Ministry of Environment and Climate Change Strategy

PROTOCOL 13
FOR CONTAMINATED SITES

Screening Level Risk Assessment

Version 4.0

Prepared pursuant to Section 64 of the *Environmental Management Act*

Approved:	Kevin Butterworth	February 1, 2021
	Director of Waste Management	Date

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1.0 Definitions

Terms defined in the *Environmental Management Act* (EMA) and the Contaminated Sites Regulation (CSR) apply to this protocol, in addition to the following:

“acceptable risk” means, in the context of screening level risk assessment (SLRA), that there are no complete exposure pathways between contamination and receptors; exposure pathway elimination must be completed as per this protocol.

“active floodplain”, in relation to a stream, means land that is
(a) adjacent to the stream,
(b) inundated by the 1 in 5 year return period flow of the stream, and
(c) capable of supporting plant species that are typical of inundated or saturated soil conditions and distinct from plant species on freely drained upland sites adjacent to the land.

“beneficial use exemption” means the exemption from the requirement to evaluate exposure of receptors to contaminants of concern associated with an eligible beneficial use, within a 3 m radius, as specified in Section 3.3.

“**bioaccumulation**” means the progressive increase in the amount of a substance in an organism, or part of an organism, which occurs because the substance’s rate of intake by an organism exceeds the rate at which the organism is able to degrade or eliminate the substance.

"**bioaccumulation factor**” [**BAF]** means a number that is
(a) assigned to a substance to measure bioaccumulation;
(b) calculated as the ratio of:
  (i) the concentration of the substance in an organism, to
  (ii) the sum of concentrations of the substance in environmental media and food; and
(c) is supported by a detailed rationale showing that the chosen factor represents best available science and is appropriate for relevant species and the site conditions including factors such as soil or water pH, hardness, range of concentrations.

“bioaccumulative substance” means a substance in which:
(a) the logarithm (base 10) of the octanol-water partition coefficient (log Kow) is greater than or equal to 4.5, or the bioaccumulation factor is greater than or equal to 2000, or the bioconcentration factor is greater than or equal to 2000; or
(b) the substance is determined by best professional judgment of the qualified professional preparing the SLRA report to have the potential to bioaccumulate based on relevant scientific information.

“bioconcentration“ means the process leading to a higher concentration of a substance in an organism compared to the concentration of the substance in the aquatic environmental media to which the organism is exposed.

“bioconcentration factor” [BCF] is a number supported by best available science that is:
(a) assigned to a substance to measure bioconcentration;
(b) calculated as the ratio of:
    (i) the concentration of the substance in an organism, to
    (ii) the sum of concentrations of the substance in aquatic environmental media; and
(c) is supported by a detailed rationale showing that the chosen factor figure represents best available science and is appropriate for relevant species and the site conditions including factors such as soil or water pH, hardness, range of concentrations.

“conceptual site model” means a written description and/or an illustrated diagram of the biologic, geologic, hydrogeologic, and environmental conditions of a site as it relates to actual or potential exposure to contamination that meets the requirements in Section 4.1.

“contaminant source area” means areas in soil where substance concentrations in soil exceed the applicable generic/matrix numerical soil standards, or, where utilized, local background concentrations or site-specific numerical soil standards.

“**detailed site investigation” [DSI]** means a site investigation completed in accordance with CSR section 59, all relevant protocols, and recognized professional practice.

“eligible beneficial use” means the use of a substance referred to in Section 3.3 for one or more of the associated beneficial purposes referred to in Section 3.3.

“high water mark” means:
(a) for freshwater; the visible high water mark of a stream where the presence and action of the water is so common and usual, and typically enduring, as to mark on the soil of the bed of the stream a character distinct from that of its banks, in vegetation, as well as in the nature of the soil itself, and includes the active floodplain associated with a site;
(b) for marine water: the high water mark as defined by the most elevated High Water Mean Tide by Fisheries and Oceans Canada and as mapped on Canadian Hydrographic Services navigational charts; and
(c) for estuarine water: the high water mark is whichever of the freshwater or marine water high water mark is further inland.

“point of compliance” means the location(s) on land or in water at which a given substance concentration in any environmental media must meet applicable standards as specified in Section 4 of Appendix A.

“potential terrestrial habitat” means land that satisfies any of the following conditions:
(a) urban park or wildlands land use classification applies;
(b) contains over 50 m^2 (where residential land use applies at the site) or over 1,000 m^2 (where commercial or industrial land use applies at the site) of contiguous undeveloped land; or
(c) lies within 300 m (where residential, commercial or industrial land use applies at the site) of sensitive habitat.

“precluding conditions” means conditions which, if present, preclude use of this protocol as specified in Section 3.2.

“preferential pathway” means a pathway that is significantly (greater than 1 order of magnitude) more water or gas permeable than the soil media that surrounds it and may be anthropogenic (including pathways such as underground utilities for sewers, water and gas lines) or natural (including pathways such as fractured bedrock, surface depressions, streambeds and ditches that intersect and drain shallow aquifers).

“qualified professional” [QP] means a person who
(a) is registered in British Columbia with a professional association, acts under that professional association's code of ethics, and is subject to disciplinary action by that professional association, and
(b) through suitable education, experience, accreditation and knowledge may be reasonably relied on to provide advice within their area of expertise.

“receiving environment” means any air, land, water, sediment (including porewater), wetland, or muskeg containing receptors, excluding artificial watercourses or impoundments that are maintained and whose primary purpose is to convey or contain storm water or treat and convey effluent, or natural water courses in circumstances approved by the director.

“receptor” means a living organism that may be exposed to a substance.

“sensitive habitat” includes**:**
(a) national, provincial, regional and municipal parks;
(b) sensitive ecosystems identified by Federal, Provincial Sensitive Ecosystem Inventories, or local governments;
(c) habitat supporting red and blue listed species identified via BC Species and Ecosystem Explorer;
(d) habitat used for sensitive sediment use as defined in the Contaminated Sites Regulation; and
(e) riparian assessment areas as defined in the Riparian Areas Protection Regulation.

“screening level risk assessment” [SLRA] means a risk assessment focused on the evaluation of exposure pathways, which is carried out in accordance with this protocol.

“SLRA Questionnaire” means the Questionnaire in Appendix B.

“source parcel” means a site or parcel which has now, or had in the past, substances which migrated to one or more neighbouring sites or areas.

