0.0178 U	**0.183**	**0.332 J**	**1.173 J**
		1	1b	MJ-110716-5	ODS33	11/07/16	16K0103	Along fence line behind fiber board dumpster	Dirt	High	Strong positive	High	7.53	0.089 U	0.089 U	0.089 U	**1.47**	0.089 U	**0.834**	0.089 U	**2.304**
		1	1c	MJ-110716-6	ODS34	11/07/16	16K0103	East wall of building south of loading dock	Dirt with white sand/gravel	Moderate	Moderate positive	Medium	11.5	0.0178 U	0.0178 U	0.0178 U	0.0178 U	**0.0842**	**0.129**	**0.271**	**0.4842**
		1	1d	MJ-110716-7	ODS35	11/07/16	16K0103	East wall of building adjacent to loading dock	Dirt with white sand/gravel	Moderate	Moderate positive	Medium	6.18	0.0173 U	0.0173 U	0.0173 U	0.0173 U	**0.169**	**0.202**	**0.312**	**0.683**
		1	1e	MJ-110716-8	ODS36	11/07/16	16K0103	Loading dock, north side of driveway	Dirt	High	Moderate positive	High	1.04	0.0169 U	0.0169 U	0.0169 U	0.0169 U	**0.595**	**0.584**	0.0169 U	**1.179**
		1	1f	MJ-110716-9	ODS32	11/07/16	16K0103	Edge of parking lot by Ecology blocks	Dirt	NA	None	Medium	1.7	0.0178 U	0.0178 U	0.0178 U	0.0178 U	**0.038**	**0.022**	0.0178 U	**0.06**
		1	1g	MJ-110716-1	RCB353	11/07/16	16K0104	NE corner 6th Ave S and S Walker St	SD solids	NA	NA	NA	13	0.182 U	0.182 U	0.182 U	**5.20**	0.182 U	0.638 Y	0.182 U	**5.2**
		1	1g	MJ-110716-2	RCB353	11/07/16	16K0104	Duplicate MJ-110716-1	SD solids	NA	NA	NA	13.1	0.183 U	0.183 U	0.183 U	**5.42**	0.183 U	0.551 Y	0.183 U	**5.42**
		1	1h	MJ-110716-3	RCB352	11/07/16	16K0104	SE corner 6th Ave S and S Walker St	SD solids	NA	NA	NA	5.1	0.0911 U	0.0911 U	0.0911 U	**1.52**	0.0911 U	0.273 Y	0.0911 U	**1.52**
11/10/16	Commercial site	2	2a	MKJ-111016-1	ODS27	11/10/16	16K0151	Base of south wall of building, in fenced yard loading dock at NW corner of property	Dirt/moss	Moderate to low	Strong positive	Medium	9.81	0.387 U	0.387 U	0.387 U	0.387 U	0.387 U	**5.95**	0.387 U	**5.95**
		2	2b	MKJ-111016-2	ODS28	11/10/16	16K0151	North side of building by roof downspout	Dirt	NA	None	High	9.32	0.0192 U	0.0192 U	0.0192 U	0.0192 U	0.0192 U	**0.412**	**0.133**	**0.545**
		2	2c	MKJ-111016-3	ODS30	11/10/16	16K0151	South side of building along edge of stone/mortar wall	Dirt/moss	Low	Moderate positive	Medium	9.11	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
		2	2d	MKJ-111016-4	ODS29	11/10/16	16K0151	East side of building by roof downspout	Street dirt/moss	Low	Moderate positive	Low	14.5	0.0957 U	0.0957 U	0.0957 U	0.0957 U	0.0957 U	**0.312**	0.0957 U	**0.312**
11/15/16	Commercial site	3	3a	Lamar-1	ODS19	11/15/16	16K0219	Painted objects in west yard	Surface wipe	Uncertain	Strong positive	High	-	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
		3	3b	Lamar-2	ODS20	11/15/16	16K0219	Painted objects in west yard	Surface wipe	Uncertain	Moderate positive	Medium	-	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
		3	3c	Lamar-3	ODS21	11/15/16	16K0219	Painted objects in west yard	Surface wipe	NA	None	High	-	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
		3	3d	Lamar-4	--	11/15/16	16K0219	Wipe blank	Surface wipe	NA	NA	NA	-	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
11/15/16	7th Ave South between South Monroe St & South Elmgrove St	4	4a	Elmgrove-1	ODS23	11/15/16	16K0219	North side of gravel berm, south side of vacant lot	Dirt	Uncertain	Moderate positive	Medium	0.81	0.0193 U	0.0193 U	0.0193 U	0.0193 U	0.0193 U	0.0193 U	**0.0229**	**0.0229**
