Ministry of
Environment and
Climate Change Strategy

Spill Sampling and Reporting Guidance

October 2019

CONTEXT

This guidance document is intended to assist responsible persons in understanding the expectations and best practices for spill sampling and the reporting of results. The intended audience of this guidance document is the qualified professionals taking samples and preparing reports in a spill scenario. This document is not designed to be a replacement to a full understanding and compliance to the sampling protocols outlined in the B.C. Field Sampling Manual or other applicable guidance documents and regulations. The responsible person(s) and/or the owner(s) of the spilled substance(s) should hire a professional that is properly qualified in the sampling of abiotic and biotic substances and proper field sampling techniques. This document relates to sampling and monitoring that is conducted during the emergency response and recovery phase of a spill incident and does not focus on long-term monitoring.

There are multiple sections under division 2.1 of the *Environmental Management Act* (EMA) – Spill Preparedness, Reponses and Recovery, where a responsible person is required to conduct, or provide information obtained from sampling and monitoring efforts. As per Section 91.2 (2)(c) of EMA, the responsible person must take actions to identify and evaluate the immediate and long-term risks and impacts of the spill incident on the environment and human health. Such identification and evaluation is conducted using an environmental impact assessment that includes sampling and monitoring to determine contamination levels and species/habitats at risk or impacted by the spill incident. As per Section 91.2 (4) of EMA, a director may order a responsible person to prepare and submit a recovery plan to resolve or mitigate the impacts of a spill. Recovery plans are outlined in the Spill Preparedness, Response and Recovery Regulation (SPRRR). Section 7 of Part 4 of the SPRRR outlines the requirements of a responsible person to submit a report at the conclusion of a recovery process which must include a record of sampling, testing, monitoring and assessment to demonstrate that the recovery plan has been carried out. Additionally, spill reporting regulation includes an end of spill report (Section 6) which also requires details on the adverse effects to flora and fauna caused by a spill incident.

Post-spill environmental recovery is essential to ensure environmental restoration, protection, and continued resource use by B.C. citizens. It is the duty of the responsible person to demonstrate how the environment and human health has been impacted by a spill, in order to ensure that appropriate response actions are taken to mitigate the impacts. As such, it is critical that sampling and monitoring is scientifically robust and follows provincial guidelines, and that results are presented in a clear and concise manner.

This guidance document is not a legal document and the information contained within it does not constitute legal advice or impose any legally binding requirements. This guidance document does not replace EMA, the associated regulations, or any other applicable law. Amendments to EMA, its regulations, or other legislation referred to in this guidance document may impact the provisions contained within it; in the event of an inconsistency, EMA or other applicable legislation will prevail. Failure to comply with EMA and/or the regulations may result in fines and/or convictions.

ACRONYMS

BTEX	benzene, toluene, ethylbenzene, and xylenes
CALA	Canadian Association for Laboratory Accreditation
CCME	Canadian Council of Ministers of the Environment
COPC	contaminants of potential concern
DQO	data quality objective
EMA	Environmental Management Act
ENV	British Columbia Ministry of Environment and Climate Change Strategy
HEPH	heavy extractable petroleum hydrocarbons
LEPH	light extractable petroleum hydrocarbons
PAH	polycyclic aromatic hydrocarbon
QP	qualified professional
QA/QC	quality assurance and quality control
SOP	standard operating procedure
SPRR	Division 2.1 Spill Preparedness, Response and Recovery Regulation (SPRRR) of the Environmental Management Act
VPH	volatile petroleum hydrocarbons

TABLE OF CONTENTS

1.0 INTRODUCTION

Following a spill, sampling programs play a vital role in documenting the extent of contamination and providing valuable information to inform clean-up strategies. Preliminary environmental sampling early in the lifetime of a spill is critical to assess post-spill recovery and guide long-term monitoring plans. The B.C. Government's polluter-pay principle ensures that those who are responsible for spills are also responsible for cleaning them up. Therefore, the responsible person pays for preparing, carrying out and completing sampling and monitoring. It is the responsibility of the responsible person to retain a qualified professional who is proficient in sampling in accordance to protocols as laid out in the B.C. Field Sampling Manual, the CCME Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment and other applicable guidance documents and regulations. An example of a qualified professional is an individual retained for sampling who has a professional designation, higher education, and previous experience associated with the type of sampling or assessments completed. As such, this document provides field data collection, sampling design and reporting guidance that is specific to spill response. This document is scalable for large and smaller spill scenarios.

