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ECOLOGY
State of Washington

Quality Assurance Project Plan

PCBs in Washington State Products

November 2021

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Each study conducted by the Washington State Department of Ecology must have an approved Quality Assurance Project Plan (QAPP). The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

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Quality Assurance Project Plan

PCBs in Washington State Products

by Kari Trumbull

November 2021

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Signatures are not available on the Internet version.
EAP: Environmental Assessment Program
HWTR: Hazardous Waste and Toxics Reduction Program
HQ: Department of Ecology Headquarters, Olympia

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2.0 Abstract

Polychlorinated biphenyls (PCBs) are considered persistent, bioaccumulative, and toxic chemicals (PBTs). PCBs persistent in the environment, build up in the food chain, and can cause adverse health effects in humans and wildlife. Exposure is associated with many health problems, including cancer and harm to immune, nervous, and reproductive systems. PCBs disrupt thyroid hormone levels in animals and humans, hindering growth and development.

PCBs were manufactured as chemical mixtures made up of a variety of the different congeners. The most common commercial PCB mixtures in the U.S. are known by their industrial trade name, Aroclor. Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs have been used in hundreds of industrial and commercial applications.

PCBs from historical intentional use in products, referred to as *legacy* PCBs, continue to be a contaminant source due to the persistence of the chemicals in the waste stream and environment. Although the manufacture of PCBs for intentional use in products was banned more than 30 years ago, PCBs can still be found in products. PCBs that are not intentionally added to products, but are instead produced as an unintended byproduct of the manufacturing process, are referred to as *inadvertent* PCBs. Processes that may result in the creation of inadvertent PCBs involve carbon, chlorine, and high temperatures, such as the production of pigments, dyes, and other chlorinated chemicals. While legacy PCBs are still present in some products currently in use, and are still the main source of environmental contamination, inadvertent PCBs are the predominant source of new PCBs in products.

The Product Testing program at the Washington State Department of Ecology (Ecology) has conducted studies to assess the levels of PCBs in products. This quality assurance project plan (QAPP) describes the current standardized procedures for conducting product testing studies for PCBs in order to further study the extent to which products contain these chemicals.

In addition, Ecology will conduct a 2021 study event to assess the levels of PCBs in some products in the printing inks product category. Data from this study will assist Ecology's Safer Products for Washington program in the next phase of their implementation process, which is to determine whether regulatory actions are needed for priority chemical-product combinations.

3.0 Background

3.1 Introduction and problem statement

Polychlorinated biphenyls (PCBs) are a family of synthetic chemicals consisting of two benzene rings joined together (a biphenyl molecule) and containing 1 to 10 chlorine atoms attached to the benzene rings (ATSDR 2000). Figure 1 shows the basic structure of PCBs, where the numbers 2-6 and 2'- 6' represent possible substitution locations for chlorine. There are 209 possible configurations of chlorine positions around the biphenyl molecule. The 209 individual PCB compounds are known as congeners and designated by a congener number 1 through 209 (EPA 2020).

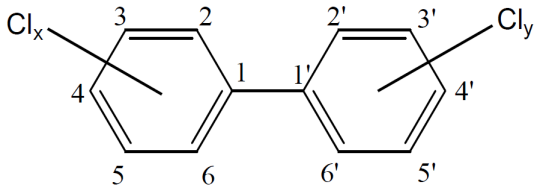

Figure 1. The general chemical structure of chlorinated biphenyls (ATSDR, 2000).

PCBs were manufactured as chemical mixtures made up of a variety of the different congeners. The most common commercial PCB mixtures in the U.S. are known by their industrial trade name Aroclor (EPA 2020). Aroclors are identified by number (e.g., 1254), with the last two digits representing the percent content of chlorine; higher Aroclor numbers reflect higher chlorine content (ATSDR 2000). Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications (Ecology and Health, 2015).

PCBs are identified as persistent, bioaccumulative, and toxic chemicals (PBTs) by many agencies and organizations including the Washington State Department of Ecology (Ecology). PCBs are persistent in the environment, build up in the food chain, and can cause adverse health effects in humans and wildlife including cancer and harm to immune, nervous, and reproductive systems (Ecology and Health, 2015).

The manufacture of PCBs, such as Aroclors, for intentional use in products was banned more than 30 years ago by the U.S. Environmental Protection Agency (EPA). Products may still contain PCBs up to 50 parts per million (ppm) under the U.S. Toxic Substances Control Act (TSCA; EPA 1979). However, PCBs continue to be inadvertently generated as byproducts in manufacturing processes, and are referred to as inadvertent PCBs (Panero et al. 2005). These inadvertent PCBs have been detected in products at levels below 50 ppm. Processes that may result in the creation of inadvertent PCBs involve carbon, chlorine, and high temperatures, such as the production of pigments, dyes, and other chlorinated chemicals (Panero et al. 2005). Inadvertent PCBs may be released to their environment from products when present, both during their use and eventual disposal.

In 2015, Ecology and the state Department of Health (Health) developed a Chemical Action Plan to address PCBs (Ecology and Health, 2015). Chemical Action Plans identify, characterize, and evaluate all uses and releases of PBTs on Washington's PBT List and provide recommendations for actions to protect human health and the environment (Chapter 173-333 Washington Administrative Code).

In 2004, Governor Gary Locke's Executive Order 04-01 required state agencies to reduce the use and purchase of products that contain PBTs. Subsequently, in 2014, Washington State law [Revised Code of Washington (RCW) 39.26.280 and RCW 39.26.290] required state agencies to limit the purchase of products and packaging containing PCBs. The state Department of Enterprise Services (DES) leads the implementation of the law. In 2019, DES Policy (DES-280-00, 2019) established the purchasing preference to incentivize the State's contract suppliers to provide products and product packaging that do not contain PCBs.

In 2019, the Washington State Legislature directed Ecology in consultation with Health to implement a regulatory program to reduce toxic chemicals in consumer products [Revised Code of Washington (RCW) 70.365]. PCBs are one of the five priority toxic chemical classes the law identified. Ecology called the implementation program "Safer Products for Washington." This program identified consumer products that are significant sources and uses of the priority chemicals. The chemical-product combinations for PCBs include paints and printing inks (Ecology, 2020).

The Product Testing program at Ecology has conducted studies to assess the levels of PCBs in products (see Section 3.2.2). This quality assurance project plan (QAPP) describes the current standardized procedures for conducting product testing studies for PCBs to further study the extent to which products contain these chemicals.

In addition, Ecology will conduct a 2021 study to assess the levels of PCBs in some products in the printing inks product category. Data from this study will assist Ecology's Safer Products for Washington program in the next phase of their implementation process, which isto determine whether regulatory actions are needed for priority chemical-product combinations.

3.2 Study area and surroundings

Personal, commercial, and industrial consumer products and children's products available to Washington State residents and businesses either in-store or online will be assessed for inclusion in a study event. Products purchased in-store are frequently purchased in the South Puget Sound region. The practice of purchasing products from larger chain stores and online is used to generally reflect merchandise sold and available to residents across Washington State.

State-purchased products are obtained from contract vendors and contractors administered by Washington State Department of Enterprise Services (DES). In addition, Ecology staff may collect products from individual Washington State agencies that have purchased from contracted vendors.

3.2.1 History of study area

Products purchased and collected during a study event are limited to selection of currently available products in Washington stores, online, and for use at state agencies at the time of the acquisition.

3.2.2 Summary of previous studies and existing data

PCBs have been detected in consumer products and reported in literature. Some examples of products identified to contain PCBs include:

- Paints (Hu and Hornbuckle, 2010).
- Newspapers, glossy magazines, sticky notes, cereal boxes, yellow plastic bags, fabric napkins, and kid's socks, and kids' pajamas (Guo et al. 2014).
- Hand soap, laundry soap, dish soap, shampoo, toothpaste, road paint, deicer, vehicle lubricants, antifreeze, vehicle wash soap, road dust suppressant, asphalt products, thermoplastic tape, as well as hydroseed and other lawn care products (City of Spokane, 2015).

Ecology's product testing program has conducted studies to assess levels of PCBs in some Washington state products.

In 2013, Ecology initiated a study to evaluate the presence of PCBs in general consumer products (Stone, 2013). Particular emphasis was placed on testing products likely to contain PCBs due to the inadvertent production of PCBs in the manufacturing process.

For the 2013 study, 68 products were separated into 74 product samples and tested for four PCB congeners, PCB-11, PCB-206, PCB-208, and PCB-209, associated with inadvertent PCBs during the manufacturing of pigments and dyes and not major constituents in Aroclor mixtures (Stone, 2014a). The product categories included product packaging, paper products, paint and paint colorants, caulks, and a miscellaneous category (printer inks and food samples). PCB-11 was detected above 1 ppb in 55% of the product samples (41 of 74 samples). PCB-206 and PCB-208 were both detected above 1 ppb in only 1 of 74 product samples, a phthalo green colorant. PCB-209 was detected above 1 ppb in 9% of the product samples (7 of 74 samples).

In 2014-2015, Ecology conducted a follow-up study to expand the types of products sampled and PCB congeners analyzed in the original 2013 study (Stone, 2014b). For the 2014-2015 study, 133 additional products were separated into 142 additional product samples and tested for the full suite of 209 PCB congeners. The product categories included:

- children's products
- clothing
- paints, colorants, and dyes
- cosmetics and body care products
- comic books
- newsprint and printed material
- office supplies
- paper containers and boxes
- product labels

- plastic packaging
- road paints
- caulks
- pesticides, lawn and road care
- a miscellaneous category

Several of the samples were collected from state purchased products in the categories of paper containers and boxes, plastic packaging, product labels, road paints, and clothing.

The 74 product samples from the 2013 study were re-analyzed to obtain results for the full suite of 209 PCB congeners. These data were combined with the 2014-2015 study results of 142 product samples tested for the 209 PCB congeners. A total of 216 product samples were analyzed from 201 consumer products.

In 2016, the combined 216 product sample results from 201 consumer products were published into one report (Stone, 2016). The investigational results found 72% of the product samples (156 of 216 samples) selected for testing had total PCBs (sum of congeners) above 1 ppb (parts per billion). Three samples contained total PCBs in the highest concentration over 1,000 ppb: a child's yellow sidewalk chalk at 1,060 ppb, a single-serving cereal packaging at 2,320 ppb, and a yellow foam office product at 2,310 ppb. PCB-11 was detected in about 54% of the product samples (116 of 216 samples) above 1 ppb. For the three samples with total PCBs above 1,000 ppb, PCB-11 accounted for 99% of the total PCB concentration.

In 2017, Ecology conducted a study to assess the levels of PCBs in products available on state contracts (Trumbull 2017a, Trumbull 2017b). The state Department of Enterprise Services (DES) leads the implementation of the law requiring state agencies to limit the purchase of products and packaging containing PCBs (RCW 39.26.280 and 39.26.290). The study was carried out to assist DES and state agencies in identifying where PCBs may be present in some state purchased products.

Some products from 6 product categories were tested: fabrics, vehicle and ferry lubricants, fish hatchery products, janitorial supplies, medical and lab supplies, and flooring material. Product categories were selected based on the likelihood to contain PCBs, products that may be released to the environment when used, high amount of product used, and/or highly consumable. A total of 175 product samples were analyzed for the 209 PCB congeners by EPA Method 1668C. Results from the 2017 study are forthcoming and will be available to the public.

3.2.3 Parameters of interest and potential sources

All 209 PCB congeners will be analyzed in samples of products. The PCB congeners are listed in Appendix A, Table A-1.

PCBs are considered persistent, bioaccumulative, and toxic chemicals (PBTs). PCBs persistent in the environment, build up in the food chain, and can cause adverse health effects in humans and wildlife (Ecology and Health, 2015). Exposure is associated with many health problems, including cancer and harm to immune, nervous, and reproductive systems. PCBs disrupt thyroid hormone levels in animals and humans, hindering growth and development (Ecology and Health, 2015). Wildlife are exposed to PCBs in the water, soil, and sediments, along with in their diet. PCBs in food are the most significant source of exposure for most people, particularly from fish

in the diet. People are also exposed to PCBs in air, water, soil, and house dust. Because PCBs are more readily absorbed than excreted, they accumulate in the body over time. While the levels of PCBs in the environment and in people are mostly declining, PCBs are still widespread. For a more detailed discussion see the Ecology and Health PCB Chemical Action Plan (Ecology and Health, 2015).

Sources of PCBs include "legacy" and "inadvertent" PCBs. The contamination of PCBs from historical intentional use in products, referred to as legacy PCBs, continue to be a source due to the persistence of the chemicals in the waste stream and environment (Ecology and Health, 2015). Although the manufacture of PCBs for intentional use in products was banned more than 30 years ago (EPA, 1979), PCBs can still be found in some products. PCBs that are not intentionally added to products, but are instead produced as an unintended byproduct of the manufacturing process are referred to as inadvertent PCBs (Panero et al. 2005). While legacy PCBs are still present in some products currently in use and are still the main source of environmental contamination, inadvertent PCBs are the predominant source of new PCBs in products (Ecology, 2020).