		4	4b	Elmgrove-2	ODS24	11/15/16	16K0219	North side of gravel berm, south side of vacant lot	Dirt	Uncertain	Moderate positive	Medium	0.57	0.0184 U	0.0184 U	0.0184 U	0.0184 U	0.0184 U	0.0184 U	0.0184 U	0.0184 U
		4	4c	Elmgrove-3	ODS25	11/15/16	16K0219	West side of gravel berm, east side of vacant lot	Dirt	Uncertain	Low positive	Low	0.34	0.0187 U	0.0187 U	0.0187 U	0.0187 U	0.0187 U	0.0187 U	0.0187 U	0.0187 U
		4	4d	Elmgrove-4	ODS26	11/15/16	16K0219	North end of berm along the east side of vacant lot	Dirt	NA	None	Medium	0.54	0.0194 U	0.0194 U	0.0194 U	0.0194 U	0.0194 U	**0.0432**	**0.0335**	**0.0767**
		4	4e	Elmgrove-5	ODS22	11/15/16	16K0219	SW corner of vacant lot	Dirt	NA	None	High	0.22	0.0186 U	0.0186 U	0.0186 U	0.0186 U	0.0186 U	0.0186 U	0.0186 U	0.0186 U
11/16/16	Commercial site	6	6a	MKJ-111616-1	CB321	11/16/16	16K0241	CB along west wall of building by refrigeration units	CB solids	Uncertain	Moderate positive	Low/ medium	6.91	0.0198 U	0.0198 U	0.0198 U	0.0198 U	0.0198 U	0.0198 U	**0.609 J**	**0.609 J**
		6	6b	MKJ-111616-2	ODS15	11/16/16	16K0241	SW corner of property, paint chips collected from trough of structural steel I-beam in pile	Paint chips	High	Strong positive	High	-	3.85 U	3.85 U	3.85 U	3.85 U	3.85 U	28.8 Y	**130**	**130**
		6	6c	MKJ-111616-3	ODS16	11/16/16	16K0241	SW side of property, storage crate with yard sweeping (contained dirt and paint chips)	Yard sweeping material	High	Strong positive	Medium	10.8	4.37 U	4.37 U	4.37 U	4.37 U	4.37 U	4.37 U	**31.5**	**31.5**
		6	6d	MKJ-111616-4	ODS17	11/16/16	16K0241	Between transformer pad and west wall of building	Dirt	High	Moderate/low positive	Low	4.43	0.0175 U	0.0175 U	0.0175 U	0.0175 U	0.0175 U	**0.143**	**0.185**	**0.328**
		6	6e	MKJ-111616-5	ODS18	11/16/16	16K0241	West fence line	Moss/dirt	NA	None	Low/ medium	6.63	0.0196 U	0.0196 U	0.0196 U	0.0196 U	0.0196 U	**0.0716**	**0.934 J**	**1.0056 J**
11/17/16	Downtown Tacoma	8	8B-a	MKJ-111716-1	ODS46	11/17/16	16K0250	Pacific Plaza parking garage, base of parapet wall	Caulk/paint	High	Strong positive	High	NA	3880 U	3880 U	3880 U	3880 U	3880 U	**91700**	**72400**	**164100**
		8	8B-b	MKJ-111716-2	ODS47	11/17/16	16K0250	Elevator entrance area	Rubberized paint, concrete sealant	High	Strong positive	High	NA	7.55 U	7.55 U	7.55 U	7.55 U	7.55 U	49.6	19.9	69.5
		8	8C-a	MKJ-111716-3	ODS48	11/17/16	16K0250	Base of bldg. at SE corner 9th Ave S and S Fawcett St	Moss	Low	Strong positive	High	NA	104 U	104 U	104 U	104 U	104 U	763	104 U	763
12/14/16	SPU OCC	9	9b	MKJ-121416-1	ODS37	12/14/16	16L0239	Along SW corner by door at carpenter shop	Moss/dirt	Low	Moderate/low positive	Low	-	0.0191 U	0.0191 U	0.0191 U	0.0191 U	**0.0417**	**0.199**	**0.238**	**0.4787**
12/14/16		10	10f	MKJ-122116-3	CB237	12/21/16	16L0321	CB in parking lot south side building at 601 S Snoqualmie St (Fkey 3487454)	SD solids	Uncertain	Moderate/low positive	Low/ medium	13.9	0.0193 U	0.0193 U	0.0193 U	0.0193 U	0.145 Y	**0.574**	**0.217**	**0.791**

Site Information				Sample Information							Study Results		Sample Results (mg/kg)								