A well-designed sampling plan involves the creation of specific objectives to provide reliable, objective, and useful information regarding the presence, and ensuing potential effects, of spilled product in the environment. It is expected that all data be collected in a way that accurately and precisely represents the area being assessed for spill-related impacts to the environment. Guidance and expectations for designing a sampling plan, adhering to best practices for quality control, statistical analysis, and reporting are provided in this document.

1.1 Definitions

Abiotic environment means the non-living physical and chemical parts of the environment.

Biotic environment means living organisms within an ecosystem.

Recovery refers to the process of assisting in the recovery of an environment that has been degraded, damaged, or destroyed by a spill incident. It includes any or all actions taken to return the site and any impacted resources to their pre-spill conditions; umbrella term that includes restoration and remediation.

Responsible person means a person who has possession, charge, or control of a substance or thing when a spill of the substance or thing occurs or is at imminent risk of occurring.

Sediment is particulate matter, such as silt, sand and gravel, that is typically transported and deposited by water or wind – e.g. particles on the bed of a body of water.

Spill incident refers to both the spilled substance(s) and the spill response actions.

Qualified person is a person who possesses the specified skills, knowledge, training, and experience to perform a specified type of work.

2.0 FIELD DATA COLLECTION AND MANAGEMENT

Proper field data collection and management is essential for producing results that are measurable, accurate, and precise. There are a number of considerations to take into account when gathering field data during the spill sampling process.

General Considerations:

- All field notes should be digitized (i.e., scanned) for record management purposes.
- All sample labels should have unambiguous identification including a unique sampling identification number, date, place, time and initials of field sampling staff.
- Field notes should include all details regarding environmental conditions and observations (e.g., cloud cover, air temperature, wind direction, site visitors, etc.). Meticulously documented data collection can help to clarify unexpected issues with data analysis and interpretation.
- Field sampling instruments and equipment must be regularly maintained and calibrated and a log of the work (including dates, times, name of the person completing the work, recorded true calibration/maintenance values and expected values) must be recorded, managed and digitized.

2.1 Sampling Design

2.1.1 Sampling Goals

In general, a complete sampling design must indicate:

- study objectives that provide reliable and precise information regarding the presence of spilled product in the environment,
- the number of samples to be collected including a justification for the sample number,
- the type of samples to be collected including a justification for the type of samples and any justification of why alternative types of samples have not been collected,
- how baseline data will be collected (note: if historical data is not available, a non-impacted background reference site in proximity to the impacted site must be sampled at), and
- location (spatial and temporal) of samples to be collected and a justification for the spatial and temporal collection of samples.

Field data should be collected based on a robust and statistically defensible sampling design. If impediments exist which prohibit collection of enough samples and replicates for a sufficiently powerful statistical analysis of data, justification for which samples are to be collected and why must be presented. If field conditions prohibit collection of samples required to complete a statistically robust sampling plan (e.g., worker safety concerns due to steep grade, lack of sediment in planned sediment sampling points, etc.), a description of the impediments, alternatives considered, and justification for the modifications must be included in data reporting. Deviations from established protocols and/or sampling plans must be clearly documented in legible, thorough field notes (i.e., date, time, location, specific protocol deviations, reason for changes, sample labels associated with changes, names of field staff involved, associated photograph/video reference numbers). See Section 3 for additional guidance on data reporting requirements.