Historically, PCBs were manufactured in nine major mixtures in the United States called Aroclors. Aroclor was the most common industrial tradename of the technical mixtures of PCB congeners sold in the United States. The nine Aroclor mixtures included Aroclors 1016, 1221, 1232, 1242, 1248, 1254, 1260, 1262, and 1268 (Ecology and Health, 2015). Aroclors had a wide range of uses: electrical transformers and capacitors, heat transfer and hydraulic systems, vacuum pumps and lubricants, surface coatings, adhesives, plasticizers, inks, insulating materials, and pesticides (ATSDR, 2000).

EPA identified 70 likely processes to produce PCBs from about 200 potential chemical processes as part of rulemaking on inadvertently generated PCBs (Panero et al. 2005). Processes likely to produce inadvertent PCBs involve carbon, chlorine, and high temperatures, such as the production of chlorinated chemicals, dyes, and pigment manufacturing (Panero et al. 2005).

Table 1 lists some chemicals determined by EPA to have a high potential for inadvertent PCB generation (based on information adapted from Munoz, 2007). Examples and uses of products that may contain inadvertent PCBs are provided for the chemical. Most of these chemical processes have not been evaluated to determine if inadvertent PCBs are actually a byproduct and present in the final product (Ecology and Health, 2015).

PCB-11 is considered a key indicator of inadvertent PCBs, as it is not typically found in Aroclor mixtures and is primarily associated with pigment manufacturing, especially yellow pigment (Hu and Hornbuckle 2010). The production of at least three classes of organic pigments are known to generate inadvertent PCBs: azo, phthalocyanine, and polycyclic pigments (Heine and Trebilcock, 2018). Figure 2 shows the organic pigments that have been found to contain inadvertent PCBs and the associated PCB congeners (Heine and Trebilcock, 2018).

Ecology determined paints and printing inks are a significant source of inadvertently generated PCBs and listed these product categories as priority products to further investigate in the Safer Products for Washington regulatory program (Ecology, 2020).

Table 1. Some high potential chemicals for inadvertent PCBs with examples of products and uses.

Information adapted from Munoz, 2007

Chemical	Products and Uses
Ethylenediamines	Surfactants, dyes, EDTA, detergents, hair care products, soaps, carbamate fungicides, photography development, cutting oils, washing powders, lubricants for plastics, fuel additives
Ethylene dichloride (or 1,2-dichloroethane)	Polyvinyl chloride (PVC), solvent, fumigant, degreaser, paint remover, fuel additive
Benzoyl peroxide	Plastics such as polyethylene, polyacrylates, and PVC, topical pharmaceuticals
Phenylchlorosilanes	Silicones for seals, hoses, adhesives, coatings, and lubricants
Chlorinated benzidines	Pigments, dyes, printing inks, coatings, textiles, paints, rubber, leather, plastics, polyurethane, protective clothing applications
Perchloroethylene (or tetrachloroethylene)	Solvent for dry cleaning, metal degreaser, processing textiles
Chlorinated paraffins	Plasticizers and/or flame retardants in PVC and other plastics, paints, textiles, rubber, adhesives, sealants, and caulks
Glycerin (or glycerol) synthesized by epichlorohydrine	Personal care products such as toothpastes, shaving creams, and soaps, polymers such as cellophane, plasticizers, polyurethane, and resins for paints and coatings, antifreeze, explosives, pharmaceuticals, food products

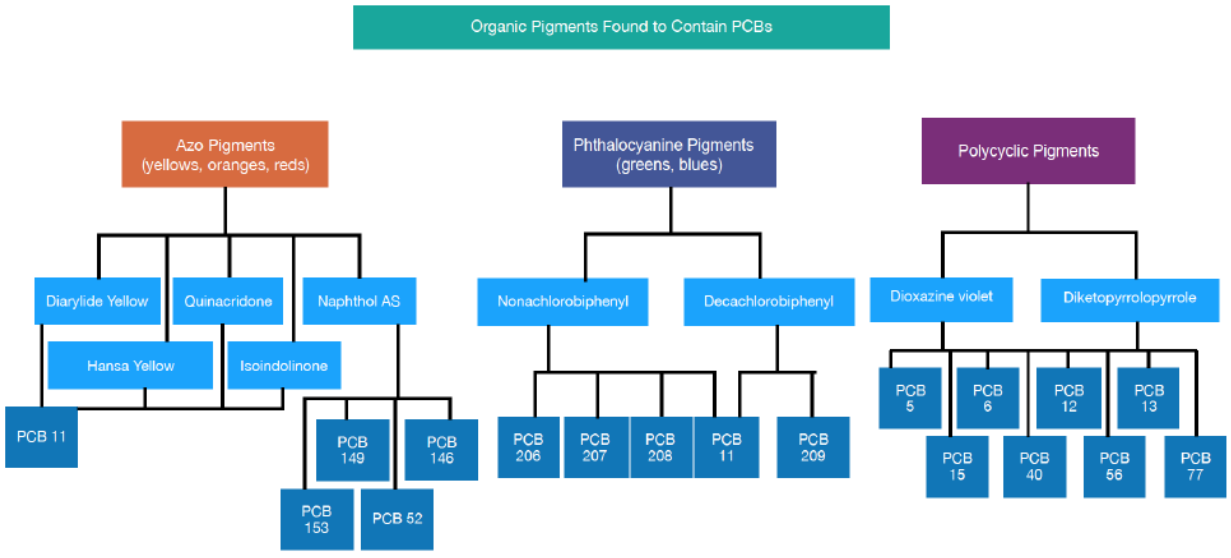

Figure 2. Organic pigments found to contain inadvertent PCBs (Heine and Trebilcock, 2018).

3.2.4 Regulatory criteria or standards

Information provided in this section focuses on the regulatory environment for PCBs in products in Washington state and U.S. federal law.

PCBs are regulated under the U.S. federal law by Title I Section 6 of the Toxic Substances Control Act (TSCA) and by EPA implementing regulations, Title 40, Part 761 of the Code of Federal Regulations (CFR; 40 CFR 761).

In 1976, TSCA banned the manufacture, processing, distribution in commerce, and use of PCBs, except when the EPA determined the uses were "totally enclosed," to be effective in 1978. TSCA further prohibited the manufacture of all PCBs by 1979, but allowed the EPA administrator to authorize certain processing, distribution in commerce, and use of PCBs if determined the activity did not present an unreasonable risk of injury to health or the environment (Ecology and Health, 2015).

In 1979 under TSCA, EPA promulgated the first of several regulations on PCBs that implemented the ban on PCBs for the intentional production and import of intentionally added PCBs, established authorizations for certain ongoing uses of PCBs, and established 50 ppm PCBs as the general regulatory limit (44 FR 31514; EPA 1979).

In 1984, EPA promulgated a rule for inadvertent generation of PCBs that are not in closed or controlled manufacturing processes (49 FR 28172). It required that the concentration of inadvertently generated PCBs in products, including recycled paper, must have an annual average of less than 25 ppm, with a maximum of 50 ppm. Additional criteria included that the concentration of monochlorinated biphenyls is discounted by a factor of 50 and dichlorinated biphenyls are discounted by a factor of 5, along with several other criteria (Ecology and Health, 2015). The discounting factor would allow for a product, such as a yellow pigment, to have the inadvertent presence of a dichlorinated PCB such as PCB-11 (if it is the only congener present) at an average of 125 ppm with a maximum of 250 ppm (Nestler et al., 2019).

The U.S. Food and Drug Administration (FDA) sets tolerance limits for PCBs as "unavoidable poisonous and deleterious substances" in both animal and human food, and food-packaging materials (ATSDR, 2000). FDA limits PCBs in paper food-packaging materials intended for or used with finished animal feed and any components intended for animal feeds to 10 ppm (21 CFR 509).

Eight PCB congeners in the PCBs chemical group are identified in Washington State's Persistent, Bioaccumulative, and Toxic (PBT) List (WAC-173-333). The rule defines the process for developing Chemical Action Plans and identifies the list of PBTs. In 2015, Ecology and Health developed a Chemical Action Plan to address PCBs in Washington State (Ecology and Health, 2015).

Washington State Governor Gary Locke's Executive Order 04-01 required state agencies to reduce the use and purchase of products that contain PBTs.

In 2014, Washington State law (RCW 39.26.280 and 39.26.290) required state agencies to limit the purchase of products and packaging containing PCBs. The state Department of Enterprise Services (DES) leads the implementation of the law. In 2019, DES Policy (DES-280-00, 2019)

established the purchasing preference to incentivize the State's contract suppliers to provide products and product packaging that do not contain PCBs.

In 2018, Washington State Governor Jay Inslee's Executive Order 18-02 established a Task Force to implement nine immediate actions to benefit Southern Resident Orca Whales. In November 2018, The Task Force published Year One Recommendations which included accelerating the implementation of the 2014 PCB purchasing law in products and product packaging purchased by the state (Southern Resident Orca Task Force, 2018).

In November 2019, the Task Force published their Final Report and Recommendations with an update on the progress of year one recommendations (Southern Resident Orca Task Force, 2019). In the update, DES had completed guidance for state agencies, published the Purchasing Preference Policy for PCBs (DES-280-00, 2019), provided training on the policy for contracting staff, and will continue to add the new language to master contracts as the old versions expire.

In 2019, the Washington State Legislature directed Ecology in consultation with Health to implement a regulatory program to reduce toxic chemicals in consumer products (RCW 70.365). The regulatory program consists of a repeating five-year cycle with four phases: (1) identify priority chemicals, (2) identify priority products, (3) determine regulatory actions, and (4) rulemaking. Ecology called the implementation program "Safer Products for Washington" (Ecology, 2020). PCBs are one of the five priority toxic chemical classes the law identified in the first five-year cycle. The Safer Products for Washington program identified consumer products that are significant sources and uses of the priority chemicals. The chemical-product combinations for PCBs include paints and printing inks (Ecology, 2020).

The determination of available and feasible safer alternatives and potential regulatory actions (to restrict, require reporting, or take no action) on these priority chemical-product combinations will be considered in the next phase of the Safer Products for Washington program.

4.0 Project Description

The Product Testing program at Ecology has conducted studies to assess the levels of PCBs in products (see Section 3.2.2). This QAPP describes the current standardized procedures for conducting product testing studies for PCBs to further study the extent to which products contain these chemicals.

In addition, Ecology will conduct a 2021 study to assess the levels of PCBs in some products in the printing inks product category. Data from this study will assist Ecology's Safer Products for Washington program in the next phase of their implementation process, which is to determine whether regulatory actions are needed for priority chemical-product combinations.

4.1 Project goals

The PCBs in printing inks 2021 study is being conducted with the following goals:

- Assess PCB congener concentrations in some printing ink products for sale and/or use in Washington State.
- Provide data for the Safer Products for Washington program.

4.2 Project objectives

The following objectives will be carried out to meet the 2021 study goals:

- Purchase and/or collect printing ink products available for sale and/or use in Washington State.
- Analyze PCB congeners in 20 unique printing ink samples from printing ink products.

4.3 Information needed and sources

In general, products selected for analysis in a study event may be identified based on (1) research of manufacturing processes of products, (2) known to be present in similar products, and (3) from sources such as peer-reviewed journal articles, Safety Data Sheets (SDS), product and ingredient labels, and public databases. These databases may include the Consumer Product Information Database, Environmental Working Group's Skin Deep® cosmetic database, High Priority Chemicals Data System (previously CSPA Manufacturer Reporting Database), and the Washington State Department of Enterprise Services (DES) contracts website.

4.4 Tasks required

The following tasks will be carried out for the 2021 study:

- Coordinate with Ecology's Manchester Environmental Laboratory (MEL) project coordinator to acquire an analytical laboratory service for analysis of PCB congeners in products.
- Conduct research to identify printing ink products available for sale and/or use in Washington state to purchase and/or collect.
- Purchase and/or collect select printing ink products for 20 unique printing ink samples.

- Record purchase and product information along with product photos in Ecology's Product Testing Database (PTDB).
- Prepare printing ink samples from printing ink products for laboratory analysis.
- Submit samples to analytical laboratory service for analysis of PCB congeners by EPA Method 1668C.
- Coordinate with Ecology's MEL project coordinator to acquire services for independent third-party data validation of PCB congener data in product samples.
- Send PCB laboratory data packages for independent third-party data validation.
- Conduct a quality assurance (QA) review of the data and assess results for usability after data validation is completed.
- Enter final laboratory data for PCB congeners into the PTDB.
- Analyze study data and write technical report.