“undeveloped land” means any bare or vegetated soil, excluding
(a) gravelled walkways,

(b) roadways or highways and associated roadside or highway margins,
(c) parking areas,
(d) soil contained and isolated in planters and similar structures, and
(e) storage areas at active commercial and industrial operations.

“water table” where used in Appendix A of this protocol, means the seasonal high water table.

2.0 Introduction

Consistent with the *Environmental Management Act* (EMA) and the Contaminated Sites Regulation (CSR), this protocol:

1. establishes substantive and procedural requirements for persons conducting screening level risk assessment for a contaminated site; and
2. provides a mechanism for demonstrating that acceptable risks exist through an assessment of exposure pathways and receptors.

If SLRA completed in accordance with this protocol indicates no unacceptable risks to receptors (i.e., passes SLRA), the SLRA report described in Section 5.0 may be submitted to the director as evidence that the site meets risk-based standards under CSR section 18 without further remediation so long as conditions at the site remain the same.

SLRA may only be used at sites classified as non-high risk as per Protocol 12, “Site Risk Classification, Reclassification and Reporting”. Subject to Section 3.3, Beneficial Use Exemption, SLRA may not be completed at a site when precluding conditions exist or there is a potential for unacceptable risk due to the presence of contamination within a complete exposure pathway, as determined in accordance with this protocol. Additional remediation or detailed risk assessment, as described in Protocol 1, “Detailed Risk Assessment”, may be completed for sites that are not eligible for SLRA.

SLRA may be used for any substance subject to the requirements specified in this protocol.

3.0 Overview

The SLRA must be completed by a qualified professional who has demonstrable experience in remediation of the type of contamination that exists at the site and who is familiar with any remediation carried out at the site. In addition, any habitat assessment carried out as part of the SLRA must be completed by a Registered Professional Biologist (RPBio) with demonstrable experience in assessment of ecological habitat.

The qualified professionals conducting the SLRA must follow the following steps:

1. Problem formulation (Section 4.1): summarize site conditions and develop a conceptual site model.
2. Checks (Section 4.2): check whether any requirements, precluding conditions, or beneficial use exemptions apply at the site.
3. Evaluation of potential exposure scenarios (Section 4.3): complete the SLRA Questionnaire to assess the potential for human or ecological receptors to be exposed to contaminated soil or groundwater.
4. Determination of risk (Section 4.4): conclude whether contamination at a site poses a potential unacceptable risk based on the SLRA Questionnaire responses.
5. Reporting of SLRA results (Section 5): prepare a report in support of the SLRA.

A flow chart summarizing the overall SLRA evaluation process (steps 1 through 4 above) is provided in Figure 1. The flowchart is provided for illustrative purposes only. The Questionnaire must be completed and takes precedence over the flowchart.

3.1 Prerequisite for SLRA

Prior to beginning SLRA, a detailed site investigation (DSI) must be completed for the contaminated site.

3.2 Precluding conditions

This protocol must not be used at contaminated sites where any of the following substances or media are present:

- inorganic substances in soil or groundwater with a soil/groundwater pH < 5, respectively;
- bioaccumulative substances;
- vapour that exceeds the generic numerical vapour standard as determined in accordance with Protocol 22, "Application of Vapour Attenuation Factors to Characterize Vapour Contamination" and with Technical Guidance 4, "Vapour Investigation and Remediation, version 2"); or
- contaminated sediment or surface water except where the contamination qualifies as a beneficial use exemption.

In addition, this protocol must not be used at contaminated sites where any of the following conditions are present:

- deep-rooting plants or trees (root structures extending below 1 m depth) in areas of soil or groundwater contamination [at sites where wildlands (natural or reverted), agricultural or low density residential land uses apply];
- very high permeability soil (for example, cobbles) or complex hydrogeologic units (for example, fractured bedrock, karst terrain);

- preferential pathways that transport contaminated groundwater directly to a receiving environment or water well; or
- groundwater contamination that extends beyond a source parcel boundary and is not demonstrated to be stable or decreasing. See Section 6.0 for requirements related to demonstration of plume stability.

This protocol must also not be used at contaminated sites where exposure pathways are present that are not specifically identified in Section 4.3.

A screening process, including a written discussion with detailed rationale, must be used to determine if any precluding conditions may be present at the site. The written discussion must demonstrate consideration of each precluding condition and provide rationale for determining applicability and supporting site data. When BAF or BCF values are used to screen for bioaccumulative substances, the rationale must state how the values are relevant to site conditions.

3.3 Beneficial use exemption

An SLRA report is not required to demonstrate the absence of complete pathways to receptors in respect of soil, sediment, groundwater or surface water contamination that is caused by an eligible beneficial use and that is within a 3 m radius of an eligible beneficial use, as described and measured below. The existence of a complete pathway between such contamination and receptors does not preclude use of the SLRA. Specific contaminants and corresponding eligible beneficial uses are prescribed in Table 3.3.1.

Table 3.3.1

Substances and Corresponding Eligible Beneficial Uses

Substance	**Eligible Beneficial Use**
zinc	galvanized materials (used to prevent rusting)
copper	copper pipe or bare copper wire (used for water supply or for cathodic protection to prevent corrosion)
boron, chromium, copper, arsenic, chlorophenols, or constituents of creosote (including petroleum hydrocarbon carrier solutions)	treated or preserved wood utility poles, structural timber or pilings
chloride, sodium	road salting (lateral distance as measured from the pavement edge or from the edge of the travelled portion of unpaved roads)

The beneficial use exemption is applicable at active or closed sites as long as the beneficial use applies. The beneficial use exemption is not applicable where the use is historical and no longer serves its intended purpose, or where the materials associated with the beneficial use are no longer being used. The exemption also does not apply at sites where the beneficial use materials were produced or stored.

4.0 Methodology

4.1 Problem formulation

Step 1: The qualified professional completing SLRA must review site information, prepare a report documenting site conditions, and include a conceptual site model.

The SLRA report must:

- describe environmental investigations completed;
- identify site conditions (contamination sources, pathways, receptors, etc.) that could give rise to potential unacceptable risks;
- identify information gaps requiring further investigation in order to evaluate potential exposure pathways;
- identify any risk management or remediation measures to be implemented if SLRA is conducted pre-remediation of the site;
- identify any risk management or remediations measures that have been implemented if SLRA is conducted post-remediation of the site;
- identify exposure pathways; and
- enable the determination of risk.