2.1.2 Sampling Parameters and Populations

Sampling parameters and populations (e.g. spill-impacted benthic invertebrates) will vary with each spilled substance and receiving environment. A thorough study design that includes measurable objectives will assist in determining the most appropriate samples and parameters. The following considerations should be taken into account when determining sampling parameters during the response and recovery phase:

- Spilled product, receiving environment, and potential for adverse effects in biota must be considered in assessing which parameters and which species should be sampled and analyzed.
- Spilled product contaminants of potential concern (COPCs), their potential short and long term effects, and their propensity to partition into specific environmental matrices, must be considered in the study design process. A list of recommended common laboratory parameters for analysis are presented in Appendix A.
- The nature of the receiving environment and how a spilled substance will partition into that environment should be considered. For example, in an acid spill to moving water, the flow rate may be high enough that sampling at the spill site days after the incident may not yield useful data due to dilution or evaporation.
- Collecting samples of opportunity is encouraged. For example, if a spill incident has caused fish or wildlife lethality, collection of dead fish for tissue concentrations of contaminants may be a useful addition to a sampling program.
- The judgement of a qualified professional regarding the most appropriate study design for each spill scenario should take precedence in the development of robust and defensible sampling and monitoring plans.

Table 1 describes potential types of biological sampling to be completed during spill response and recovery, but is not an exhaustive list. Qualified professionals should be trained in proper sampling protocols prior to mobilization in an emergency situation.

Table 1. Potential sampling parameters and populations suggested during the response and recovery phase.

Type of Survey	Sampling Guidance	Protocols & Parameters
Soil	Soil sampling is recommended in response situations where the receiving environment of the spill is soil, or the spilled substance may have interacted with soil. Soil sampling and monitoring post-spill may be conducted to assess long-term impacts to higher trophic levels through bioavailability of COPCs.	Appropriate protocols for soil sampling can be found in the BC Field Sampling Guide and the CCME Guidance Manual, Volume 3. Recommended parameters to be analyzed in soil are found in Appendix A.
Water	Water sampling is recommended in response situations where the receiving environment of the spill is water or the spilled substance may have reached water.	Appropriate protocols for water sampling can be found in the BC Field Sampling Guide and the CCME Guidance Manual, Volume 3. Water sampling should be analyzed for both general water chemistry and presence of COPCs. Recommended parameters to be analyzed in water are found in Appendix A.
Sediment	Sediment sampling is recommended in response situations where sediment is present in the receiving environment of the spill or the spilled substance may have interacted with sediment.	Appropriate protocols for sediment sampling can be found in the BC Field Sampling Guide and the CCME Guidance Manual, Volume 3. Sediment analysis should assess the concentration of COPCs present. Recommended parameters to be analyzed in sediment are found in Appendix A.
Spilled Substance	When the chemical makeup of the spilled substance is unknown or unavailable, it may be appropriate to sample the spilled substance. For example, acute toxicity due to benzene, toluene, ethylbenzene, and xylenes (BTEX) are an immediate concern and polycyclic aromatic hydrocarbons (PAHs) are important components contributing to longer-term/chronic toxicity, and should be identified in a potential spilled substance.	Sampling of any potentially hazardous materials should comply with WorkSafe BC's Occupational Health and Safety Regulation. Recommended parameters to be analyzed, based on the suspected spilled substance, are found in Appendix A.
Habitat assessments	For spills that have the potential to reduce wildlife habitat size and/or habitat function, habitat assessments may be appropriate to quantify spill impacts to wildlife. Depending on timing, additional surveys to identify impacted sensitive wildlife habitat features (e.g. dens, nests) may be appropriate.	Standards for surveying wildlife inventory have been published in ENV's Resources Information Standards Committee's (RISC) standard protocols for wildlife habitat surveys.