4.5 Systematic planning process

This QAPP and subsequent Addenda to this QAPP address suitable systematic planning for the specific study.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 2 shows the responsibilities of those who will be involved in this study.

Table 2. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
Craig Manahan Reducing Toxic Threats Unit, HWTR Phone: 360-407-7355	Client	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP.
Kari Trumbull Toxic Studies Unit SCS Phone: 360-407-6093	Project Manager/ Principal Investigator	Writes the QAPP. Writes the draft statement of work for analytical laboratory services. Oversees product purchasing, tracking purchases, sample processing, chain-of-custody, and shipment of samples to the lab. Conducts QA review of data, analyzes and interprets data, enters data into PTDB, and final PTDB study review. Writes the draft report and final report.
Prajwol Tuladhar Toxic Studies Unit SCS Phone: 360-407-6745	Project Assistant	Conducts product data entry into internal PTDB and photographing products. Assists with sample processing, chain-of-custody, and shipment of samples to the laboratory.
Chrissy Wiseman Toxic Studies Unit SCS Phone: 360-407-7672	Project Assistant	Assists with product purchasing, as needed.
James Medlen Toxic Studies Unit SCS Phone: 360-407-6194	Unit Supervisor for the Project Manager	Provides internal review of the QAPP, approves the budget, and approves the final QAPP.
Jessica Archer SCS Phone: 360-407-6698	Section Manager for the Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Alan Rue MEL Phone: 360-871-8801	Manchester Lab Director	Reviews and approves the final QAPP.
Nancy Rosenbower MEL Phone: 360-328-9308	MEL Project Coordinator	Coordinates with the Project Manager to acquire services for PCB congener laboratory analysis and independent third-party data validation.
Christina Frans MEL Phone: 360-871-8829	MEL Quality Assurance Coordinator	Reviews and approves draft statement of work for lab analysis and data validation services. Reviews lab data package and data validation package to verify the statement of work requirements are met.
Arati Kaza Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP. May perform routine audit of product testing process during study event.
Samuel Iwenofu Phone: 360-407-6346	Temporary Acting Ecology QA Officer	Reviews the draft QAPP.

EAP: Environmental Assessment Program.
MEL: Manchester Environmental Laboratory.
QA: Quality Assurance.
SCS: Statewide Coordination Section
HWTR: Hazardous Waste and Toxics Reduction Program
PTDB: Product Testing Database
QAPP: Quality Assurance Project Plan

5.2 Special training and certifications

Ecology staff assisting on product testing studies will have completed training documented on the Product Testing Preparation Staff Training Checklist. Training includes reviewing the study-specific QAPP, current approved product testing standard operating procedures (SOPs), and the location of personal protective equipment and safety equipment (e.g. first aid kit, eye wash station). Product testing training is outlined in Ecology's Product Testing SOP (PTP001) for Product Collection and Sample Processing, Version 2.1 (Wiseman 2021a).

5.3 Organization chart

Table 2 lists the key individuals and responsibilities.

5.4 Proposed project schedule

Tables 3 – 5 list key activities, due dates, and lead staff for the 2021 study.

Table 3. Proposed schedule for completing 2021 product collection and laboratory work

Task	Due date	Lead staff
Product purchase complete	Feb 2021	Kari Trumbull
Product data entry complete	Feb 2021	Prajwol Tuladhar
Internal product data entry QA complete	March 2021	Kari Trumbull
Samples sent to analytical laboratory complete	March 2021	Kari Trumbull
Laboratory analyses complete and data package receipt	May 2021	Analytical Laboratory Service

QA: Quality Assurance

Table 4. Proposed schedule for 2021 data and study reviews

Task	Due date	Lead staff
Validation of laboratory data package complete	July 2021	Data Validation Service
Laboratory data QA reviewed	August 2021	Kari Trumbull
Laboratory data uploaded in PTDB	August 2021	Kari Trumbull
PTDB study QA review complete	September 2021	Kari Trumbull

QA: Quality Assurance
PTDB: Product Testing Database

Table 5. Proposed schedule for completing 2021 final report

Task	Due date	Lead staff
Draft to supervisor	October 2021	Kari Trumbull
Draft to internal peer reviewer	October 2021	Kari Trumbull
Draft to client/stakeholders	November 2021	Kari Trumbull
Final draft to publications team	December 2021	Kari Trumbull
Final report due on web	March 2022	Publications Team

5.5 Budget and funding

The estimated budget for product collection and laboratory analysis (including acquired services) for the 2021 study is displayed in Tables 6 and 7. Products will be purchased to provide up to 20 unique product samples of printing inks for laboratory analysis. The field quality control (QC) samples include product collection and sample processing QC samples for the study event. The lab QC samples include samples that are not provided free of charge by the laboratory.

The estimated total cost of the 2021 study is $ 33,251.

Table 6. Study budget for purchasing products, 2021

Activity	Number of Unique Product Samples	Number of Field QC Samples^	Estimated Cost per Product Sample	Subtotal Cost
Purchase printing inks products[#]	20	2	$ 150	$ 3,000

^Product collection and sample processing QC samples includes: up to 1 sample processing water blanks and up to 1 tool cleaning hexane rinse blank.
[#]Some products may provide more than one unique sample per product depending on printing ink product and some products may be purchased in replicate (more than one product of the same product) to provide a sufficient amount of sample for lab analysis and field sample duplicates.
QC: quality control.

Table 7. Study budget for laboratory analysis and data validation, 2021

Activity	Number of Lab Samples	Number of Lab QC Samples^	Estimated Cost per Sample	Subtotal Cost
PCB congeners extraction and analysis	22	4	$ 895	$ 23,270
PCB congener data validation	22	4	na	$ 3,000
MEL acquisition service fee*	na	na	na	$ 3,981

^Lab QC samples that are not provided free of charge includes: 1 lab product sample duplicate and up to 3 laboratory control standard duplicates.
*Fee is 30% of lab analysis cost minus cost of data validation with external data validation service.
QC: quality control.
na: not applicable.

6.0 Quality Objectives

6.1 Data quality objectives

The overall quality objective is to obtain results of documented accuracy (e.g. bias and precision) in product samples from a specific product at the time of purchase or collection. Common indicators of data quality include the measurement quality objectives (MQOs) for precision, bias, and sensitivity described in Section 6.2 and Table 8.

6.2 Measurement quality objectives

6.2.1 Targets for precision, bias, and sensitivity

MQOs for analysis of PCB congeners, expressed in terms of acceptable precision, bias, and sensitivity, are shown in Table 8. MQOs are to obtain data of sufficient quality to determine concentrations of the 209 PCB congeners and calculate total PCB concentrations (sum of PCB congeners) in product samples. MQOs may vary depending on the individual PCB congener and type of product matrix.

Table 8. Measurement quality objectives for laboratory analyses

Analyte[+]	Laboratory Control Standard Duplicates (RPD)^	Sample Duplicates (RPD)^	Laboratory Control Standards* (Recovery)	Surrogate Standards* (Recovery)	Method Blanks[#]	Lowest Concentration of Interest
209 PCB Congeners	± 30%	± 50%	60-135%	5-145%	< 0.10 ppb	< 0.25 ppb wet weight (as received)

[+]Target analytes for 209 PCB congeners are listed in Appendix Table A-1.
^RPD when both results are greater than 5 times the reporting limit.
*Criteria for laboratory control standards [also referred to as ongoing precision and recovery (OPR) standards] and surrogate standards (also referred to as labeled compounds) are listed in Table 6 of the EPA Method 1668C for specific native and labeled congeners and excerpt shown in Appendix Table A-2.
[#]Criteria for method blanks is described in Section 9.5.2 of the EPA Method 1668C (EPA 2010).
RPD = relative percent difference.
ppb = part per billion.

6.2.1.1 Precision

Precision is a measure of the variability in the results of replicate measurements due to random error. Laboratory analysis precision will be assessed through laboratory duplicate samples for all matrices and analyses. Table 8 shows MQOs for laboratory control standard duplicates and extracted sample duplicates.

6.2.1.2 Bias

Bias is the difference between the sample mean and the true value. Laboratory analysis bias will be assessed through laboratory control standards. MQOs for percent recoveries are shown in Table 8.

6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of an analytical method to detect a substance above background level, and is often described as a detection or reporting limit. The expected lowest concentrations of interest for PCB congeners are shown in Table 8, and are based on the estimated quantitation limit for PCB congeners.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

Comparability will be ensured by implementing standardized procedures for sampling and analysis.

Data from this study can be compared to publically available data of similar product types and analyzed using substantially the same analytical methods, if available.

6.2.2.2 Representativeness

Products purchased and collected for this study will be representative of those available to Washington State residents and agencies.

6.2.2.3 Completeness

The project manager will consider the study to have achieved completeness if 95% of the laboratory samples are analyzed acceptably.

6.3 Acceptance criteria for quality of existing data

Not applicable to this study.

6.4 Model quality objectives

Not applicable to this study.

7.0 Study Design

7.1 Study boundaries

Personal, commercial, and industrial consumer products and children's products available to Washington State residents and businesses, either in-store or online, may be purchased and collected for selection in a study event (section 3.2). Product categories that may contain PCBs or determined to be further investigated for PCBs will be identified in a study event (section 3.2.3). Product categories and specific products selected in a study event will be identified based on research of manufacturing processes of products, known to be present in similar products, and from sources such as peer-reviewed journal articles, safety data sheets (SDSs), product and ingredient labels, and public databases (section 4.3).

Some products may be included in a study event that advertises no PCBs in the product. Some purchased products from prior product testing studies may be included in a study event. Product component samples can be collected from a component of the original product stored at Ecology.

Products purchased and collected for a study event will be documented in Ecology's Product Testing Database (PTDB) (section 8.5), processed into product component samples (section 9.2), then shipped to the analytical laboratory for PCB congener analysis.

The 209 PCB congeners will be tested in product samples to assess the concentrations by solvent extraction, followed by high-resolution gas chromatography mass spectrometry analysis at the analytical laboratory.

For the 2021 study, products will be purchased or collected from the printing inks product category.

7.2 Field data collection

Equity Considerations in Sample Collection

Ecology is committed to the principles of equity and environmental justice and shares the EPA's goal "to provide an environment where all people enjoy the same degree of protection from environmental and health hazards and equal access to the decision-making process to maintain a healthy environment in which to live, learn, and work" (Ecology and EPA, 2019).

Product categories in a study event will be evaluated to include products, as available, during purchase and collection that are accessible and/or relevant to diverse ethnic, cultural, and economic groups in Washington State.

7.2.1 Sampling locations and frequency

Products in a study can be purchased from retail stores, online through internet retailers, and from state agency procurement. Products can also be collected from state agencies which purchased products from Washington State contracts. In-store purchases and site collections will be coordinated to minimize the frequency of product collection events. Locations of products purchased and collected will be recorded in the Product Documentation Log (section 8.7) and in Ecology's PTDB (section 8.5).

For the 2021 study, printing ink products will primarily be purchased online available for sale and/or use in Washington state.

7.2.2 Field parameters and laboratory analytes to be measured

The 209 PCB congeners to be analyzed in product samples are listed in Appendix Table A-1. PCB congeners may co-elute during analysis, and the mixture of coeluting congeners may differ depending on the laboratory's analytical conditions. Co-elution of congeners are quantified as the concentration of a mixture of more than one congener during laboratory analysis (EPA, 2010).

7.3 Modeling and analysis design

Not applicable to this study.

7.3.1 Analytical framework

Not applicable to this study.

7.3.2 Model setup and data needs

Not applicable to this study.

7.4 Assumptions underlying design

Products used in a study reflect current on-the-market products at the time of purchase and current in-use products at time of collection, not previous in-use products that consumers have had exposure to. Manufacturing formulations are subject to change in response to changes in the regulatory environment. The profile of PCBs in products has evolved substantially over the last several decades due to changes in the regulatory requirements and manufacturing formulations.

7.5 Possible challenges and contingencies

7.5.1 Logistical problems

Limitations in the selection of available products during product purchase and collection may require extending the timeframe and/or planning additional study events.

7.5.2 Practical constraints

Limitations in receiving products through online purchases may occur due to unforeseen product unavailability and/or shipping delays after purchase. Some product purchases may need to be cancelled if the products are on back-order and not received within the proposed timeframe and/or extending the timeframe. Products may be reordered through a different online retailer if available.

7.5.3 Schedule limitations

Limitations in the availability of project assistants, laboratory extraction and analysis of complex product matrices, and the validation process of complex data may affect the study and extend the proposed schedule.

8.0 Field Procedures

8.1 Invasive species evaluation

Not applicable to this study.