Once site conditions have been reviewed and summarized, a conceptual site model must be prepared. The conceptual site model must describe the:

- biologic, geologic, hydrogeologic, and environmental conditions of a site as related to actual or potential exposure to contamination;
- type, source and extent of contamination including how contamination developed and its current and potential future extent, with consideration of seasonal effects, long-term trends and plume stability;
- pathways for contaminant migration (how contaminants behave and how they might be transported and where); and
- potential receptors (who or what may be affected).

The conceptual site model must be illustrated in a diagram or flowchart format (for example, as shown in Figure 2) and must summarize site conditions and linkages between contamination sources, exposure pathways, and receptors.

4.2 Check for requirements, precluding conditions, and exemptions

Step 2: Following preparation of the problem formulation, the qualified professional completing the SLRA must check whether any precluding conditions or beneficial use exemptions apply at the site. Precluding conditions are described in Section 3.2. Exemptions for contamination due to eligible beneficial uses are described in Section 3.3.

4.3 Evaluation of potential exposure scenarios

Step 3: The next step is to evaluate whether human or ecological receptors are likely to be exposed to potentially harmful concentrations of substances in soil or groundwater. Potentially harmful concentrations are those that exceed:

- generic numerical soil standards (CSR Schedule 3.1, Parts 2 and 3);
- matrix numerical soil standards (CSR Schedule 3.1, Part 1);
- site-specific numerical soil standards developed under Protocol 2, "Site-Specific Numerical Soil Standards";
- generic numerical water standards (CSR Schedule 3.2);
- background soil concentrations, as established under Protocol 4, "Establishing Background Concentrations in Soil," if local background concentrations exceed the above standards;
- background groundwater concentrations as established under Protocol 9, "Determining Background Groundwater Quality," if local background concentrations exceed the above standards;
- site-specific numerical groundwater standards for zinc developed under Protocol 10, "Hardness Dependent Site-Specific Freshwater Standards for Zinc"; or
- director's interim standards or criteria.

The SLRA Questionnaire is completed in this step. The questionnaire has seven series of questions that qualitatively assess whether potential exposure pathways are complete or operative for six exposure pathways and one default pathway. The exposure pathways are summarized as follows.

- The first two pathways evaluate the potential for human exposure to contaminated soils (questions HS-1 to HS-3) and groundwater (questions HW-1 to HW-3). Except where plume stability is demonstrated in accordance with Section 6.0, qualified professionals must follow Appendix A when answering HW3.

- The third pathway evaluates the potential for terrestrial biota to be exposed to contaminated soil (questions TS-1 to TS-5). Qualified Professionals must follow Appendix B when answering TS-4 and TS-5.
- The following three pathways evaluate the potential for exposure of aquatic biota, crops, and livestock to contaminated groundwater (questions AW-1 to AW-3, IW-1 to IW-3, and LW-1 to LW-3, respectively). Except where plume stability is demonstrated in accordance with Section 6.0, qualified professionals must follow Appendix A when answering AW3, IW3 and LW-3.
- The remaining pathway evaluates the potential for exposure to groundwater contamination greater than default numerical environmental quality standards (questions DF-1 and DF-2). Except where plume stability is demonstrated in accordance with Section 6.0, qualified professionals must follow Appendix A when answering DF-2.

All seven exposure pathways must be evaluated. However, it may not be necessary to answer all questions within each of the exposure pathway series.

Questions should be answered in the sequence indicated in the SLRA Questionnaire and require a “yes” or “no” response. Some questions may also require the provision of supporting rationale, figures, tables, calculations or forms as indicated in the notes Section of the questionnaire. A “yes” response to any question indicates the potential presence of a contaminant, pathway, or receptor and “yes” responses to all questions within an exposure pathway series indicates the exposure pathway is a complete and operative pathway. A “no” response to any question within an exposure pathway series indicates that a contaminant, pathway or receptor is not present for that pathway and that the pathway is inoperative. If a “no” response is provided to a given question within a series, then the remaining questions in that series need not be answered (see Figure 1).

Questions HW-3, AW-3, LW-3, IW3, and DF-2 may be answered with a ‘no’ response if there has been a demonstration of plume stability in accordance with Section 6.0.

4.4 Determination of risk

Step 4: The results of the SLRA Questionnaire are used to determine whether contamination at a site poses either acceptable risks or potential for unacceptable risks.

Sites for which there are “yes” responses to all questions within an exposure pathway series are considered to have an operative exposure and potential unacceptable risk for that pathway. Sites that have a potential unacceptable risk for one or more exposure pathways are considered to fail the SLRA. Further remediation – or completion of a detailed risk assessment – is necessary for these sites to address the exposure pathways.

Sites for which a “no” response was provided for at least one question within each of the seven exposure pathways series (all pathways are inoperative), or where a “yes” response only applies in relation to the beneficial use exemption, are considered to have acceptable risks.

5.0 Reporting

Step 5: A SLRA report submitted to the ministry (in support of an approval in principle or certificate of compliance) must be completed in accordance with this protocol by a qualified professional, must be prepared in accordance with standards of professional practice, and, at a minimum, must include:

- a summary description of the site conditions meeting the requirements of Section 4.1;
- a conceptual site model meeting the requirements in Section 4.1;
- an accurately completed SLRA Questionnaire with supporting diagrams, plan maps, cross sections, and forms (Forms A-1, A-2, B-1, B-2, and B-3, as appropriate);
- a digital spreadsheet file with calculations/output where Appendix A is used;
- groundwater monitoring and geochemical data and trend analyses demonstrating plume stability in accordance with Section 6.0 (where plume stability assessment is used in this protocol);
- the reporting requirements under Section 7.0 of Protocol 27, "Soil Leaching Tests for Use in Deriving Site-Specific Numerical Soil Standards" if leachate testing is undertaken (as per Appendix A);
- written discussion demonstrating absence of precluding conditions in accordance with Section 3.2;
- specification of any eligible beneficial uses (including associated contaminants and contaminated media) including location and extent of contamination;
- specification of the contaminants addressed in the SLRA;
- specification of any risk management measures implemented;
- specification of any risk controls to be included in a performance verification plan; for example, prescribed long term monitoring and maintenance measures to be implemented to ensure the long term integrity of any surface barriers, if present at the site, or, institutional controls to prohibit drinking water use at the subject parcel for protection of future drinking water use;
- conclusions regarding whether contamination at a site poses acceptable risks or potential unacceptable risks; and
- written statements in Form C prepared by the qualified professional(s) responsible for the SLRA.