Terrestrial invertebrates	When there is a spill in proximity to terrestrial invertebrates and their habitat, tissue COPC samples may be collected to determine potential bioavailability of spill products from soil to biota and the potential exposure of insectivorous wildlife to COPCs. If invertebrate species at risk are observed or known to be present in the area, additional surveys to quantify the impact to these species at risk are recommended.	Further details regarding terrestrial invertebrate sampling can be found in the CCME Guidance Manual Volume 3 (Standard Operating Procedure [SOP] #14).
Terrestrial vertebrates	Surveys to identify impacted sensitive habitat features (e.g. dens, nests) may be appropriate for spills with an impact to terrestrial vertebrates. Tissue COPC sampling may be considered when mortality of terrestrial vertebrates has occurred. If species at risk are observed or known to be present in the area, additional surveys to quantify the impact to these species at risk is recommended.	Standards for surveying wildlife inventory and collecting tissue samples have been published in ENV's RISC standard protocols for wildlife surveys (Manuals 1-39). *Warning*: Small mammals may be carriers of zoonotic viruses (i.e., hantavirus) which can be fatal in humans. Ensure appropriate safety protocols are followed.
Fish and fish habitat	When there is a spill in proximity to or within a fish-bearing watercourse, sampling may be appropriate to determine the potential exposure of fish to COPCs, potential bioaccumulation of COPCs, or to assess the condition of fish communities in the impacted area. Fish habitat assessments and inventory monitoring may be required if the spill has negatively impacted fish populations, health and habitat. If fish species at risk are observed or known to be present in the area, additional surveys to quantify the impact to these species at risk is recommended.	Tissue COPCs should be assessed in fish samples. Appropriate protocols for fish sampling, fish habitat assessments and inventory monitoring can be found in the BC Field Sampling Guide, the CCME Guidance Manual, Volume 3, ENV's RISC standard protocols for aquatic ecosystems and ENV's Fish Collection Methods and Standards.
Aquatic invertebrates	When there is a spill in proximity to aquatic invertebrates, sampling may be appropriate to determine the potential exposure of these invertebrates to COPCs. Inventory monitoring may also be completed when there is an anticipated loss to aquatic invertebrate populations as a result of a spill.	The assessment of tissue COPCs is an important indicator of the potential bioavailability of spill products from soil to biota. Appropriate protocols for invertebrate sampling can be found in the BC Field Sampling Guide, the CCME Guidance Manual Volume 3, and ENV's Freshwater Biological Sampling Manual.
Plants	Sampling of plants directly within the spill zone may be appropriate to determine potential bioaccumulation of spill products in plants and the potential exposure of herbivorous wildlife to COPCs. Species sample choice should be based on sampling study design goals and can include plants visually impacted by the spill, species that are more susceptible to impacts of COPCs, and plants ingested by higher trophic level species.	Tissue COPCs should be assessed when analyzing plant samples. Further details regarding plant sampling can be found in the CCME Guidance Manual Volume 3 (SOP #13).

2.1.3 Sampling Location Choice

Sampling site selection *must* strive to be representative of all impacted receiving environments. Control and reference sites need to be chosen with the same criteria as impacted sampling sites (e.g., flow rates, soil substrates, wildlife and/or human use, vegetation, etc.) with the exception of the spill impact. In the event that key locations are not sampled, justification should be provided in the sampling report. A statistically defensible and representative number of samples should be taken within the defined sampling area. This section addresses additional considerations to incorporate into the sampling design when sampling in moving water, still water, or terrestrial sampling.

2.1.3.1 Spills to moving water

In every case of spill products entering a moving waterway, a major consideration in creating an appropriate sampling and monitoring plan should be that moving water moves spilled product in the direction of water flow. Therefore, the following points must be considered:

- River/stream structures (such as riffles or pools) must be considered when assessing which locations may be appropriate for sampling to assess environmental impacts (e.g., some spill products may preferentially collect in areas where water flow is slower than in main channels or other faster flowing areas).
- The progression of sampling should always be completed from downstream to upstream. Moving from downstream to upstream in moving water reduces the possibility of contamination of samples from in-stream works.
- Flow rates of receiving environments must be considered in relation to spill products and sampling should be located spatially and temporally appropriately to capture representative impacts. For example, a spill of physical substances such as coal into a receiving environment with a high flow rate is likely to remain closer to the spill site for a longer period than a spill of a liquid product which is likely to be diluted and moved downstream much quicker.