8.2 Measurement and sampling procedures

Product collection, sample processing, and recording product and sample component data in Ecology's Product Testing Database (PTDB) is outlined in Ecology's Product Testing SOPs:

- Ecology's Product Testing SOP (PTP001) for Product Collection and Sample Processing, Version 2.1 (Wiseman, 2021a).
- Ecology's Product Testing SOP (PTP002) for Database Data Entry and Data Entry Quality Assurance, Version 2.1 (Wiseman, 2021b).

Product collection may occur by purchasing products in stores, by collecting products and samples at specific site locations, and by purchasing products online. Ecology product testing staff will take a product collection tote containing the necessary tools and equipment to be used for the sample collection event. The tote will include Product Documentation Log (section 8.7), product testing camera, large, medium, and small plastic sample bags to store products, pens and labels, clean and decontaminated tools for collecting aliquots of product samples (if applicable, section 8.4), and gloves. Product testing staff will minimize the use of cosmetics, personal care products, and personal accessories during product collection and sample processing because these items may contribute to low-level background contamination with PCBs.

QC field blank and trip blank samples will be collected during product collection whether purchasing products in stores or collecting products and samples at specific site locations. Field and trip blanks are not collected for purchasing products online. Field blanks consist of a piece of multipurpose paper[1] (no recycled content) placed into a new resealable plastic sample bag and the bag will never be opened during product collection. Trip blanks consist of a piece of multipurpose paper[1] (no recycled content) placed into a new resealable plastic sample bag and the bag will be opened during product collection. One field blank and one trip blank will be collected for each product collection day, which could include multiple site locations. These blanks will be handled exactly the same as other product samples (e.g., during sample processing), and will be submitted to the analytical laboratory for analysis.

Products purchased in stores and collected at site locations will be brought to Ecology's product testing processing room and secured in a locked cabinet. Products purchased online will be delivered to Ecology's shipping and receiving department and stored in a locked location. Packages will be collected by product testing staff then secured in a locked cabinet in the product testing processing room.

[1] Low levels of PCBs are anticipated to be present in the multipurpose paper. One sample of a multipurpose paper product was tested in Ecology's product testing 2013-2015 PCB study and had 0.17 ppb total PCBs (ECY ID 00-2-6-1, Stone 2016). Assessment of the multipurpose paper samples as QC blanks will include comparison of PCB concentrations in each QC field and trip blank set and an overall comparison of PCB concentrations to product samples.

The purchase (in store and online) and site collection events will be documented and recorded in Ecology's PTDB. Products will be photographed, recorded into Ecology's PTDB, placed in individual plastic sample bags labeled with a product testing Ecology identification number (ECY ID, see section 8.5), and stored in labeled totes in locked cabinets until sample processing. Gloves will be worn (and a new pair replaced between handling different products) when separating, recording, and photographing products. Products will be placed on a new piece of aluminum foil (dull side up) when not stored in individual sample bags.

The processing and preparation of products into product component samples for laboratory analysis is discussed in the sample preparation methods section (section 9.2) of this QAPP.

8.3 Containers, preservation methods, holding times

Sample containers, minimum quantity, storage and preservation, and holding times for sample matrices are shown in Table 9. Hand-reduced and aliquoted laboratory samples will be stored in certified clean amber (if available) wide-mouth glass jars with Teflon lined lids. Laboratory samples consisting of homogenous mixtures and oils will be stored in original unopened product containers if not aliquoted. All samples will be stored with minimal exposure to light and kept at ambient temperatures.

There are no demonstrated maximum holding times for PCB congeners in products and product sample matrices. Following EPA Method 1668C for PCB congener analysis, aqueous samples may be stored up to one year in the dark at less than 6 degrees Celsius, solid samples stored up to one year in the dark at less than -10 degrees Celsius, and all sample extracts stored for up to one year in the dark at less than -10 degrees Celsius (EPA 2010).

Table 9. Sample containers, preservation, and holding times.

Analyte	Matrix	Minimum Quantity^	Container	Sample Storage and Preservative*	Estimated Holding Time*
PCB Congeners	Solids: paper, textiles, plastics and polymers, solid homogeneous mixtures	5 grams to 10 grams	amber glass jar or original unopened product container	minimize exposure to light, keep at ambient temperature	1 year
PCB Congeners	Liquids: liquid, gel, and cream homogenous mixtures (e.g. printing inks, paints)	5 grams to 10 grams	amber glass jar or original unopened product container	minimize exposure to light, keep at ambient temperature	1 year
PCB Congeners	Oils	5 grams to 10 grams	amber glass jar or original unopened product container	minimize exposure to light, keep at ambient temperature	1 year
PCB Congeners	QC paper#, QC solvent#, QC water#	5 grams (paper), 50 ml (solvent), 500 ml (water)	amber glass jar	minimize exposure to light, keep at ambient temperature	1 year

^A greater minimum quantity may be needed for samples with lab sample duplicates.
*No demonstrated maximum holding times or preservation methods have been established for product matrices.
#Quality control (QC) paper, solvent, and water samples collected during product collection, tool cleaning, and sample processing.

8.4 Equipment decontamination

All tools used in the preparation and processing of solid-type product component samples and collection of aliquots of liquid-type samples will be decontaminated following a low-level tool cleaning procedure specific to testing for PCB congeners. The procedure is outlined Appendix B.

8.5 Sample ID

For testing product samples, unique Ecology identification numbers (ECY IDs) are auto-generated by Ecology's PTDB during the product and component data entry process. Product testing ECY IDs combine information from the store or collection location, purchase or collection event number, unique product in the event, and component or sample number of the product. For example, WX-1-2-1 corresponds to: WX for WAXIE Sanitary Supply, 1 indicates the first time Ecology purchased from WX, 2 refers to a unique product in the purchase, and 1 indicates the first sample or component from the product.

Product component samples sent for analysis to the analytical laboratory will include a MEL ID number generated from a seven-digit work order number for the study sample set, followed by a dash and a two-digit number specific for each sample in the set (e.g. 1234567-01).

The product testing sample ID and MEL sample ID number will be recorded on both the sample containers and the chain of custody form.

8.6 Chain of custody

Chain of custody will be maintained for all samples throughout the study. Products collected for the study will be stored in locked cabinets in Ecology's product testing processing room for the duration of the study. Samples will be stored in locked cabinets in Ecology's product testing processing room until shipped to the analytical laboratory. Ecology staff will use the analytical laboratory's chain of custody form (or MEL's chain of custody form if one is not provided by the analytical laboratory) for shipment of product component samples to the laboratory.

8.7 Field log requirements

Product purchasing and collection events will be recorded in a bound notebook with pre-numbered pages. A permanent ink pen will be used to record all entries, and corrections will be made with single line strikethrough, initials, and date. The Product Documentation Log includes the following information:

- Study QAPP Name
- Project Manager (PM) Name
- Collector/Sampler Name
- Collection Date
- Store or Site Name and Address
- Purpose of Product Collection (optional)
- Explanation of Marketing (if applicable)
- Arrival Time at the Product Collection Location
- Number of Products Purchased/Collected
- Location Contact Name, Phone Number and Email Address
- Miscellaneous/Comments
- Return Time to Ecology

Advertisements, photos of product marketing, and other information gathered during the purchasing and collection event for this study will be recorded and uploaded or scanned into Ecology's PTDB.

8.8 Other activities

Necessary activities are detailed in other sections of this QAPP.

9.0 Laboratory Procedures

9.1 Lab procedures table

Table 10 summarizes the sample matrices, number of samples, expected range of results, reporting limits, and extraction and analytical methods for PCB congeners.

Samples will be sent to an analytical laboratory for extraction and analysis using EPA Method 1668C for PCB congener analysis (EPA 2010). EPA method 1668C describes several different extraction techniques that may be used depending on the matrix type: Soxhlet/Dean Stark or Soxhlet extraction for solid-type samples and solid-phase, separatory funnel, or continuous liquid/liquid extraction for liquid-type and oil samples. Modification of the extraction procedures in EPA Method 1668C may be needed for extraction of non-standard product matrix samples. The extraction procedure determined for the specific sample matrix should achieve the maximum recovery of the extractant. The analytical laboratory will contact the project manager regarding major deviations from the method extraction procedures or other extraction and analysis issues that occur before proceeding further with the analysis. The project manager will determine the appropriate corrective actions.

Table 10 lists the number of samples and the sample matrix described for the product samples and QC samples for the 2021 study.

Table 10. Measurement methods (laboratory), 2021.

Analyte	Sample Matrix	2021 Study Sample Number	Expected Range of Results^	Detection or Reporting Limit+	Sample Extraction Method	Analytical Method
209 PCB Congeners	Solids: paper, textiles, plastics and polymers, solid homogeneous mixtures	na	< 0.25 ppb to 2,300 ppb total PCBs	< 0.25 ppb per congener, wet weight (as received)	EPA 1668C*	EPA 1668C
209 PCB Congeners	Liquids: liquid, gel, and cream homogenous mixtures (e.g. printing inks, paints)	up to 20 printing inks	< 0.25 ppb to 390 ppb total PCBs	< 0.25 ppb per congener, wet weight (as received)	EPA 1668C*	EPA 1668C
209 PCB Congeners	Oils	na	< 0.25 ppb to 14 ppb total PCBs	< 0.25 ppb per congener, wet weight (as received)	EPA 1668C*	EPA 1668C
209 PCB Congeners	QC paper#, QC solvent#, QC water#	up to 1 QC solvent and up to 1 QC water	< 0.25 ppb total PCBs	< 0.25 ppb per congener, wet weight (as received)	EPA 1668C*	EPA 1668C

^Based on data from previous Ecology product testing studies for PCB congener analysis.
+Actual detection or reporting limit are dependent on the levels of interferences and laboratory background levels rather than instrumental limitations and may vary by congener.
*Modification of the extraction procedures in EPA Method 1668C may be needed for extraction of non-standard product matrix samples.
#Quality control (QC) paper, solvent, and water samples collected during product collection, tool cleaning, sample processing, and/or cryomilling.
na = not applicable
ppb = parts per billion

9.2 Sample preparation method(s)

The procedure for processing solid-type samples (i.e. paper, textiles, and plastics) and collecting aliquots of liquid-type samples (i.e. liquid homogenous mixtures and oils) for PCB analysis is outlined below. Solid-type products are deconstructed into individual components that comprise the product. For example, an outdoor jacket can be separated into at least four component samples: outside fabric, inside fabric, interior filling, and zipper. The product components of interest for lab analysis are processed into samples. Multiple product component samples from one product may be submitted to the laboratory for testing. Liquid-type samples are collected as an aliquot of the original product component.

One process blank will be collected for each sample processing day. Processing blanks will consist of either:

- A piece of multipurpose paper (no recycled content, see footnote 3, Section 8.2) placed in the center of the workspace where solid-type products are processed into samples.
- Or an open sample jar filled with DI water placed in the center of the workspace where liquid-type products are aliquoted into samples.

Product testing sample processing for PCB congener analysis

- Processing Solid Samples
  - Line a clean table with aluminum foil, dull side up.
  - Place a new piece of aluminum foil, large enough to place under the product that will be processed for a sample, on the table with dull side up.
  - Weigh the empty labeled sample jar and place jar on processing surface with lid set loosely on top of the jar.
  - Use a clean tool (i.e. scissors) that is wrapped in aluminum foil (dull side towards blades) and cleaned following the tool cleaning procedure (section 8.4). Remove aluminum foil around tool and place on clean aluminum foil processing area.
  - Set the product that will be processed for a sample next to the clean aluminum foil processing area. Open the bag that contains the product.
  - Change gloves (change gloves before processing every sample) and remove the product from open bag and place the product on clean processing area (aluminum foil). Minimize handling and contact of the selected product component with gloved hands and the aluminum foil surface during processing into sample.
  - Hand-reduce the sample of product component to at least approximately 2 millimeter (mm) by 2 mm in size into the sample jar using a clean tool.
  - Weigh the jar and record the weight of final processed sample on label.
- Collecting Aliquots of Liquid Samples
  - Liquid, gel, and cream homogeneous mixtures and oil samples will be sent to the lab in original unopened container, if possible.
  - If product container is too large or heavy to ship to the lab (e.g. a gallon of paint) then:
    - Wear appropriate PPE (e.g. gloves, eyewear, and lab coat) while collecting product component samples.
    - Vigorously mix product in unopened original container. Open lid of product container.
    - Open lid of clean sample jar with clean gloves and pour a well-mixed aliquot of the original product into clean jar.
    - Replace lid of jar without touching inside of jar or lid.
    - Ensure that the aliquot poured from original container does not run down side of container but is a clean pour directly from original container into clean sample jar.
    - Collect aliquot in a fume hood, if possible, or a well-ventilated area.
  - Collecting aliquots of product component samples at site locations where product cannot be vigorously mixed or equipment like an automatic pump is not connected to the container for dispersion of product sample (e.g. 55 gallon drum of lubricant) then:
    - Wear appropriate PPE (e.g. gloves, eyewear, and protective clothing) while collecting product component samples.
    - Use a cleaned and decontaminated (Section 8.4 for procedure) glass with glass plug coliwasa (composite liquid sampler) to collect a minimum of 100 ml of a representative sample from large container or drum.