6.0 Plume stability

The demonstration of stable or decreasing contaminant plumes must include the evaluation of groundwater conditions within and at the margins of contaminant plumes and provide evidence of both stable or decreasing substance concentrations throughout and no additional vertical or lateral migration or rebound effects. A minimum of two years of groundwater monitoring and geochemical data (including seasonal variations over a two- year period) demonstrating stable or decreasing groundwater concentrations and conditions is necessary.

Trend analysis (Mann-Kendall test, $\alpha=0.05$) of the monitoring data used to support the demonstration of stable or decreasing concentrations within and at the margins of the contaminant plume is required as part of assessment of plume stability.

The plume stability assessment must be carried out by a qualified professional with demonstrable experience in (a) assessment of groundwater flow, contaminant fate and transport, and aqueous geochemistry, and (b) trend analysis.

Where plume stability is demonstrated, completion of Appendix A is not necessary.

Revision history

Approved Date	**Effective Date**	**Document Version**	**Notes**
July 7, 2008	August 1, 2008	V2	
November 1, 2017	November 1, 2017	V3	Updated as part of the Stage 10 Amendment to the Regulation.
January 9, 2019	January 9, 2019	V3.1	Miscellaneous amendments.
February 1, 2021	February 1, 2021	V4	Minor revisions as part of the Stage 13 Amendment to the CSR.

APPENDIX A

Soil Leachate and Groundwater Transport Assessment (Questions HW-3, AW-3, LW-3, IW-3 and DF-2 in SLRA Questionnaire)

The soil leachate and groundwater transport assessment component of SLRA considers the potential for contaminated groundwater to migrate to a downgradient point of compliance using a contaminant fate and transport model. A point of compliance is used as a proxy for a receptor. Contaminated groundwater may originate from both soils (as soil leachate) and groundwater within a contaminant source area.

This assessment involves four steps.

1) Determination of substance concentrations in soil leachate (leachate concentrations) in the contaminant source area (contaminant partitioning from soil to infiltrating water).

2) Calculation of predicted leachate concentrations at the water table (leachate fate and transport through the unsaturated zone).

3) Calculation of predicted substance concentrations in groundwater (groundwater concentrations) in the saturated zone (mixing of leachate and groundwater in the saturated zone).

4) Calculation of predicted groundwater concentrations at the point of compliance (solute fate and transport in the saturated zone).

Steps 1, 2 and 3 must be completed. Step 4 need only be completed if predicted groundwater concentrations in the saturated zone, or maximum measured groundwater concentrations, exceed the applicable CSR generic numerical water standards.

SLRA model equations are provided at the end of this appendix.

1.0 Step 1 - Determination of predicted soil leachate concentrations in source area

Leachate concentrations in the source area (C_L) must be determined for inorganic substances using a soil leaching test approved in Section 1.1 for the relevant substances. If no test is approved for the substances, leachate concentrations must be calculated using a partitioning equation in accordance with Section 1.3. For organic substances, leachate concentrations may be determined using an approved soil leaching test in accordance with Section 1.2 or calculated using a partitioning equation in accordance with Section 1.3. Leachate concentrations in the source area, and parameter values used to derive them, must be summarized on **Form A-1**.

1.1 Inorganic substance leachate concentrations (using leachate test)

For inorganic substances prescribed in an approved soil leaching test, where soil pH is 5 or greater, the procedures and requirements outlined in Sections 4 through 6 of Protocol 27 must be followed to determine predicted leachate concentrations.

There are two laboratory methods used for leachate testing of inorganic substances in soils. The laboratory methods consist of:

- with the exception of chloride ion and sodium ion, the "Liquid-Solid Partitioning (Leachability) as a Function of pH (Metals, Inorganics, and SVOCs)" (BC Soil Leachate Test) as provided in the BC Environmental Laboratory Manual; and
- for chloride ion and sodium ion, the "Saturated Paste Extraction for Soils" (BC Saturated Paste Extraction Test) as provided in the BC Environmental Laboratory Manual.

The inorganic substances that must be evaluated using the BC Soil Leachate Test or BC Saturated Paste Extraction Test under SLRA are identified in the respective leachate tests.

1.2 Organic substance leachate concentrations (using leachate test)

Leachate testing may also be conducted for certain organic substances in soil. If leachate testing is undertaken for these substances, the procedures and requirements outlined in Sections 4 through 6 of Protocol 27 must be followed to determine predicted leachate concentrations.

There are two laboratory methods available for leachate testing of organic substances depending on the volatility of the substance. The laboratory methods consist of:

- Liquid-Solid Partitioning (Leachability) of VOCs (BC VOC Soil Leachate Test) as provided in the BC Environmental Laboratory Manual; and
- BC Soil Leachate Test.

The organic substances that may be evaluated using the BC VOC Soil Leachate Test or BC Soil Leachate Test under SLRA are identified in the respective leachate tests.

1.3 Organic/inorganic substance leachate concentrations (using partitioning equations)

Leachate concentrations for organic substances may also be calculated using partitioning equations (Equation A-1) and measured soil concentrations. This approach must be used for organic substances for which there is no available soil leachate test in Protocol 27. In addition, where soil pH is 5 or greater, this approach must be used for inorganic substances for which there is no available leachate test in the BC Soil Leachate Test or BC Saturated Paste Extraction Test.

Under this approach, the soil concentrations used in Equation A-1 must be based on a minimum of three soil samples collected from the contaminant source area. These samples must have substance(s) concentrations equal to or greater than the 90^{th} percentile of measured concentrations of the substance(s), as obtained in the detailed site investigation (DSI), and, as confirmed by laboratory analysis. Where the contaminant source area or volume of contaminated soil is greater than 300 m^2 or 900 m^3, respectively, or where soil contamination is heterogeneous and randomly distributed (for example, contaminated fill), additional soil samples above the minimum requirement, proportionate with the larger extent of contamination or heterogeneity of the soil, must be included in the determination of the soil concentration to be used in Equation A-1.