2.1.3.2 Spills to still water

Naturally occurring thermal stratification in still water depends on the density of water at specific temperatures. Spill products and/or spill product constituents in still waters are likely to stratify in a similar manner (i.e., denser contaminants separating into deeper strata with lighter contaminants closer to the surface). Sampling and monitoring to assess environmental impacts of a spill in still waters must therefore include sampling at distinct depth profiles to define contaminant stratification at impacted sites and at the same depth profiles at comparable reference/control sites.

2.1.3.3 Spills to land

In order to determine the intensity of sampling in spills to land, site size, type of contaminant, historical contamination, and potential mechanisms for contaminant transport should be investigated. Sampling protocols under BC Contaminated Sites Regulations (BC CSR) may apply. Soil substrate types should be considered when determining how contaminants to terrestrial environments move and partition. CCME's Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment can also be used to inform study design.

2.2 QUALITY ASSURANCE AND QUALITY CONTROL

The general expectation for environmental sampling and monitoring in a spill scenario is that sample collection will be completed in a scientifically robust and defensible manner. Quality assurance (QA) and quality control (QC) is a critical component of a thorough sampling and monitoring program.

QC samples collected to assess the quality of sampling and analyses, possible cross-contamination of samples, and homogeneity of sample media must be considered in every sampling plan. Specific data quality objectives (DQOs; quantifiable limits used to determine if data is of the calibre expected) should be defined along with study objectives.

Regardless of the spill size/longevity of the sampling campaign, it is expected that, at a *minimum*:

- QC samples will represent approximately 10% of total sample numbers and those samples will be analyzed and addressed in data reporting.
- Field sample replicates will be collected at sample sites to estimate environmental variance. Three replicate samples are highly recommended to support more robust statistical analysis.
- Equal numbers of field sample replicates should be collected both at impacted and non-impacted (reference/control) sites.

It is expected that a Canadian Association for Laboratory Accreditation (CALA) certified laboratory will be used for laboratory analysis of samples collected to assess spill impacts to the environment. In situations where CALA certification for specific novel laboratory protocols does not exist, the principles and guidelines outlined in the B.C. Environmental Laboratory Manual must be considered, and thorough detailed laboratory protocols must be presented along with results. In addition to analytical summary tables, laboratory results (including laboratory QA/QC results, chain of custody documentation, references to approved laboratory methods, etc.) must be reported. See Section 3 for additional guidance on reporting results.

The following list of QC samples is not an exhaustive list but should be considered in every sampling plan.

2.2.1 REPLICATES

Replicates are multiple samples collected at the same location and time by the same person using the same equipment and procedures. The purpose of replicate samples is to assess the precision of each analyte assessed within replicate samples.

For a spill scenario, at a minimum, triplicates should be collected at each sample site. The number of replicates collected per site should be equal at each site (i.e., if triplicates are collected at impacted site 1, triplicates should also be collected at impacted sites 2, 3, 4, etc. *and* at reference/control sites). If triplicates are not possible due to extenuating circumstances (e.g., small mammal monitoring resulted in low replicate numbers due to poor weather conditions) clear documentation and justification (including photographs) must be provided regarding deviations.

2.2.2 SPLIT SAMPLES

Split samples are sub-samples taken from one large sample that has been homogenized and divided into two or more sub-samples. The purpose of split samples is to assess the precision of laboratory analytical methods with a “blind” laboratory assessment (i.e., the laboratory analysts should not know which samples are split into which two distinct samples).

For a spill scenario, split samples should be collected for analysis of complex matrices such as impacted sediments. If split samples are to be collected, approximately 10% of samples sent per batch to the analytical laboratory (e.g., 10% of samples on each chain of custody form) should be split samples.