- Open lid of clean sample jar with clean gloves and discharge collected sample from the coliwasa sampler into clean jar.
- Replace lid of jar without touching inside of jar or lid.
- Ensure that the outside of coliwasa sampler containing sample does not touch any surface before releasing sample collected from original container into clean sample jar.
- Wipe outside of sampler with absorbent towels (collect in waste bag and dispose in appropriately designated waste container) and replace used coliwasa sampler in original wrapping (aluminum foil) until it can be cleaned.

Cryomilling is the mechanical milling of solid-type samples at cryogenic temperature (the temperature of liquid nitrogen is -196 degrees Celsius) into small particles in size. Some product samples consisting of plastic- and polymer-type products may need to be cryomilled to obtain a homogenous sample before extraction and analysis. Product samples determined to be cryomilled will be initially processed following the procedure for solid sample processing to reduce sample size. Then the samples will be sent to Ecology's Manchester Environmental Laboratory (MEL) for cryomilling following the lab's SOP for Cryomill Preparation of Samples.

The stainless steel grinding jars, stainless milling balls, and any additional equipment in contact with the product sample (e.g. stainless steel spatulas or forceps) used in the cryomill process will be cleaned following the product testing tool cleaning and decontamination procedure for PCB congeners analysis (section 8.4). The hexane rinse of the cryomill equipment will be collected. One cryomill hexane rinse blank will be collected for each cryomill batch (MEL has 6 cryomill grinding jar sets so each cryomill batch will consist of 6 product samples).

Cryomilled samples and cryomill hexane rinse blanks will be returned to the project manager to ship to the analytical laboratory or sent directly to the analytical laboratory under reduced temperatures (less than 4 degrees Celsius). The cryomill samples and rinse blanks will be maintained under reduced temperatures during shipment to the analytical laboratory for PCB congener extraction and analysis. Copies of the cryomill benchsheet or logbook, the chain-of-custody form, and any additional lab documentation will be provided to the project manager with the return of cryomilled samples and blanks.

Product component samples sent to the analytical laboratory will undergo solvent extraction followed by analysis for 209 PCB congeners by EPA Method 1668C using high resolution gas chromatography/high resolution mass spectrometry (EPA 2010). Modifications of the extraction techniques in EPA Method 1668C may be required to account for the non-standard product matrices.

9.3 Special method requirements

Non-standard product matrices may require modification of the extraction procedures in EPA Method 1668C for product samples. The extraction process will be described in the case narrative of the analytical laboratory data package.

9.4 Laboratories accredited for methods

The analytical laboratory will be an Ecology-accredited laboratory for PCB congener analysis by EPA Method 1668C.

10.0 Quality Control Procedures

10.1 Table of field and laboratory quality control

Table 11 displays the laboratory quality control (QC) samples required for PCB analysis. The laboratory QC samples have associated MQOs (section 6.2) that will be used to evaluate the quality and usability of the sample results. Collection and processing of QC samples will follow procedures outlined in section 8.2 (field and trip blanks), section 8.4 (tool cleaning hexane rinse blanks), and section 9.2 (sample processing blanks and cryomill hexane rinse blanks) of this QAPP. The collection and processing QC samples will be included in the batch of product samples sent to the laboratory for analysis. They will be extracted and analyzed at the lab similar to product samples.

Batches typically consist of matrix matched samples. A set number of laboratory QC samples are planned in the budget; this number is not to be exceeded. A variety in product sample matrices may result in more matrix matched batches with fewer samples which may exceed the budget for lab QC samples in order to meet the requirement in Table 11. The analytical laboratory will consult with the project manager on the allocation of samples into batches and laboratory QC samples for each batch when a variety of product matrices are analyzed. The project manager will determine if a batch will include a variety of product matrices with the full set of laboratory QC samples or smaller matrix matched batches with a limited laboratory QC sample set. One full laboratory QC sample set for every 20 samples will be met, at a minimum, regardless of matrix.

Table 11. Quality control samples, types, and frequency.

Analyte	Collection and Processing QC Samples^	Laboratory Method Blanks	Laboratory Sample Duplicates*	Laboratory Control Standards	Laboratory Control Standard Duplicates	Laboratory Surrogate Standards
209 PCB Congeners	as collected	1/batch	1/batch	1/batch	1/batch	every sample

Batch: 20 samples or fewer and typically matrix matched
^Includes field sample duplicates, field and trip blanks, sample processing blanks, and/or tool cleaning and cryomill hexane rinse blanks.
*Laboratory sample duplicates are analyzed only for product samples.

10.2 Corrective action processes

Deviations from this QAPP when conducting the described activities – including product purchase and collection, product documentation and data entry in Ecology's PTDB, and sample processing – will be discussed in the final report. Substantial deviations will be described in a QAPP addendum pre-approved by the QA Officer.

Deviations from the specified laboratory methods or QC criteria, or instances in which data results do not meet MQOs, will be documented in the case narratives of the laboratory data packages and data validation package. The deviations will be described in the final study report. The project manager will determine appropriate corrective actions which may include samples re-sampled, re-analyzed, rejected, or used with appropriate qualification.

11.0 Data Management Procedures

11.1 Data recording and reporting requirements

Documentation of purchase and collection events will be recorded in the Product Documentation Log (section 8.7). Study data will be recorded in Ecology's internal Product Testing Database (PTDB). Study data collected and recorded in the PTDB include: purchase receipts, products purchased (in store and online) and collected, product descriptions, product photos, description of product components, methods used to process component samples, laboratory results, and case narratives.

Laboratory data packages in electronic format will be sent to the project manager after analysis is complete by the analytical laboratory service. The laboratory data packages will then be sent to an independent third-party for data validation. The project manager will conduct a QA review of the data and assess results for usability after data validation is complete (see Sections 13 and 14). The project manager will upload the validated and approved data to the internal PTDB. The final data will be transferred to the public PTDB upon completion of the final report by the project manager. Laboratory data with accompanying product information for the study will be available to the public through an external search application in Ecology's PTDB[2].

11.2 Laboratory data package requirements

The analytical laboratory service will deliver a Tier 4 Level data package in electronic format to Ecology after completing laboratory analysis. The analytical laboratory service will submit laboratory data as a fully paginated and bookmarked comprehensive PDF format file with all required specific content, along with data in EDD format (.csv or .xlsx files). The data package must include all raw data and QA/QC documentation that would be needed to perform an independent review of the results. This documentation includes benchsheets, calibration reports, chromatograms, and spectra for all calibration standards and samples.

Case narratives will be included to discuss any problems encountered with the analyses, corrective action taken, changes to the requested analytical method, and a glossary for data flags and qualifiers. All sample results and QC data will be included with the package.

11.3 Electronic transfer requirements

Laboratory case narratives and data packages will be in PDF format, and EDDs will be in a spreadsheet format, that meets Ecology's product testing formatting requirements or alternative format approved by the project manager.

11.4 EIM/STORET data upload procedures

Not applicable to this study. Section 11.1 describes the database where data will be stored for this study.

11.5 Model information management

Not applicable to this study.

[2] https://apps.ecology.wa.gov/ptdbpublicreporting/

12.0 Audits and Reports

12.1 Field, laboratory, and other audits

Analytical laboratories must participate in performance and system audits of their routine procedures.

The product testing process conducted at Ecology will be audited at a minimum of one audit a year.

12.2 Responsible personnel

Ecology's QA Officer or her/his designee will conduct the product testing process audit. The processes can include: product acquisition, product documentation and data entry in the PTDB, sample screening, sample processing, chain-of-custody, and adherence to product testing QAPPs and SOPs.

12.3 Frequency and distribution of reports

A published report summarizing the data and findings will be generated in the short report format for each study event, unless specified differently in an Addendum to this QAPP. A final published short report will include at a minimum:

- An overview of the study.
- Goals and objectives of the study.
- General description of products purchased or collected.
- Discussion of methods, data quality, and the significance of any problems encountered.
- Summary tables and graphs of laboratory data.
- Discussion of laboratory results.
- Conclusions and Recommendations.

Other forms of study documentation may include presentations, focus sheet, press release, technical memorandum, and/or peer-reviewed journal article.

12.4 Responsibility for reports

The project manager will be the lead responsible for the final published short report.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

The project manager will conduct a final review of product purchases and collections, product components, component samples shipped to the laboratory, and additional product data entered into Ecology's PTDB by the project sampling assistant or additional product testing staff.

13.2 Laboratory data verification

Laboratory data verification is the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements. An independent third-party data validator service will be acquired to perform the Level 4 data validation for the study. Laboratory data verification is part of the process in a Level 4 data validation (Section 13.3).

13.3 Validation requirements, if necessary

The acquired analytical laboratory service conducting the analyses will review laboratory results prior to submitting the data package in electronic format to the project manager. The laboratory data package will then be sent to an independent third-party for data validation service. The complete PCB congener data package will be reviewed following EPA guidelines (EPA, 2016), this QAPP, and QC requirements of EPA Method 1668C. The data validation service will prepare a report of the Level 4 data validation, which includes an overall assessment of data quality, usability, and whether project MQOs were met. The project manager will conduct a QA review of the data and assess results for usability after data validation is completed.

13.4 Model quality assessment

This study does not involve modeling or analysis of existing data.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining project objectives were met

Upon completion of the independent data validation process, the project manager will assess the data for usability and determine whether study objectives were met. Data from all field and laboratory procedures will be examined to determine whether they were measured with the proper procedures, fall into the expected range of results, and meet reporting limits as described in Sections 8 and 9. Data will also be examined to determine whether all MQOs and QC procedures have been met as described in Sections 6 and 10.

If all specifications are met, the quality of the data should be usable for meeting study objectives. If the MQOs have not all been met, the project manager will examine the data to determine whether they are still usable and whether the data quantity and quality are sufficient to meet project objectives. The project manager will determine appropriate corrective actions for data that do not meet the criteria which may include samples re-sampled, re-analyzed, rejected, or used with appropriate qualification. The project manager will be responsible for analyzing the data and determining how the results will be summarized and documented in the final report.

14.2 Treatment of non-detects

EPA Method 1668C allows for low-level detection of PCB congeners. However, PCB congeners may be present in laboratory method blanks at higher concentrations than the detection limit. Congener results that are less than five times the detected method blank concentration will be censored and qualified as non-detects, "U" or "UJ".

PCB congener results censored as non-detects will be:

- qualified as "U" (the analyte was not detected at or above the reported concentration) when the concentration is less than five times the detected method blank concentration and greater than the limit of quantitation (LOQ).
- qualified as "UJ" (the analyte was not detected at or above the estimated concentration) when the concentration is less than five times the detected method blank concentration and less than the LOQ but greater than the estimated detection limit (EDL).
- qualified as "UJ" when the concentration of a tentatively identified PCB congener, qualified as "NJ," is less than five times the detected method blank concentration and less than the LOQ but greater than the EDL.

Non-detected congener results will not be included in calculation of total PCBs, the sum of PCB congeners in the sample.

14.3 Data analysis and presentation methods

PCB congener results below the LOQ and above the EDL will be qualified "J" (indicating that the analyte was positively identified and the concentration is an estimate). PCB congener results less than five times the method blank contamination will be censored as non-detects (section 14.2).

Total PCBs will be calculated from PCB congener results as the sum of PCB congeners in the sample and include only detected congener results that are qualified "J," as estimates, and detected congeners without qualification. Non-detected congener results and congener results qualified as "NJ" (indicating the analyte has been tentatively identified and the concentration is an estimate), will not be included in the total PCB sum of congeners. Total PCB calculations will be qualified "J" when 10% or more of the detected congener concentration results are qualified "J."

In addition, PCB congener profiles will be examined and discussed. A summary of the data will be presented in the final report. Results will be displayed in tables, graphs, and/or charts.

14.4 Sampling design evaluation

The number and type of samples collected and tested should be sufficient to meet the objectives of the specific study event. The results of the study may lead to future study events with a larger sample size and/or a wider variety of products. Additional study events will be described in a QAPP addendum.

14.5 Documentation of assessment

Documentation of assessment will occur in the final report (see Section 12).