Predicted leachate concentrations must be calculated for each substance using the arithmetic mean of the measured soil concentrations for each substance and using property values for organic carbon partitioning coefficient (K_{oc}) and dimensionless Henry's law constant (H') from Table A-1 (organic substances). Property values for the distribution coefficient (K_d) must be obtained from Table A-3 and Table A-4 (inorganic substances). For substances not listed in Table A-1, substance property values for K_{oc}, H' and K_d, as applicable based on substance type (organic or inorganic), must be obtained from the US Environmental Protection Agency Risk Assessment Information System (RAIS) Chemical Parameters database.

A site-specific or default value for fraction of organic carbon (f_{oc}) must be used in Equation A-1. Site-specific or literature values may be substituted for parameters with default values (n, n_a, n_w, ρ_b) in Equation A-1. Default values for f_{oc}, n, n_a, n_w, ρ_b are indicated in **Forms A-1 and A-2**.

2.0 Step 2 - Calculation of predicted soil leachate concentrations at the water table

The predicted leachate concentrations at the water table (C_z) are calculated using Equation A-2. In this step, the measured or calculated predicted leachate concentrations in the contaminant source area are used as the source concentration (C_L) in Equation A-2. The leachate concentrations used in Equation A-2 are obtained from 1.1 through 1.3 above, as applicable.

Predicted leachate concentrations at the water table must be calculated for each substance using property values for K_{oc} and unsaturated zone biodegradation half-life ($t_{1/2u}$) from Tables A-1 and A-2 (for organic substances) and distribution coefficient (K_d) values from Tables A-3 and A-4 (for inorganic substances). Where an unsaturated zone biodegradation half-life is not specified for an organic substance, or for any inorganic substance, a default value of 1E+99 days must be used.

For substances not listed in Table A-1, substance property values for K_{oc} and K_d must be obtained from the RAIS database. Biodegradation half-life values must be selected as per the preceding paragraph.

Site-specific values must be used for parameters d, Z, and I in Equation A-2. Procedures for determining site-specific values of source depth (Z) and infiltration rate (I) are provided in Protocol 2. Where a discrete value of source depth cannot be determined using Protocol 2, the applicable numerical soil standards must be used to define the source depth. A site-specific or default value for f_{oc} must be used for determining K_d in Equation A-2. Site-specific or literature values may be substituted for parameters with default values (n_w, ρ_b) in Equation A-2. Default values for f_{oc}, n_w, ρ_b are indicated in **Forms A-1 and A-2**.

Predicted leachate concentrations at the water table, and parameter values used to calculate them, must be summarized on **Form A-1**.

3.0 Step 3 - Calculation of predicted groundwater concentrations in the saturated zone

The predicted groundwater concentrations below the source area ($C_{gw'}$) are calculated using a dilution factor (DF) to account for mixing across the water table. In this step, the predicted leachate concentrations at the water table (C_z from 2.0 above) are divided by the dilution factor. Equation A-3 is used to calculate the predicted groundwater concentrations in the saturated zone below the source.

Predicted groundwater concentrations must be calculated for each substance using site-specific values for the parameters K, i, X, I and d_a in Equations A-3 and A-4. Procedures for determining site-specific values of source length (X) and infiltration rate (I) are provided in Protocol 2. Where a discrete value of source length cannot be determined using Protocol 2, then the applicable numerical soil standards must be used to define the source length. A minimum value of 0.08 m/yr must be used for the infiltration rate. The remaining site-specific parameters (K, i, and d_a) must be determined based on a site-specific hydrogeological investigation.

In Equation A-3, the dilution factor (DF) is calculated. The DF represents the degree of dilution due to mixing of leachate and groundwater at the water table. A value of one (1) must be used for the DF in Equation A-3 where the soil contamination source extends into the water table. In Equation A-4, where the mixing zone thickness (d_m) is calculated at greater than the aquifer thickness (d_a), the mixing zone thickness term must be set equal to the aquifer thickness.

Predicted groundwater concentrations in the saturated zone, and parameter values used to derive them, are to be summarized on **Form A-1**.

The final component of Step 3 is to determine whether any predicted groundwater concentrations exceed the corresponding CSR numerical water standards.

- If “yes” for any contaminant, then proceed to Step 4 to calculate predicted groundwater concentrations at the point of compliance for those contaminants.

- If “no” for all contaminants, but measured groundwater concentrations exceed CSR numerical water standards for some or all of the contaminants, proceed to Step 4 to calculate predicted groundwater concentrations at the point of compliance based on groundwater data for those contaminants.

- If “no” for all contaminants, and measured groundwater concentrations are less than CSR numerical water standards for all contaminants, then enter a “no” response to Question HW-3, AW-3, IW-3, or LW-3, as appropriate (soil to groundwater contaminant transport pathway is incomplete).

4.0 Step 4 - Calculation of predicted groundwater concentrations at the point of compliance

Predicted groundwater concentrations at the point of compliance (C_x) are calculated using Equation A-5. Following from Step 3, for each substance, the predicted groundwater concentration below the source ($C_{gw'}$) or maximum measured groundwater concentration below the source (C_{gwmax}), whichever is greatest, is used as the source concentration (C_{gw}) in Equation A-5.

Predicted groundwater concentrations at the point of compliance must be calculated for each substance using property values for K_{oc} and saturated zone biodegradation half-life ($t_{1/2s}$) from Tables A-1 and A-2 (for organic substances) and distribution coefficient (K_d) values from Tables A-3 and A-4 (for inorganic substances). Where a saturated zone biodegradation half-life is not specified for an organic substance, or for any inorganic substance, a default value of 1E+99 days must be used.

For substances not listed in Table A-1, substance property values for K_{oc} and K_d must be obtained from the RAIS database. Biodegradation half-life values must be selected as per the preceding paragraph.

Site-specific values must be used for parameters C_{gwmax}, x, K, i and Y in Equation A-5. The allowable value for distance to point of compliance (x) is dependent on the applicable water use and is measured from all points along the boundary of the contaminant plume or, where groundwater contamination is not present, all points along the boundary of the contaminant source area. For DW, IW and LW water use, the points of compliance are any water well on the parcel and all points along the parcel boundary. For AW water use, the points of compliance are 10 m inland from the high water mark of a receiving environment on the parcel and all points along the parcel boundary. For each water use, the lowest value of x must be used. The maximum allowable value for x is 500 m regardless of water use.