Date of Site Visit	Site Description	Site No.	Loc ID	Sample ID	Station ID[a]	Sample Date	SDG	Sample Location Description	Material	Representative-ness of Sample Relative to Target	Sampson Response	Handler Gestalt	TOC (%)	Aroclor 1016	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260	Total PCBs
	South Snoqualmie St area	10	10g	MKJ-122116-4	RCB72	12/21/16	16L0321	CB at NE corner 6th Ave S and S Alaska St (#572802)	SD solids	Uncertain	Moderate/low positive	Low/ medium	19.7	0.0193 U	0.0193 U	0.0193 U	0.0193 U	**0.035**	**0.066**	**0.0483**	**0.1493**
12/14/16	24th Ave South & South Washington St	11	11b	MKJ-122116-2	RCB251	12/21/16	16L0321	CB at NE corner S Washington St and 24th Ave S	SD solids	Uncertain	Moderate positive	Medium	22.2	0.0197 U	0.0197 U	0.0197 U	0.0197 U	0.0197 U	0.0497 Y	**0.0354**	**0.0354**
		11	11c	MKJ-122116-1	RCB67	12/21/16	16L0321	CB at NW corner S Washington St and 24th Ave S (#949648)	SD solids	NA	None	Medium	4.18	0.0194 U	0.0194 U	0.0194 U	0.0194 U	0.0194 U	**0.0282**	**0.0242**	**0.0524**
12/14/16	South Myrtle St and Fox Ave South	12	12b	MKJ-121416-2	ODS38	12/14/16	16L0239	Near CB on west side of Fox Ave S, plastic milk crate	Methanol wash	Moderate	Strong positive	High	-	2.45 U	2.45 U	2.45 U	74.5	2.45 U	2.45 U	2.45 U	74.5
		12	12c	MKJ-122216-1	ODS38	12/22/16	16L0332	Soil adjacent to MKJ-122216-2 where plastic crate found	Soil	Moderate	Moderate positive	Medium	3.56	0.0188 U	0.0188 U	0.0188 U	0.0188 U	**0.0811**	0.13	0.149	0.3601
		12	12e	MKJ-122216-2	RCB179	12/22/16	16L0332	CB east side of Fox Ave S (#576051)	SD solids	NA	NA	NA	7.02	0.0184 U	0.0184 U	0.0184 U	0.0184 U	**0.261**	0.195	0.106	0.562
12/15/16	South Kenyon St & 8th Ave South	13	13b	MKJ-122916-2	RCB229	12/29/16	16L0392	CB at plant driveway, north (#577063)	SD solids	Uncertain	Moderate positive	Medium	1.79	0.0189 U	0.0189 U	0.0189 U	0.0189 U	**0.0238**	**0.0531**	**0.0869**	**0.1638**
		13	13c	MKJ-122916-3	RCB310	12/29/16	16L0392	CB at plant driveway, south (#577078)	SD solids	Uncertain	Moderate positive	Medium	5.89	0.0199 U	0.0199 U	0.0199 U	0.0199 U	**0.0723**	**0.126**	**0.175**	**0.3733**
		13	13d	MKJ-122916-4	RCB279	12/29/16	16L0392	CB west side of 8th Ave S across from plant driveway, north (#577062)	SD solids	NA	None	Medium	1.84	0.018 U	0.018 U	0.018 U	0.018 U	**0.0633**	**0.183**	**0.273**	**0.5193**
		13	13e	MKJ-122916-5	RCB311	12/29/16	16L0392	CB west side of 8th Ave S across from plant driveway, south (#577076)	SD solids	NA	None	Medium	0.86	0.0186 U	0.0186 U	0.0186 U	0.0186 U	**0.019**	0.0186 U	**0.0388**	**0.0578**
		13	13f	MKJ-122216-3	ODS50	12/22/16	16L0332	South side of IM#2. Cracks in concrete panel	Street dirt	Uncertain	Moderate/low positive	Low/ medium	2.91	0.0183 U	0.0183 U	0.0183 U	0.0183 U	**0.127**	**0.197**	**0.167**	**0.491**
		13	13h	MKJ-122216-4	RCB278	12/22/16	16L0332	CB north side of S Kenyon St	SD solids	Uncertain	Moderate/low positive	Low/ medium	12.5	0.0197 U	0.0197 U	0.0197 U	0.0197 U	**0.0923**	**0.131**	**0.0789**	**0.3022**
		13	13i	MKJ-122216-5	RCB74	12/22/16	16L0332	CB south side of S Kenyon St opposite RCB278 (#907769)	SD solids	Uncertain	Moderate/low positive	Low/ medium	2.77	0.0188 U	0.0188 U	0.0188 U	0.0188 U	**0.0211**	**0.0357**	**0.0359**	**0.0927**