15.0 References

Agency for Toxic Substances and Disease Registry (ATSDR), 2000. Toxicological profile for Polychlorinated Biphenyls (PCBs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. https://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=142&tid=26

City of Spokane, 2015. PCBs in Municipal Products. City of Spokane Wastewater Management Department. Revised July 21, 2015. https://static.spokanecity.org/documents/publicworks/wastewater/pcbs/pcbs-in-municipal-products-report-revised-2015-07-21.pdf

DES-280-00, 2019. Purchasing Preference for Products and Product Packaging That Do Not Contain Polychlorinated Biphenyls (PCBs). Washington State Department of Enterprise Services. Effective date: January 1, 2019. https://des.wa.gov/sites/default/files/public/documents/About/Procurement_reform/Policies/DES-280-000PCB.pdf

Ecology and Health, 2015. PCB Chemical Action Plan. Publication 15-07-002, 223 pages. Washington State Department of Ecology and Washington State Department of Health. February 2015. https://apps.ecology.wa.gov/publications/summarypages/1507002.html

Ecology and EPA, 2019. Environmental Performance Partnership Agreement, State Fiscal Years 2020 – 2021, July 1, 2019 – June 30, 2021. Washington State Department of Ecology and U.S. Environmental Protection Agency – Region 10. Publication number: 19-01-004, 100 pages. https://apps.ecology.wa.gov/publications/documents/1901004.pdf

Ecology, 2020. Priority Consumer Products Report to the Legislature: Safer Products for Washington Implementation Phase 2. Publication 20-04-019, 199 pages. Washington State Department of Ecology, Olympia, WA. https://apps.ecology.wa.gov/publications/summarypages/2004019.html

Environmental Protection Agency (EPA), 1979. EPA Bans PCB Manufacture; Phases out Uses. EPA press release on April 19, 1979. Retrieved from https://archive.epa.gov/epa/aboutepa/epa-bans-pcb-manufacture-phases-out-uses.html

EPA, 2010. Method 1668C: Chlorinated Biphenyl Congeners in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS. EPA-820-R-10-005. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Engineering and Analysis Division. April 2010.

EPA, 2016. National Functional Guidelines for High Resolution Superfund Methods Data Review. EPA Report Number 542-B-16-001. United States Environmental Protection Agency, Washington D.C. https://www.epa.gov/sites/production/files/2016-05/documents/hrsm_nfg.pdf

EPA, 2020. Learn about Polychlorinated Biphenyls (PCBs). Retrieved from https://www.epa.gov/pcbs/learn-about-polychlorinated-biphenyls-pcbs

Guo, J., Capozzi, S., Kraeutler, T. and L. Rodenburg, 2014. Global Distribution and Local Impacts of Inadvertently Generated Polychlorinated Biphenyls in Pigments. Environmental Science and Technology, 48: 8573-8580. https://pubs.acs.org/doi/pdf/10.1021/es502291b

Heine, L. and Trebilcock, C. 2018. Inadvertent PCBs in Pigments: Market Innovation for a Circular Economy. Northwest Green Chemistry. http://srrttf.org/wp-content/uploads/2019/07/NGC-inadvertant-PCB-White-Paper-for-SRRTTF-20181016.pdf

Hu, D. and Hornbuckle, K.C. 2010. Inadvertent Polychlorinated Biphenyls in Commercial Paint Pigments. Environmental Science and Technology, 44: 2822-2827. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2853905/pdf/es902413k.pdf

Munoz, G. 2007. Processes that Inadvertently Produce PCBs. Optimizing Contaminant Trackdown: Focusing on Wastewater Treatment Plants and Related Systems. The New York Academy of Science.

Nestler, N., Heine, L., and Montgomery, A. 2019. Pigments and inadvertent polychlorinated biphenyls (iPCBs): Advancing no and low iPCB pigments for newsprint, and paper and paperboard packaging. Northwest Green Chemistry. http://srrttf.org/wp-content/uploads/2019/07/Final20190628_iPCBs-and-Pigments.pdf

Panero, M., Boehme, S., and Muñoz, G. 2005. Pollution Prevention and Management Strategies for Polychlorinated Biphenyls in the New York/New Jersey Harbor. New York Academy of Sciences, New York.

Southern Resident Orca Task Force, 2018. Southern Resident Orca Task Force, Report and Recommendations. November 16, 2018. https://www.governor.wa.gov/sites/default/files/OrcaTaskForce_reportandrecommendations_11.16.18.pdf

Southern Resident Orca Task Force, 2019. Southern Resident Orca Task Force, Final Report and Recommendations. November 2019. https://www.governor.wa.gov/sites/default/files/OrcaTaskForce_FinalReportandRecommendations_11.07.19.pdf

Stone, A. 2013. Quality Assurance Project Plan: Polychlorinated Biphenyls (PCBs) in General Consumer Products. Publication 13-04-008, 23 pages. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/documents/1304008.pdf

Stone, A. 2014a. Polychlorinated Biphenyls (PCBs) in General Consumer Products. Publication 14-04-035, 64 pages. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/documents/1404035.pdf

Stone, A. 2014b. Addendum #1 to Quality Assurance Project Plan: PCBs in General Consumer Products. Publication 13-04-008a, 7 pages. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/documents/1304008a.pdf

Stone, A. 2016. Polychlorinated Biphenyls in Consumer Products. Publication 16-04-014, 61 pages. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/SummaryPages/1604014.html

Trumbull, K. 2017a. PCBs in State Purchased Products – 2017: Addendum to Quality Assurance Project Plan: Product Testing Program, Version 1.0. Publication 17-04-004. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/summarypages/1704004.html

Trumbull, K. 2017b. Addendum 1 to PCBs in State Purchased Products – 2017: Addendum to Quality Assurance Project Plan: Product Testing Program, Version 1.0. Publication 17-04-045. Washington State Department of Ecology, Olympia. https://apps.ecology.wa.gov/publications/summarypages/1704045.html

Wiseman, C. 2021a. Product Testing Standard Operating Procedure for Product Collection and Sample Processing, Version 2.1. Document No. PTP001. Publication 21-03-201. Washington State Department of Ecology, Olympia, WA. https://apps.ecology.wa.gov/publications/SummaryPages/2103201.html

Wiseman, C. 2021b (*In publication*). Product Testing Standard Operating Procedure for Database Data Entry and Data Entry Quality Assurance, Version 2.1. Document No. PTP002. Washington State Department of Ecology, Olympia, WA.

16.0 Appendices

Appendix A. 209 PCB Congeners and Quality Control Acceptance Criteria

Table A-1. 209 PCB congeners.

Congener Number	Chlorobiphenyl (CB) Congener Name[#,+]	CAS Number
PCB-001	2-MoCB	2051-60-7
PCB-002	3-MoCB	2051-61-8
PCB-003	4-MoCB	2051-62-9
PCB-004	2,2'-DiCB	13029-08-8
PCB-005	2,3-DiCB	16605-91-7
PCB-006	2,3'-DiCB	25569-80-6
PCB-007	2,4-DiCB	33284-50-3
PCB-008	2,4'-DiCB	34883-43-7
PCB-009	2,5-DiCB	34883-39-1
PCB-010	2,6-DiCB	33146-45-1
PCB-011	3,3'-DiCB	2050-67-1
PCB-012	3,4-DiCB	2974-92-7
PCB-013	3,4'-DiCB	2974-90-5
PCB-014	3,5-DiCB	34883-41-5
PCB-015	4,4'-DiCB	2050-68-2
PCB-016	2,2',3-TrCB	38444-78-9
PCB-017	2,2',4-TrCB	37680-66-3
PCB-018	2,2',5-TrCB	37680-65-2
PCB-019	2,2',6-TrCB	38444-73-4
PCB-020	2,3,3'-TrCB	38444-84-7
PCB-021	2,3,4-TrCB	55702-46-0
PCB-022	2,3,4'-TrCB	38444-85-8
PCB-023	2,3,5-TrCB	55720-44-0
PCB-024	2,3,6-TrCB	55702-45-9
PCB-025	2,3',4-TrCB	55712-37-3
PCB-026	2,3',5-TrCB	38444-81-4
PCB-027	2,3',6-TrCB	38444-76-7
PCB-028	2,4,4'-TrCB	7012-37-5
PCB-029	2,4,5-TrCB	15862-07-4
PCB-030	2,4,6-TrCB	35693-92-6
PCB-031	2,4',5-TrCB	16606-02-3
PCB-032	2,4',6-TrCB	38444-77-8
PCB-033	2',3,4-TrCB	38444-86-9
PCB-034	2',3,5-TrCB	37680-68-5
PCB-035	3,3',4-TrCB	37680-69-6
PCB-036	3,3',5-TrCB	38444-87-0
PCB-037	3,4,4'-TrCB	38444-90-5
PCB-038	3,4,5-TrCB	53555-66-1
PCB-039	3,4',5-TrCB	38444-88-1
PCB-040	2,2',3,3'-TeCB	38444-93-8
PCB-041	2,2',3,4-TeCB	52663-59-9
PCB-042	2,2',3,4'-TeCB	36559-22-5

Congener Number	Chlorobiphenyl (CB) Congener Name[#,+]	CAS Number
PCB-043	2,2',3,5-TeCB	70362-46-8
PCB-044	2,2',3,5'-TeCB	41464-39-5
PCB-045	2,2',3,6-TeCB	70362-45-7
PCB-046	2,2',3,6'-TeCB	41464-47-5
PCB-047	2,2',4,4'-TeCB	2437-79-8
PCB-048	2,2',4,5-TeCB	70362-47-9
PCB-049	2,2',4,5'-TeCB	41464-40-8
PCB-050	2,2',4,6-TeCB	62796-65-0
PCB-051	2,2'4,6'-TeCB	68194-04-7
PCB-052	2,2',5,5'-TeCB	35693-99-3
PCB-053	2,2',5,6'-TeCB	41464-41-9
PCB-054	2,2',6,6'-TeCB	15968-05-5
PCB-055	2,3,3',4-TeCB	74338-24-2
PCB-056	2,3,3',4'-TeCB	41464-43-1
PCB-057	2,3,3',5-TeCB	70424-67-8
PCB-058	2,3,3',5'-TeCB	41464-49-7
PCB-059	2,3,3',6-TeCB	74472-33-6
PCB-060	2,3,4,4'-TeCB	33025-41-1
PCB-061	2,3,4,5-TeCB	33284-53-6
PCB-062	2,3,4,6-TeCB	54230-22-7
PCB-063	2,3,4',5-TeCB	74472-34-7
PCB-064	2,3,4'6-TeCB	52663-58-8
PCB-065	2,3,5,6-TeCB	33284-54-7
PCB-066	2,3',4,4'-TeCB	32598-10-0
PCB067	2,3',4,5-TeCB	73575-53-8
PCB-068	2,3',4,5'-TeCB	73575-52-7
PCB-069	2,3',4.6-TeCB	60233-24-1
PCB-070	2,3',4',5-TeCB	32598-11-1
PCB-071	2,3',4'6-TeCB	41464-46-4
PCB-072	2,3',5,5'-TeCB	41464-42-0
PCB-073	2,3',5',6-TeCB	74338-23-1
PCB-074	2,4,4'5-TeCB	32690-93-0
PCB-075	2,4,4',6-TeCB	32598-12-2
PCB-076	2',3,4,5-TeCB	70362-48-0
PCB-077	3,3'4,4'-TeCB	32598-13-3
PCB-078	3,3',4,5-TeCB	70362-49-1
PCB-079	3,3'4,5'-TeCB	41464-48-6
PCB-080	3,3',5,5'-TeCB	33284-52-5
PCB-081	3,4,4',5-TeCB	70362-50-4
PCB-082	2,2',3,3',4-PeCB	52663-62-4
PCB-083	2,2',3,3',5-PeCB	60145-20-2
PCB-084	2,2',3,3',6-PeCB	52663-60-2
PCB-085	2,2',3,4,4'-PeCB	65510-45-4
PCB-086	2,2',3,4,5-PeCB	55312-69-1
PCB-087	2,2',3,4,5'-PeCB	38380-02-8
PCB-088	2,2',3,4,6-PeCB	55215-17-3
PCB-089	2,2',3,4,6'-PeCB	73575-57-2
PCB-090	2,2',3,4',5-PeCB	68194-07-0
PCB-091	2,2',3,4',6-PeCB	68194-05-8
PCB-092	2,2',3,5,5'-PeCB	52663-61-3