The remaining site-specific parameters (C_{gwmax}, K, I, and Y) must be determined based on site-specific hydrogeological investigation. For average linear groundwater velocity, the calculated value or a minimum value of 5 m/yr, whichever is greater, must be used. A site-specific or default value for f_{oc} must be used in Equation A-5. Site-specific or literature values may be substituted for parameters with default values (n, n_e, ρ_b) in Equation A-5. Default values for $f_{oc,}$ n, n_a, ρ_b are indicated in forms and A-1 and A-2.

All calculations must be conducted using the ministry's Groundwater Protection Model (GPM).

Predicted groundwater concentrations at the point of compliance, and parameter values used to calculate them, must be summarized on **Form A-2**.

The final component of Step 4 is to determine whether any predicted groundwater concentrations at the point of compliance exceed the corresponding CSR numerical water standards.

- If "yes" for any contaminant or sample location, then enter a "yes" response to Question HW-3, AW-3, IW-3, or LW-3, as appropriate (contamination has the potential to reach a receptor). The site fails the screening level risk assessment for this exposure scenario.

- If "no" for all contaminants and sample locations, then enter a "no" response to Question HW-3, AW-3, IW-3, or LW-3, as appropriate (contamination does not have the potential to reach a receptor). The site passes the screening level risk assessment for this exposure scenario.

Forms A-1 and A-2 are located in the SLRA Questionnaire and Forms attachment. See Figure 3 for a summary graphical depiction of the soil leachate and groundwater transport assessment process. The GPM is provided in Technical Guidance 13, "Groundwater Protection Model". Derivation and supporting information on the GPM is available in Protocol 28, "2016 Standards Derivation Methods".

Appendix A: Schedule 1

SLRA Model Equations

Equation A-1:
Soil/leachate partitioning

$$C_L = \frac{C_s}{\left[K_d + \left(\frac{n_w + H' n_a}{\rho_b}\right) \right]} * 1000$$

$$K_d = K_{oc} f_{oc}$$

$$n_a = n - n_w$$

C_L = leachate concentration at source (µg/L)
C_s = soil concentration at source (µg/g)
K_d = distribution coefficient (L/kg, Table A-3 and Table A-4))
K_{oc} = organic carbon partitioning coefficient (L/kg, Table A-1)
f_{oc} = fraction of organic carbon (dimensionless)
n_w = water-filled porosity (dimensionless)
n_a = air-filled porosity (dimensionless)
n = total porosity (dimensionless)
H' = dimensionless Henry's law constant (Table A-1)
ρ_b = dry bulk density of soil (g/cm^3)
1000 = units conversion factor (1000 µg/mg)

Equation A-2:
Leachate transport in the unsaturated zone

$$C_z = C_L * \exp\left[\frac{b}{2\,\partial_u}\left(1 - \left(1 + \frac{4\lambda_u\,\partial_u R_u}{v_u}\right)^{1/2}\right)\right]$$

$$b = d - Z\ (m)\ (b = 0 \text{ where } d<Z \text{ (source extends into water table)})$$

$$\partial_u = 0.1b$$

$$\lambda_u = \frac{\ln 2}{t_{1/2u}} \text{ where } \ln 2 = 0.6931$$

$$R_u = 1 + \frac{\rho_b}{n_w} K_d$$

$$v_u = \frac{I}{n_w} \text{and } I = P - (RO + EV)$$

C_z = leachate concentration at water table (µg/L)
C_L = leachate concentration at source (µg/L) – from soil leachate tests or Equation A-1, as applicable.
d = depth to water table from ground surface (m)
Z = source depth below ground surface (m)
∂_u = dispersivity in unsaturated zone (m)
λ_u = biodegradation rate in unsaturated zone ($days^{-1}$ * 365 days/yr)
$t_{1/2u}$ = half-life in unsaturated zone (days, Table A-1)
R_u = retardation factor in unsaturated zone (dimensionless)
v_u = leachate velocity in unsaturated zone (m/yr)
I = infiltration rate (m/yr)
P = precipitation rate (m/yr)
RO+EV = runoff plus evapotranspiration rate (m/yr)
K_d defined in Equation A-1
n_w defined in Equation A-1
ρ_b defined in Equation A-1

Equation A-3:

Leachate/groundwater mixing

$$C_{gw'} = \frac{C_z}{DF} \text{ where } DF = 1 + \left(\frac{d_m V}{X\,I}\right)$$

$$DF = 1 \text{ if } d - Z < 0 \text{ (source extends into water table)}$$

$$V = K\,i$$

$C_{gw'}$ = predicted groundwater concentration below source (µg/L)
C_z = leachate concentration at water table (µg/L) – from Equation A-2
DF = dilution factor
d_m = mixing zone thickness (Equation A-4)
V = Darcy flux or specific discharge (m/yr)
K = hydraulic conductivity (m/s*3.154E+07 s/yr)
i = hydraulic gradient (dimensionless)
X = source length (m)
I defined in Equation A-2

d defined in Equation A-2
Z defined in Equation A-2

Equation A-4:

Leachate/groundwater mixing – mixing zone thickness

$$d_m = 0.1X + d_a \left[1 - \exp\left(-\frac{XI}{Vd_a}\right)\right] \text{ or } d_a\text{, whichever is lesser}$$

d_m = mixing zone thickness (m)
d_a = aquifer thickness (m)

X defined in Equation A-3
I defined in Equation A-2
V defined in Equation A-3

Equation A-5:

Solute transport in the saturated zone

$$C_x = C_{gw}\ \exp\left\{\frac{x}{2\,\partial_x}\left[1 - \left(1 + \frac{4\lambda_s\,\partial_x R_f}{v}\right)^{1/2}\right]\right\}\ \mathrm{erf}\left[\frac{Y}{4\left(\partial_y x\right)^{1/2}}\right]$$

$$C_{gw} = \max\ (C_{gw'},\ C_{gwmax})$$

$$\partial_x = 0.1x \text{ and } \partial_y = 0.1\,\partial_x$$

$$\lambda_s = \frac{\ln 2}{t_{1/2s}} \text{ where } \ln 2 = 0.6931$$

$$R_f = 1 + \frac{\rho_b}{n} K_d \text{ where } K_d = K_{oc} f_{oc}$$

$$v = \frac{V}{n_e} = \frac{K\,i}{n_e}$$

C_x = predicted groundwater concentration at point of compliance (µg/L)
C_{gw} = groundwater concentration below source (µg/L) = greater of $C_{gw'}$ and C_{gwmax}