		13	13j	MKJ-121516-1	ODS39	12/15/16	16L0240	North side of S Kenyon St, across from blue door at 816	Street dirt	Moderate	Moderate positive	Medium	-	0.0177 U	0.0177 U	0.0177 U	0.0177 U	**0.154**	**0.186**	**0.163**	**0.503**
12/15/16	South Elmgrove St	14	14b	MKJ-121516-2	ODS40	12/15/16	16L0240	Planter strip on north side of S Elmgrove St adjacent to driveway	Dirt	High	Strong positive	High	-	1.85 U	1.85 U	1.85 U	1.85 U	**57.2**	13.9 Y	**6.61**	**63.81**
		14	14c	MKJ-121516-3	ODS41	12/15/16	16L0240	Along plant 1 fence line directly opposite of MKJ-121516-2	Dirt	NA	NA	NA	-	0.885 U	0.885 U	0.885 U	0.885 U	**39.5**	0.885 U	7.41	46.91
		14	14e	MKJ-122116-10	RCB73	12/22/16	16L0321	CB NW corner S Elmgrove St and 8th Ave S (#577392)	SD solids	NA	None	Medium	11.1	0.0197 U	0.0197 U	0.0197 U	0.0197 U	**0.297**	**0.38**	**0.247**	**0.924**
12/15/16	South Austin St	15	15a	MKJ-121516-4	ODS42	12/15/16	16L0240	5 ft. north of p pole 1379076 at base of west gate post	Street dirt	Moderate to low	Moderate positive	Low/ medium	-	0.188 U	0.188 U	0.188 U	0.188 U	0.188 U	**0.621**	**2.03**	**2.651**
		15	15b	MKJ-121516-5	ODS43	12/15/16	16L0240	75 ft. east of 2nd Ave S, north side of S Austin St	Street dirt	Moderate to low	Moderate positive	High	-	0.017 U	0.017 U	0.017 U	0.017 U	0.017 U	**0.0466**	**0.0496**	**0.0962**
		15	15c	MKJ-121516-6	ODS44	12/15/16	16L0240	NE corner of 2nd Ave S and S Austin St	Street dirt	Moderate to low	Moderate positive	Medium/ high	-	0.0172 U	0.0172 U	0.0172 U	0.0172 U	0.0172 U	**0.0792**	**0.425**	**0.5042**
		15	15d	MKJ-122116-5	RCB139	12/21/16	16L0321	Junction box north side of street opposite old recycling site	SD solids	Uncertain	Moderate/low positive	Medium	6.15	0.0182 U	0.0182 U	0.0182 U	0.0182 U	**0.0358**	**0.105**	**0.16**	**0.3008**
		15	15e	MKJ-122116-6	RCB203	12/21/16	16L0321	North side of street, 2nd CB east of 2nd Ave S (#779588)	SD solids	Uncertain	Moderate/low positive	Medium	2.11	0.0171 U	0.0171 U	0.0171 U	0.0171 U	**0.0585**	**0.0523**	**0.0728**	**0.1836**
		15	15e	MKJ-122116-7	RCB203	12/21/16	16L0321	Duplicate of MKJ-122116-6	SD solids	Uncertain	Moderate/low positive	Medium	2.83	0.018 U	0.018 U	0.018 U	0.018 U	**0.0334**	**0.0506**	**0.0958**	**0.1798**
		15	15f	MKJ-122116-8	RCB70	12/21/16	16L0321	North side of street, 3rd CB east of 2nd Ave S (#779589)	SD solids	Uncertain	Moderate/low positive	Medium	2.74	0.0183 U	0.0183 U	0.0183 U	0.0183 U	**0.0244**	**0.0478**	**0.0763**	**0.1485**
		15	15g	MKJ-122116-9	RCB71	12/21/16	16L0321	South side of street, 1st CB east of 2nd Ave S (#956180)	SD solids	NA	None	Medium	12.1	0.0192 U	0.0192 U	0.0192 U	0.0192 U	**0.057**	**0.166**	**0.643**	**0.866**
12/15/16	South Chicago St	16	16a	MKJ-122916-1	RCB165	12/29/16	16L0392	CB, south side of S Chicago St (#779611)	SD solids	NA	None	Medium/ high	1.08	0.0197 U	0.0197 U	0.0197 U	0.0197 U	0.0197 U	0.0197 U	0.0197 U	0.0197 U

OCC – operations control center

[a] Station IDs are assigned to specific geographic locations and do not change when additional samples are collected at these locations. CB = private catch basin; RCB = catch basin in the right-of-way; ODS = outside of the drainage system.

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