Congener Number	Chlorobiphenyl (CB) Congener Name[#,+]	CAS Number
PCB-093	2,2',3,5,6-PeCB	73575-56-1
PCB-094	2,2',3,5,6'-PeCB	73575-55-0
PCB-095	2,2',3,5',6-PeCB	38379-99-6
PCB-096	2,2',3,6,6'-PeCB	73575-54-9
PCB-097	2,2',3',4,5-PeCB	41464-51-1
PCB-098	2,2',3',4,6-PeCB	60233-25-2
PCB-099	2,2',4,4',5-PeCB	38380-01-7
PCB-100	2,2',4,4',6-PeCB	39485-83-1
PCB-101	2,2',4,5,5'-PeCB	37680-73-2
PCB-102	2,2',4,5,6'-PeCB	68194-06-9
PCB-103	2,2',4,5',6-PeCB	60145-21-3
PCB-104	2,2',4,6,6'-PeCB	56558-16-8
PCB-105	2,3,3',4,4'-PeCB	32598-14-4
PCB-106	2,3,3',4,5-PeCB	70424-69-0
PCB-107	2,3,3',4',5-PeCB	70424-68-9
PCB-108	2,3,3',4,5'-PeCB	70362-41-3
PCB-109	2,3,3',4,6-PeCB	74472-35-8
PCB-110	2,3,3',4',6-PeCB	38380-03-9
PCB-111	2,3,3',5,5'-PeCB	39635-32-0
PCB-112	2,3,3',5,6-PeCB	74472-36-9
PCB-113	2,3,3',5',6-PeCB	68194-10-5
PCB-114	2,3,4,4',5-PeCB	74472-37-0
PCB-115	2,3,4,4',6-PeCB	74472-38-1
PCB-116	2,3,4,5,6-PeCB	18259-05-7
PCB-117	2,3,4',5,6-PeCB	68194-11-6
PCB-118	2,3',4,4',5-PeCB	31508-00-6
PCB-119	2,3',4,4',6-PeCB	56558-17-9
PCB-120	2,3',4,5,5'-PeCB	68194-12-7
PCB-121	2,3',4,5',6-PeCB	56558-18-0
PCB-122	2',3,3',4,5-PeCB	76842-07-4
PCB-123	2',3,4,4',5-PeCB	65510-44-3
PCB-124	2',3,4,5,5'-PeCB	70424-70-3
PCB-125	2',3,4,5,6'-PeCB	74472-39-2
PCB-126	3,3',4,4',5-PeCB	57465-28-8
PCB-127	3,3',4,5,5'-PeCB	39635-33-1
PCB-128	2,2',3,3',4,4'-HxCB	38380-07-3
PCB-129	2,2',3,3',4,5-HxCB	55215-18-4
PCB-130	2,2',3,3',4,5'-HxCB	52663-66-8
PCB-131	2,2',3,3',4,6-HxCB	61798-70-7
PCB-132	2,2',3,3',4,6'-HxCB	38380-05-1
PCB-133	2,2',3,3',5,5'-HxCB	35694-04-3
PCB-134	2,2',3,3',5,6-HxCB	52704-70-8
PCB-135	2,2',3,3',5,6'-HxCB	52744-13-5
PCB-136	2,2',3,3',6,6'-HxCB	38411-22-2
PCB-137	2,2',3,4,4',5-HxCB	35694-06-5
PCB-138	2,2',3,4,4',5'-HxCB	35065-28-2
PCB-139	2,2',3,4,4',6-HxCB	56030-56-9
PCB-140	2,2',3,4,4',6'-HxCB	59291-64-4
PCB-141	2,2',3,4,5,5'-HxCB	52712-04-6
PCB-142	2,2',3,4,5,6-HxCB	41411-61-4

Congener Number	Chlorobiphenyl (CB) Congener Name[#,+]	CAS Number
PCB-143	2,2',3,4,5,6'-HxCB	68194-15-0
PCB-144	2,2',3,4,5',6-HxCB	68194-14-9
PCB-145	2,2',3,4,6,6'-HxCB	74472-40-5
PCB-146	2,2',3,4',5,5'-HxCB	51908-16-8
PCB-147	2,2',3,4',5,6-HxCB	68194-13-8
PCB-148	2,2',3,4',5,6'-HxCB	74472-41-6
PCB-149	2,2',3,4',5',6-HxCB	38380-04-0
PCB-150	2,2',3,4',6,6'-HxCB	68194-08-1
PCB-151	2,2',3,5,5',6-HxCB	52663-63-5
PCB-152	2,2',3,5,6,6'-HxCB	68194-09-2
PCB-153	2,2',4,4',5,5'-HxCB	35065-27-1
PCB-154	2,2',4,4',5,6'-HxCB	60145-22-4
PCB-155	2,2',4,4',6,6'-HxCB	33979-03-2
PCB-156	2,3,3',4,4',5-HxCB	38380-08-4
PCB-157	2,3,3',4,4',5'-HxCB	69782-90-7
PCB-158	2,3,3',4,4',6-HxCB	74472-42-7
PCB-159	2,3,3',4,5,5'-HxCB	39635-35-3
PCB-160	2,3,3',4,5,6-HxCB	41411-62-5
PCB-161	2,3,3',4,5',6-HxCB	74472-43-8
PCB-162	2,3,3',4',5,5'-HxCB	39635-34-2
PCB-163	2,3,3',4',5,6-HxCB	74472-44-9
PCB-164	2,3,3',4',5',6-HxCB	74472-45-0
PCB-165	2,3,3',5,5',6-HxCB	74472-46-1
PCB-166	2,3,4,4',5,6-HxCB	41411-63-6
PCB-167	2,3',4,4',5,5'-HxCB	52663-72-6
PCB-168	2,3',4,4',5',6-HxCB	59291-65-5
PCB-169	3,3',4,4',5,5'-HxCB	32774-16-6
PCB-170	2,2',3,3',4,4',5-HpCB	35065-30-6
PCB-171	2,2',3,3',4,4',6-HpCB	52663-71-5
PCB-172	2,2',3,3',4,5,5'-HpCB	52663-74-8
PCB-173	2,2',3,3',4,5,6-HpCB	68194-16-1
PCB-174	2,2',3,3',4,5,6'-HpCB	38411-25-5
PCB-175	2,2',3,3',4,5',6-HpCB	40186-70-7
PCB-176	2,2',3,3',4,6,6'-HpCB	52663-65-7
PCB-177	2,2',3,3',4',5,6-HpCB	52663-70-4
PCB-178	2,2',3,3',5,5',6-HpCB	52663-67-9
PCB-179	2,2',3,3',5,6,6'-HpCB	52663-64-6
PCB-180	2,2',3,4,4',5,5'-HpCB	35065-29-3
PCB-181	2,2',3,4,4',5,6-HpCB	74472-47-2
PCB-182	2,2',3,4,4',5,6'-HpCB	60145-23-5
PCB-183	2,2',3,4,4',5',6-HpCB	52663-69-1
PCB-184	2,2',3,4,4',6,6'-HpCB	74472-48-3
PCB-185	2,2',3,4,5,5',6-HpCB	52712-05-7
PCB-186	2,2',3,4,5,6,6'-HpCB	74472-49-4
PCB-187	2,2',3,4',5,5',6-HpCB	52663-68-0
PCB-188	2,2',3,4',5,6,6'-HpCB	74487-85-7
PCB-189	2,3,3',4,4',5,5'-HpCB	39635-31-9
PCB-190	2,3,3',4,4',5,6-HpCB	41411-64-7
PCB-191	2,3,3',4,4',5',6-HpCB	74472-50-7
PCB-192	2,3,3',4,5,5',6-HpCB	74472-51-8

Congener Number	Chlorobiphenyl (CB) Congener Name[#,+]	CAS Number
PCB-193	2,3,3',4',5,5',6-HpCB	69782-91-8
PCB-194	2,2',3,3',4,4',5,5'-OcCB	35694-08-7
PCB-195	2,2',3,3',4,4',5,6-OcCB	52663-78-2
PCB-196	2,2',3,3',4,4',5,6'-OcCB	42740-50-1
PCB-197	2,2',3,3',4,4',6,6'-OcCB	33091-17-7
PCB-198	2,2',3,3',4,5,5',6-OcCB	68194-17-2
PCB-199	2,2',3,3',4,5,5',6'-OcCB	52663-75-9
PCB-200	2,2',3,3',4,5,6,6'-OcCB	52663-73-7
PCB-201	2,2',3,3',4,5',6,6'-OcCB	40186-71-8
PCB-202	2,2',3,3',5,5',6,6'-OcCB	2136-99-4
PCB-203	2,2',3,4,4',5,5',6-OcCB	52663-76-0
PCB-204	2,2',3,4,4',5,6,6'-OcCB	74472-52-9
PCB-205	2,3,3'4,4',5,5',6-OcCB	74472-53-0
PCB-206	2,2',3,3',4,4',5,5',6-NoCB	40186-72-9
PCB-207	2,2',3,3',4,4',5,6,6'-NoCB	52663-79-3
PCB-208	2,2',3,3',4,5,5',6,6'-NoCB	52663-77-1
PCB-209	DeCB	2051-24-3

[#]Abbreviations for chlorination levels of chlorinated biphenyl (CB):
MoCB: monochlorobiphenyl
DiCB: dichlorobiphenyl
TrCB: trichlorobiphenyl
TeCB: tetrachlorobiphenyl
PeCB: pentachlorobiphenyl
HxCB: hexachlorobiphenyl
HpCB: heptachlorobiphenyl
OcCB: octachlorobiphenyl
NoCB: nonachlorobiphenyl
DeCB: decachlorobiphenyl

[+]Depending on the laboratory's analytical conditions, PCB congeners may co-elute during analysis and are quantified as the concentration of a mixture of more than one congener during laboratory analysis (EPA, 2010).

Table A-2. Quality control acceptance criteria for OPR and labeled compounds in samples, excerpt from EPA Method 1668C (EPA 2010).

Congener Number	Chlorobiphenyl (CB) Congener Name[#]	OPR (or LCS) Percent Recovery	Labeled Compound Percent Recovery in Sample
PCB-001	2-MoCB	60-135	na
PCB-003	4-MoCB	60-135	na
PCB-004	2,2'-DiCB	60-135	na
PCB-015	4,4'-DiCB	60-135	na
PCB-019	2,2',6-TrCB	60-135	na
PCB-037	3,4,4'-TrCB	60-135	na
PCB-054	2,2',6,6'-TeCB	60-135	na
PCB-077	3,3',4,4'-TeCB	60-135	na
PCB-081	3,4,4',5-TeCB	60-135	na
PCB-104	2,2',4,6,6'-PeCB	60-135	na
PCB-105	2,3,3',4,4'-PeCB	60-135	na
PCB-114	2,3,4,4',5-PeCB	60-135	na
PCB-118	2,3',4,4',5-PeCB	60-135	na
PCB-123	2',3,4,4',5-PeCB	60-135	na
PCB-126	3,3',4,4',5-PeCB	60-135	na
PCB-155	2,2',4,4',6,6'-HxCB	60-135	na
PCB-156	2,3,3',4,4',5-HxCB	60-135	na
PCB-157	2,3,3',4,4',5'-HxCB	60-135	na
PCB-167	2,3',4,4',5,5'-HxCB	60-135	na
PCB-169	3,3',4,4',5,5'-HxCB	60-135	na
PCB-188	2,2',3,4',5,6,6'-HpCB	60-135	na
PCB-189	2,3,3',4,4',5,5'-HpCB	60-135	na
PCB-202	2,2',3,3',5,5',6,6'-OcCB	60-135	na
PCB-205	2,3,3',4,4',5,5',6-OcCB	60-135	na
PCB-206	2,2',3,3',4,4',5,5',6-NoCB	60-135	na
PCB-208	2,2',3,3',4,5,5',6,6'-NoCB	60-135	na
PCB-209	DeCB	60-135	na
PCB-001L*	$^{13}C_{12}$-2-MoCB	15-145	5-145
PCB-003L*	$^{13}C_{12}$-4-MoCB	15-145	5-145
PCB-004L*	$^{13}C_{12}$-2,2'DiCB	15-145	5-145
PCB-015L*	$^{13}C_{12}$-4,4'-DiCB	15-145	5-145
PCB-019L*	$^{13}C_{12}$-2,2',6-TrCB	15-145	5-145
PCB-037L*	$^{13}C_{12}$-3,4,4'-TrCB	15-145	5-145
PCB-054L*	$^{13}C_{12}$-2,2',6,6'-TeCB	15-145	5-145
PCB-077L*	$^{13}C_{12}$-3,3',4,4'-TeCB	40-145	10-145
PCB-081L*	$^{13}C_{12}$-3,4,4',5-TeCB	40-145	10-145
PCB-104L*	$^{13}C_{12}$-2,2',4,6,6'-PeCB	40-145	10-145
PCB-105L*	$^{13}C_{12}$-2,3,3',4,4'-PeCB	40-145	10-145
PCB-114L*	$^{13}C_{12}$-2,3,4,4',5-PeCB	40-145	10-145
PCB-118L*	$^{13}C_{12}$-2,3',4,4',5-PeCB	40-145	10-145
PCB-123L*	$^{13}C_{12}$-2',3,4,4',5-PeCB	40-145	10-145
PCB-126L*	$^{13}C_{12}$-3,3',4,4',5-PeCB	40-145	10-145
PCB-155L*	$^{13}C_{12}$-2,2',4,4',6,6'-HxCB	40-145	10-145
PCB-156L*	$^{13}C_{12}$-2,3,3',4,4',5-HxCB	40-145	10-145
PCB-157L*	$^{13}C_{12}$-2,3,3',4,4',5'-HxCB	40-145	10-145
PCB-167L*	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB	40-145	10-145
PCB-169L*	$^{13}C_{12}$-3,3',4,4',5,5'-HxCB	40-145	10-145
PCB-188L*	$^{13}C_{12}$-2,2',3,4',5,6,6'-HpCB	40-145	10-145