$C_{gw'}$ = predicted groundwater concentration below source (µg/L) – from Equation A-3
C_{gwmax} = maximum measured groundwater concentration below source (µg/L)
x = distance to point of compliance as determined in Appendix A, Section 4.0 (m). Maximum allowable value is 500 m.
∂_x = longitudinal dispersivity (m)
∂_y = transverse dispersivity (m)
λ_s = biodegradation rate in saturated zone (days^{-1}*365 days/yr)
$t_{1/2s}$ = half-life in saturated zone (days, Table A-1)
R_f = retardation factor in saturated zone (dimensionless)
v = average linear groundwater velocity in saturated zone (m/yr)
n_e = effective porosity (dimensionless)
Y = source width (m) = maximum extent of contaminated groundwater perpendicular to the groundwater flow direction
ρ_b defined in Equation A-1
n defined in Equation A-1
K_d defined in Equation A-1
V defined in Equation A-3

Appendix A Table A-1

Table A-1 Substance properties

Substance	Chemical Abstract Service # (CAS)	Henry's Law Constant H' (-)	Organic Carbon Partitioning Coefficient Koc (L/kg)	Biodegradation Half-life Unsaturated t1/2u (days)	Biodegradation Half-life Saturated t1/2s (days)
		Value	Value	Value	Value
acenaphthene	83-32-9	0.00752	5,030	145	290
acetone	67-64-1	0.00143	2.36	95	190
acrolein	107-02-8	0.00499	1		
acrylonitrile	107-13-1	0.00564	8.51		
allyl chloride	107-05-1	0.450	39.6		
aluminum	7429-90-5	-	-	-	-
anthracene	120-12-7	0.00227	16,400	195	390
antimony	7440-36-0	-	-	-	-
arsenic	7440-38-2	-	-	-	-
barium	7440-39-3	-	-	-	-
benz(a)anthracene	56-55-3	4.91E-04	177,000		
benzene	71-43-2	0.227	146	195	390
benzo(a)pyrene	50-32-8	1.87E-05	587,000		
benzo(b+j)fluoranthenes[1]	205-99-2 & 205-82-3	8.30E-06	599,000		
benzotrichloride	98-07-7	0.0106	1,000		
benzyl chloride	100-44-7	0.0168	446		
beryllium	7440-41-7	-	-	-	-
bis(2-chloro-1-methylethyl) ether	108-60-1	0.00303	82.9		
bis(2-chloroethyl) ether	111-44-4	6.95E-04	32.2		
boron	7440-42-8	-	-	-	-
bromobenzene	108-86-1	0.101	234		
bromodichloromethane [BDCM]	75-27-4	0.0867	31.8		
bromoform	75-25-2	0.0219	31.8		
bromomethane	74-83-9	0.300	13.2		
butadiene, 1,3-	106-99-0	3.01	39.6		
cadmium	7440-43-9	-	-	-	-
carbon disulfide	75-15-0	0.589	21.7		
carbon tetrachloride	56-23-5	1.13	43.9	6	11

Substance	Chemical Abstract Service # (CAS)	Henry's Law Constant H' (-)	Organic Carbon Partitioning Coefficient Koc (L/kg)	Biodegradation Half-life Unsaturated t1/2u (days)	Biodegradation Half-life Saturated t1/2s (days)
		Value	Value	Value	Value
chloride ion	16887-00-6	-	-	-	-
chlorobenzene	108-90-7	0.127	234		
chlorobenzotrifluoride, 4-	98-56-6	1.42	1,610		
chlorobutane, 1-	109-69-3	0.683	72.2		
chloroform	67-66-3	0.150	31.8	32	63
chloronaphthalene, 2-	91-58-7	0.0131	2,480		
chloronitrobenzene, 2-	88-73-3	3.80E-04	371		
chloronitrobenzene, 4-	100-00-5	2.00E-04	363		
chlorophenol, 2-	95-57-8	4.58E-04	Table A-2		
chlorophenol, 3-	108-43-0	1.41E-05	300		
chlorophenol, 4-	106-48-9	2.56E-05	300		
chloroprene	126-99-8	2.29	60.7		
chlorotoluene, 2-	95-49-8	0.146	383		
chromium, hexavalent	18540-29-9	-	-	-	-
chromium, trivalent	16065-83-1	-	-	-	-
cobalt	7440-48-4	-	-	-	-
copper	7440-50-8	-	-	-	-
cyanide	57-12-5	0.989	-	-	-
chrysene	218-01-9	2.14E-04	181,000		
crotonaldehyde, trans-	123-73-9	7.93E-04	1.79		
dibenz(a,h)anthracene	53-70-3	5.77E-06	1,910,000		
dibromo-3-chloropropane, 1,2-	96-12-8	0.00601	116		
dibromobenzene, 1,4-	106-37-6	0.0365	375		
dibromochloromethane [DBCM]	124-48-1	0.0320	31.8		
dibromoethane, 1,2-	106-93-4	0.0266	39.6		
dichlorobenzene, 1,2-	95-50-1	0.0785	383		
dichlorobenzene, 1,3-	541-73-1	0.108	375		
dichlorobenzene, 1,4-	106-46-7	0.0990	375		
dichlorodifluoromethane	75-71-8	14.0	43.9		
dichlorodiphenyltrichloroethane, total [DDT][2]	-[3]	3.40E-04	169,000		
dichloroethane, 1,1-	75-34-3	0.230	31.8	115	230
dichloroethane, 1,2-	107-06-2	0.0482	39.6	60	120
dichloroethylene, 1,1-	75-35-4	1.07	31.8		
dichloroethylene, 1,2-cis-	156-59-2	0.167	39.6		