2.2.3 DUPLICATES

2.2.3.1 Laboratory Duplicates

Laboratory duplicates are field samples that have been split into two samples by the analytical laboratory (after sample submission). A laboratory duplicate is similar in function to a field split sample however laboratory analysts are not “blind” to which samples are duplicated. The purpose of a laboratory duplicate is to determine laboratory method precision. Laboratory duplicates are expected at a rate of 10% of analyzed samples with a minimum of one laboratory duplicate per laboratory processed “batch” of samples.

Site-specific DQOs should be considered for each sampling and monitoring plan. In the absence of site specific DQOs, a minimum of the recommended laboratory DQOs for laboratory duplicates (as per the B.C. Environmental Laboratory Manual; reiterated below in Table 2) must be considered.

Table 2. Recommended DQOs for Laboratory Duplicates.

Parameter		**Recommended DQO (as relative percent difference - RPD)[1]**
Soil & Sediment		
Organics	PAHs	50%
	All other typical organics	40%
Metals	High variability metals[2]	40%
	All other metals	30%
Inorganics	Default DQO for most common parameters	30%
Water		
Organics	All typical organics	30%
Metals	Default DQO for most common parameters	20%
Inorganics	Default DQO for most common parameters	20%

[1]Applicable at concentrations >5x method detection limits

[2]High variability metals include: Ag, Al, Ba, Hg, K, Mo, Na, Pb, Sn, Sr, Ti

Laboratory analyses should, in some cases, include additional specific laboratory QC samples which must also be critically assessed for overall data QA/QC. These include certified reference materials, analyte spikes, and surrogate spikes.

2.2.4 BLANKS

2.2.4.1 Field Blanks

Field blanks are samples of analyte-free reagent solutions sent from the lab to the field which are meant to be handled in the same way field samples are. The purpose of field blanks is to determine any contamination which may be arising from sample collection equipment, sample handling, general conditions during sampling, or sample transport.

For a spill scenario where contaminant levels are being compared to low guidelines or where detection limits are low (e.g., some sediment PAHs), field blanks should be included as part of the QC sampling regime.

2.2.4.2 Rinsate/Equipment Blanks

Equipment rinsate blanks are typically considered when there is decontamination of equipment to be re-used in sampling. In this case, at least one rinsate blank should be collected during sampling.

2.2.4.3 Trip Blanks

Trip blanks are used to detect and identify contamination of samples travelling to and from the lab. Trip blanks are often associated with volatile organic compound (VOC) testing. For example, if samples are stored near vehicles or gasoline, these blanks will help determine what VOCs are from the trip and what VOCs are associated with the sample.

2.2.4.4 Laboratory (Method/Instrument) Blanks

Laboratory blanks are samples which are treated the same way as field samples submitted to the laboratory (from sample submission to reporting), however they only include laboratory method solvents. The purpose of a laboratory blank is to determine any contamination which may arise from laboratory sample handling, processing, or analytical methods. Laboratory blanks are expected per each laboratory processed “batch” of samples.

2.3 STATISTICAL ANALYSIS

Statistical analysis is a vital component of a sampling and monitoring results analysis. Statistical analysis can help prove that a sampling and monitoring program correctly detects a significant effect, if one exists. Variance decreases with larger sample sizes, which highlights real effects over natural background variability. There are multiple methods that may be appropriate for statistical analysis during sampling programs. The specific techniques and methods of statistical analysis to choose are left to the expertise of the qualified professional to determine, based on sample design and study objectives. The chosen methods of data analysis should be clearly documented in the spill sampling report.

3.0 REPORTING GUIDANCE

Clear and concise reporting of the results of a sampling program is essential for the documentation of findings and the communication of key trends and findings to Ministry staff.

The following components of a sampling report are highly recommended, but do not represent a comprehensive list of all information to be captured in a sampling and monitoring report. Any additional context, graphs, or tables that improve that comprehension of sampling results should be included.

Table 3. Recommended Components of a Spill Sampling Report.