Congener Number	Chlorobiphenyl (CB) Congener Name[#]	OPR (or LCS) Percent Recovery	Labeled Compound Percent Recovery in Sample
PCB-189L*	$^{13}C_{12}$-2,3,3',4,4',5,5'-HpCB	40-145	10-145
PCB-202L*	$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OcCB	40-145	10-145
PCB-205L*	$^{13}C_{12}$-2,3,3'4,4',5,5',6-OcCB	40-145	10-145
PCB-206L*	$^{13}C_{12}$-2,2',3,3',4,4',5,5',6-NoCB	40-145	10-145
PCB-208L*	$^{13}C_{12}$-2,2',3,3',4,5,5',6,6'-NoCB	40-145	10-145
PCB-209L*	$^{13}C_{12}$-DeCB	40-145	10-145
PCB-028L*,^	$^{13}C_{12}$-2,4,4'-TrCB	15-145	5-145
PCB-111L*,^	$^{13}C_{12}$-2,3,3',5,5'-PeCB	40-145	10-145
PCB-178L*,^	$^{13}C_{12}$-2,2',3,3',5,5',6-HpCB	40-145	10-145

[#]Abbreviations for chlorination levels of chlorinated biphenyl (CB):
MoCB: monochlorobiphenyl
DiCB: dichlorobiphenyl
TrCB: trichlorobiphenyl
TeCB: tetrachlorobiphenyl
PeCB: pentachlorobiphenyl
HxCB: hexachlorobiphenyl
HpCB: heptachlorobiphenyl
OcCB: octachlorobiphenyl
NoCB: nonachlorobiphenyl
DeCB: decachlorobiphenyl
*Suffix "L" indicates labeled compound.
^Cleanup standards.
OPR: ongoing precision and recovery standards
LCS: laboratory control standards
na: not applicable

Appendix B. Product Testing Tool Cleaning and Decontamination for PCB Congeners Analysis

All tools used in the preparation and processing of solid-type product component samples and collection of aliquots of liquid-type samples will be decontaminated following a low-level tool cleaning procedure specific to testing for PCB congeners. The procedure is outlined below.

- Wear appropriate personal protective equipment (PPE) including gloves, eyewear, and lab coat while cleaning tools.
  - Nitrile gloves are required for all tool decontamination processes and Silver Shield gloves can be worn in addition to (over) nitrile gloves when using solvents such as hexane.
- Transport cleaning supplies and tools to the sink using a cart if needed.
- Prepare a dilute 1% solution of 10 ml cleaning agent (Liquinox®) to 1-liter deionized (DI) water in pre-labeled product testing soap wash bottle.
- Set up a drying location for clean tools by placing a large piece of aluminum foil covered with KimWipes®, or other pretested absorbent towels, on the precleaned countertop.
  - Preclean countertop and work area including fume hood surface with dilute Liquinox® and DI water followed by a rinse with 24% ethanol in DI water.
- Wash the prep room clean tool bin with dilute Liquinox® and DI water and rinse with 24% ethanol in DI water prior to use then line with aluminum foil (dull side up).
  - Use this bin to transport and store clean tools.
- Follow steps 1 through 4 to wash one tool individually until all tools are cleaned. Continue with steps 5 and 6 to rinse tools with hexane followed by individual wrapping of each tool with aluminum foil once dry. Replace gloves, KimWipes®, and aluminum foil as necessary throughout the process to prevent cross contamination.
  - Step 1: Spray a small amount of the dilute Liquinox® onto a clean scrub brush and scrub each tool thoroughly for at least 30 seconds, or longer if there are visible pieces of product on the tool.
  - Step 2: Rinse the tool at least three times with DI water to remove the cleaning solution.
  - Step 3: Follow with rinsing tool with 24% ethanol in DI water.
  - Step 4: Place tools on KimWipes® layer over aluminum foil surface. Gently pat tool dry with a clean KimWipe® and place on a piece of clean dull side up aluminum foil (no KimWipe® layer).
    - Thoroughly rinse the scrub brush prior to cleaning the next tool.
  - Step 5 performed in the fume hood: Transfer an appropriate volume of hexane (certified ACS HPLC grade ≥ 99.5% purity) for rinsing tools from the original storage container to a certified clean glass jar (e.g. new glass jar used for product samples). Use a glass pipette equipped with pipette bulb to rinse both sides of the stainless steel tool surface with hexane (avoid handle especially if handle is plastic).
    - Rinse tools with hexane over a stainless steel collection tray or bowl.

      If collecting hexane rinse as QC samples, collect hexane rinse into a prelabeled new glass sample jar setting in the stainless steel collection tray or bowl.

If no QC hexane rinse samples are needed, at the end of the tool rinse process pour the hexane rinse waste into a designated container for waste solvent and place in the appropriate flammable cabinet in the Hazardous Material Storage room.

- Place hexane rinsed tool on a clean aluminum foil (dull side up) lined surface inside the fume hood.

  Allow all solvent to evaporate in the fume hood until tool is dry. Leave tool surfaces open and do not overlay tools.
- Hexane is located in the flammable cabinets in the Hazardous Material Storage room.
- Do not use KimWipes® on tool after hexane rinse.

- Step 6: For individual wrapping of each tool, lay out a small piece of foil dull side up and place clean tool on foil. Gently fold foil around tool (it is okay to avoid wrapping handle of tool if placing directly into clean tool bin).
  - Wrap tools in aluminum foil after all hexane has evaporated then place in the clean tool bin until use.
  - Place all tools in clean tool bin in the same direction (e.g. handles and cutting edges).

- Continue with the above process until all tools are clean. Use new gloves when moving from cleaning to rinsing to wrapping tools. Use the tool cleaning and decontamination process on any tools and equipment that will be used to process solid samples or collect aliquots of samples.
- Tools may not be reused between processing different samples and must be cleaned again following the above process.

Appendix C. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

Ambient: Background or away from point sources of contamination. Surrounding environmental condition.

Anthropogenic: Human-caused.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Acronyms and Abbreviations

e.g.	For example
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
et al.	And others
i.e.	In other words
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
PBTs	Persistent, bioaccumulative, and toxic chemicals
PCB	Polychlorinated biphenyls
PTDB	Product Testing Database
QA	Quality assurance
QAPP	Quality assurance project plan
QC	Quality control
RPD	Relative percent difference
WAC	Washington Administrative Code

Units of Measurement

°C	degrees centigrade
Dw	dry weight
G	gram, a unit of mass
Kg	kilograms, a unit of mass equal to 1,000 grams
m	meter
mm	millimeter
mg	milligram
mg/d	milligrams per day
mg/kg	milligrams per kilogram (parts per million)
mg/L	milligrams per liter (parts per million)
mL	milliliter
ng/g	nanograms per gram (parts per billion)

ng/kg	nanograms per kilogram (parts per trillion)
ng/L	nanograms per liter (parts per trillion)
pg/g	picograms per gram (parts per trillion)
pg/L	picograms per liter (parts per quadrillion)
s.u.	standard units
µg/g	micrograms per gram (parts per million)
µg/kg	micrograms per kilogram (parts per billion)
µg/L	micrograms per liter (parts per billion)
µm	micrometer
µM	micromolar (a chemistry unit)
ww	wet weight

Quality Assurance Glossary

Accreditation: A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data. For Ecology, it is "Formal recognition by (Ecology)…that an environmental laboratory is capable of producing accurate analytical data." [WAC 173-50-040] (Kammin, 2010)

Accuracy: The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms *precision* and *bias* be used to convey the information associated with the term *accuracy* (USGS, 1998).

Analyte: An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella (Kammin, 2010).

Bias: The difference between the sample mean and the true value. Bias usually describes a systematic difference reproducible over time and is characteristic of both the measurement system and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI) (Kammin, 2010; Ecology, 2004).

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process (USGS, 1998).

Calibration: The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured (Ecology, 2004).

Check standard: A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards but should be referred to by their actual designator, e.g., CRM, LCS (Kammin, 2010; Ecology, 2004).

Comparability: The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator (USEPA, 1997).

Completeness: The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator (USEPA, 1997).

Continuing Calibration Verification Standard (CCV): A quality control (QC) sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run (Kammin, 2010).

Control chart: A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system (Kammin, 2010; Ecology 2004).

Control limits: Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean (Kammin, 2010).

Data integrity: A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading (Kammin, 2010).

Data quality indicators (DQI): Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity (USEPA, 2006).

Data quality objectives (DQO): Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (USEPA, 2006).

Data set: A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010).

Data validation: An analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data set. It involves a detailed examination of the data package, using both professional judgment and objective criteria, to determine whether the MQOs for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability, and integrity, as these criteria relate to the usability of the data set. Ecology considers four key criteria to determine if data validation has actually occurred. These are:

- Use of raw or instrument data for evaluation.
- Use of third-party assessors.
- Data set is complex.
- Use of EPA Functional Guidelines or equivalent for review.

Examples of data types commonly validated would be:

- Gas Chromatography (GC).
- Gas Chromatography-Mass Spectrometry (GC-MS).
- Inductively Coupled Plasma (ICP).

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:

- No qualifier – data are usable for intended purposes.
- J (or a J variant) – data are estimated, may be usable, may be biased high or low.
- REJ – data are rejected, cannot be used for intended purposes.
  (Kammin, 2010; Ecology, 2004).

Data verification: Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set (Ecology, 2004).

Detection limit (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero (Ecology, 2004).

Duplicate samples: Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis (USEPA, 1997).

Field blank: A blank used to obtain information on contamination introduced during sample collection, storage, and transport (Ecology, 2004).

Initial Calibration Verification Standard (ICV): A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples (Kammin, 2010).

Laboratory Control Sample (LCS): A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples (USEPA, 1997).

Matrix spike: A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects (Ecology, 2004).

Measurement Quality Objectives (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness (USEPA, 2006).

Measurement result: A value obtained by performing the procedure described in a method (Ecology, 2004).

Method: A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed (EPA, 1997).

Method blank: A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples (Ecology, 2004; Kammin, 2010).

Method Detection Limit (MDL): This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero (Federal Register, October 26, 1984).

Percent Relative Standard Deviation (%RSD): A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$\%RSD = (100 * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010).

Parameter: A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all parameters (Kammin, 2010; Ecology, 2004).

Population: The hypothetical set of all possible observations of the type being investigated (Ecology, 2004).

Precision: The extent of random variability among replicate measurements of the same property; a data quality indicator (USGS, 1998).

Quality assurance (QA): A set of activities designed to establish and document the reliability and usability of measurement data (Kammin, 2010).

Quality Assurance Project Plan (QAPP): A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives (Kammin, 2010; Ecology, 2004).

Quality control (QC): The routine application of measurement and statistical procedures to assess the accuracy of measurement data (Ecology, 2004).

Relative Percent Difference (RPD): RPD is commonly used to evaluate precision. The following formula is used:

$$[Abs(a-b)/((a + b)/2)] * 100$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Replicate samples: Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled (USGS, 1998).

Representativeness: The degree to which a sample reflects the population from which it is taken; a data quality indicator (USGS, 1998).

Sample (field): A portion of a population (environmental entity) that is measured and assumed to represent the entire population (USGS, 1998).

Sample (statistical): A finite part or subset of a statistical population (USEPA, 1997).

Sensitivity: In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit (Ecology, 2004).

Spiked blank: A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method (USEPA, 1997).

Spiked sample: A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency (USEPA, 1997).

Split sample: A discrete sample subdivided into portions, usually duplicates (Kammin, 2010).

Standard Operating Procedure (SOP): A document which describes in detail a reproducible and repeatable organized activity (Kammin, 2010).

Surrogate: For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis (Kammin, 2010).

Systematic planning: A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning (USEPA, 2006).

References for QA Glossary

Ecology, 2004. Guidance for the Preparation of Quality Assurance Project Plans for Environmental Studies. Washington State Department of Ecology, Olympia, WA. https://apps.ecology.wa.gov/publications/SummaryPages/0403030.html.

Kammin, B., 2010. Definition developed or extensively edited by William Kammin, 2010. Washington State Department of Ecology, Olympia, WA.

USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4. http://www.epa.gov/quality/qs-docs/g4-final.pdf.

USGS, 1998. Principles and Practices for Quality Assurance and Quality Control. Open-File Report 98-636. U.S. Geological Survey. http://ma.water.usgs.gov/fhwa/products/ofr98-636.pdf.