Study Objectives	• Clear identification of the objectives of the sampling program. • Results that tie back to study objectives and prove that study objectives were met through empirical evidence, or describe why study objectives were not met. • Objectives that are based around specific, measurable, and realistic goals.
Description of Sampling Design & Methods	• Description of the sampling program design, containing all design components outlined in Section 2.1.1. • Brief overview of the methods used during sampling and, if applicable, a description of why methods departed from best practices and established protocols.
Presentation of Results & Statistical Analysis	• Clear and concise summary of quantitative results and relevance of those results to the general sampling & monitoring study objectives. • Comparison to background data, or the background data of a comparable site, including justification on why the site is considered comparable. • Methods of statistical analysis of the data collected at test, baseline, and control sites, including a discussion on the amount of error in reported values. • Identification of trends and key findings, easily communicated through trends analysis, tables, and graphs (when applicable). • Clearly marked tables, graphs, and photographs that include headers, descriptions, abbreviation definitions, measurement units, and axis labels, as appropriate. • Raw data, including laboratory results, QA/QC results, and chain of custody documentation should be presented in an appendix or an easily referenced location. Raw data alone with no analysis should never be presented.
Professional Declaration	• As per the Ministry of Environment and Climate Change Strategy (the Ministry) interim policy under the Professional Governance Act, qualified professional declaration forms, including a Declaration of Competency and a Conflict of Interest form, must be completed and submitted along with the spill sampling report. These forms are available on the Ministry's Professional Accountability Policy website.
Summary Tables	A summary table, if applicable, to easily communicate the claims made in the analysis of results. The following components of a summary table should include: • max • min • average ± error • numbers of samples collected/analyzed • guideline comparisons (if applicable) • detection limits (if applicable) • numbers of samples analyzed below detection limits (if applicable) It is recommended that formatting style (such as, bolding) is used to highlight results that exceed guidance or baseline comparison data, as applicable. Potential caveats to data quality must be clearly identified in any presented summarized data and/or statistical summary tables.

RELEVANT SOURCES

Canadian Association for Laboratory Accreditation Inc (CALA). https://www.cala.ca/index.html

ENV (British Columbia Ministry of Environment and Climate Change Strategy). 1994-2018. Inventory Standards for Aquatic Ecosystems. Victoria, BC. https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/laws-policies-standards-guidance/inventory-standards/aquatic-ecosystems

ENV. 1997 . Fish Collection Methods and Standards. Lands and Parks. Fish Inventory Unit for the Aquatic Ecosystems Task Force, Resources Inventory Committee. Victoria, BC. https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/fishml04.pdf

ENV. 1997. Freshwater Biological Sampling Manual. Lands and Parks. Water Management Branch. Victoria, BC. https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/freshwaterbio.pdf

ENV. 1997-2010. Inventory Standards for Terrestrial Ecosystems, Ecology. Prepared by the Resources Information Standards Committee of Lands and Parks for the Terrestrial Ecosystems Task Force. Victoria, BC. https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/laws-policies-standards-guidance/inventory-standards/terrestrial-ecosystems-ecology

ENV. 1997-2018. Inventory Standards for Terrestrial Ecosystems, Biodiversity. Manuals 1-43. Prepared by the Resources Information Standards Committee of Lands and Parks for the Terrestrial Ecosystems Task Force. Victoria, BC. https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/laws-policies-standards-guidance/inventory-standards/terrestrial-ecosystems-biodiversity

ENV. 2013. B.C. Environmental Laboratory Manual. Prepared in cooperation with the B.C. Environmental Laboratory Technical Advisory Committee. Water and Air Monitoring and Reporting Section. Victoria, BC. https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-environmental-laboratory-manual

ENV. 2015. B.C. Field Sampling Manual. Water and Air Monitoring and Reporting Section. Victoria, BC. https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual

ENV. 2015. B.C. Technical Guidance for Site Remediation. Victoria, BC. https://www2.gov.bc.ca/gov/content/environment/air-land-water/site-remediation/guidance-resources/technical-guidance

ENV. 2019. British Columbia Approved Water Quality Guidelines. Water Protection and Sustainability Branch. Victoria, BC. https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-guidelines/approved-water-quality-guidelines

CCME (Canadian Council of Ministers of the Environment). 2016. Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment. Volumes 1-4. Prepared by the Soil Quality Guidances Task Group. Mississauga, ON. https://www.ccme.ca/en/resources/contaminated_site_management/assessment.html

Environmental Management Act, SBC 2003, c53. Queen's Printer. Victoria, BC.

APPENDIX A: PARAMETERS TO BE ASSSESSED

Below is a list of COPCs that could be analysed in a spill scenario. This is not an exhaustive or prescriptive list of all COPCs andis intended as guidance only and should be used as a starting point to inform and assess environmental impacts during spill response and recovery in a sampling and monitoring program.

Expectations and Considerations:

- Spilled product should be the primary consideration when determining which COPCs to analyze. It is expected that the most recent research on potential effects of COPCs in spilled products will be assessed and investigated.
- Receiving environments must also be considered when deciding which COPCs to analyze. For example, if a COPC is known to preferentially partition into soils over water, it is expected that analyses of those COPCs will be thoroughly investigated in soils and soil dwelling organisms to assess potential bioaccumulation of COPCs in higher trophic levels.
- Consideration must be given to potential adverse effects of the spilled substance breakdown products. COPCs may, through natural environmental processes such as weathering, breakdown into variants of the parent compound. In some cases, breakdown products can cause more adverse effects than parent compounds on the receiving environment.

The following lists of parameters to be analyzed are not comprehensive and should be modified based on each spill scenario. The tables below are recommended parameters to consider when assessing specific sampling matrices or impacts from specific spilled substances. Both tables should be considered together to select parameters based on the qualities of the matrix and the spilled substances.

Table 1: Parameters to be Analyzed: Conventional Quality Parameters for Select Matrices

Sampling Matrix	Analyzed Parameters
Water	• pH • Temperature • Dissolved Oxygen • Conductivity • Water Clarity/Turbidity (NTU) • Total Suspended Solids (TSS) • Total organic/inorganic carbon (TOC/TIC) • Acidity/Alkalinity • Hardness • Nitrogen • Sulphate
Sediment	• pH • Moisture • Particle Size • Total organic/inorganic carbon (TOC/TIC)
Soil	• pH • Moisture

Table 2: Parameters to be Analyzed: COPCs for Select Spilled Substances

Spilled Substance Category	Spilled Substance	Analyzed Parameters
Petroleum Product and Drilling/Production Associated	Diesel	• Benzene (BTEX) • Toluene (BTEX) • Ethylbenzene (BTEX) • Total Xylenes (BTEX) • Light extractable petroleum hydrocarbons (LEPH) • Heavy extractable petroleum hydrocarbons (HEPH) • Volatile petroleum hydrocarbons (VPH) • Styrene • 1,3,5-trimethylbenzene • Butylbenzenes • Isopropylbenzene • 1-propylbenzene • n-nonane • PAHs: naphthalene, acenapthene, 1-methylnaphthalene, 2-methylnaphthalene, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b+j)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, quinoline
	Crude oil/Condensate	• BTEX • LEPH • HEPH • VPH • PAHs: see those listed for diesel (above)
	Produced Water	• BTEX • LEPH • HEPH • VPH • PAHs: see those listed for diesel (above) • Metals • Sodium • Chloride • Sulfate • Ammonia, Nitrate, Nitrite
Firefighting Associated	Flame-retardant Foams	• Perfluorooctanesulfonic acid (PFOA) • Perfluorooctane sulfonate (PFOS) • Perfluorobutanesulfonic acid (PFBS) • Per- and Polyfluoroalkyl substances (PFAS)
Solid Particulates	Coal	• Metals: copper, lead, zinc, cobalt, arsenic, mercury, selenium • PAHs: see those listed for diesel (above) • Total suspended solids (TSS) in water