Substance	Chemical Abstract Service # (CAS)	Henry's Law Constant H' (-)	Organic Carbon Partitioning Coefficient Koc (L/kg)	Biodegradation Half-life Unsaturated t1/2u (days)	Biodegradation Half-life Saturated t1/2s (days)
		Value	Value	Value	Value
dichloroethylene, 1,2-trans-	156-60-5	0.383	39.6		
dichloromethane	75-09-2	0.133	21.7	55	110
dichlorophenol, 2,3-	576-24-9	1.26E-05	502		
dichlorophenol, 2,4-	120-83-2	1.75E-04	Table A-2	1,820	3,640
dichlorophenol, 2,5-	583-78-8	1.26E-05	492		
dichlorophenol, 2,6-	87-65-0	1.09E-04	502		
dichlorophenol, 3,4-	95-77-2	1.26E-05	492		
dichloropropane, 1,2-	78-87-5	0.115	60.7		
dichloropropene, 1,3- (cis + trans)	542-75-6	0.145	72.2		
dicyclopentadiene	77-73-6	2.56	1,510		
diethyl ether	60-29-7	0.0503	9.70		
diisopropanolamine [DIPA]	110-97-4	2.92E-09	10		
dimethylaniline, N,N- [DMA]	121-69-7	0.00232	78.7		
ethyl acetate	141-78-6	0.00548	5.58		
ethyl acrylate	140-88-5	0.0139	10.7		
ethylbenzene	100-41-4	0.322	446	145	290
ethylene glycol	107-21-1	2.45E-06	1.00	105	210
fluoranthene	206-44-0	3.62E-04	55,500	115	230
fluorene	86-73-7	0.00393	9,160	175	350
fluoride	16984-48-8	-	-	-	-
HEPHs	-[3]	0.012	15,800		
hexachlorobenzene	118-74-1	0.0695	6,200		
hexachlorobutadiene	87-68-3	0.421	845		
hexachlorocyclopentadiene	77-47-4	1.10	1,400		
hexachloroethane	67-72-1	0.159	197		
iron	7439-89-6	-	-	-	-
isobutanol	78-83-1	4.00E-04	2.92		
isopropylbenzene	98-82-8	0.470	698		
lead	7439-92-1	-	-	-	-
LEPHs/LEPHw/EPHw10-19	-[3]	0.057	2,500	175	350
manganese	7439-96-5	-	-	-	-
mercury	7439-97-6	0.467	-	-	-
methacrylonitrile	126-98-7	0.0101	13.1		
methanol	67-56-1	1.86E-04	1.00	18	36
methomyl	16752-77-5	8.05E-10	10		

Substance	Chemical Abstract Service # (CAS)	Henry's Law Constant H' (-)	Organic Carbon Partitioning Coefficient Koc (L/kg)	Biodegradation Half-life Unsaturated t1/2u (days)	Biodegradation Half-life Saturated t1/2s (days)
		Value	Value	Value	Value
methyl acetate	79-20-9	0.00470	3.06		
methyl ethyl ketone [MEK]	78-93-3	0.00233	4.51	65	130
methyl methacrylate	80-62-6	0.0130	9.14		
methyl tert-butyl ether [MTBE]	1634-04-4	0.0240	11.6	345	690
methylstyrene, alpha-	98-83-9	0.104	698		
molybdenum	7439-98-7	-	-	-	-
naphthalene	91-20-3	0.0180	1,540	175	350
nickel	7440-02-0	-	-	-	-
nitrobenzene	98-95-3	9.81E-04	226	95	190
nitroso-di-N-butylamine, N-	924-16-3	5.40E-04	915		
nitrotoluene, 2-	88-72-2	5.11E-04	371		
nitrotoluene, 3-	99-08-1	3.80E-04	363		
nitrotoluene, 4-	99-99-0	2.30E-04	363		
nonylphenol and nonylphenol ethoxylates[4]	84852-15-3	4.65E-05	25,000		
pentachlorobenzene, 1,2,3,4,5-	608-93-5	0.0287	3,710		
pentachlorophenol [PCP]	87-86-5	1.00E-06	Table A-2	383	767
perfluorooctane sulfonate [PFOS]	1763-23-1	0.449	71,700		
phenanthrene	85-01-8	0.00173	16,700		
phenol	108-95-2	1.36E-05	187	265	530
propylene glycol, 1,2-	57-55-6	5.27E-07	1		
propylene oxide	75-56-9	0.00285	5.19		
pyrene	129-00-0	4.87E-04	54,300		
pyridine	110-86-1	4.50E-04	71.7		
selenium	7782-49-2	-	-	-	-
silver	7440-22-4	-	-	-	-
sodium ion	17341-25-2	-	-	-	-
strontium	7440-24-6	-	-	-	-
styrene	100-42-5	0.112	446		
sulfolane	126-33-0	1.98E-04	9.08		
tetrachlorobenzene, 1,2,3,4-	634-66-2	0.0311	2,270		
tetrachlorobenzene, 1,2,4,5-	95-94-3	0.0409	2,220		
tetrachloroethane, 1,1,1,2-	630-20-6	0.102	86.0		
tetrachloroethane, 1,1,2,2-	79-34-5	0.0150	94.9		
tetrachloroethylene	127-18-4	0.724	94.9		

Substance	Chemical Abstract Service # (CAS)	Henry's Law Constant H' (-)	Organic Carbon Partitioning Coefficient Koc (L/kg)	Biodegradation Half-life Unsaturated t1/2u (days)	Biodegradation Half-life Saturated t1/2s (days)
		Value	Value	Value	Value
tetrachlorophenol, 2,3,4,5-	4901-51-3	6.91E-06	Table A-2		
tetrachlorophenol, 2,3,4,6-	58-90-2	3.61E-04	Table A-2		
tetrahydrofuran	109-99-9	0.00288	10.8		
thallium	7440-28-0	-	-	-	-
tin	7440-31-5	-	-	-	-
toluene	108-88-3	0.271	234	65	130
trichlorobenzene, 1,2,3-	87-61-6	0.0511	1,380		
trichlorobenzene, 1,2,4-	120-82-1	0.0581	1,360		
trichloroethane, 1,1,1-	71-55-6	0.703	43.9	80	160
trichloroethane, 1,1,2-	79-00-5	0.0337	60.7		
trichloroethylene	79-01-6	0.403	60.7		
trichlorofluoromethane	75-69-4	3.97	43.9	2,165	4,330
trichlorophenol, 2,4,5-	95-95-4	6.62E-05	Table A-2		
trichlorophenol, 2,4,6-	88-06-2	1.06E-04	Table A-2		
trichloropropane, 1,1,2-	598-77-6	0.0130	94.9		
trichloropropane, 1,2,3-	96-18-4	0.0140	116		
trichloropropene, 1,2,3-	96-19-5	0.720	116		
trimethylbenzene, 1,3,5-	108-67-8	0.359	602		
tungsten	7440-33-7	-	-	-	-
uranium	7440-61-1	-	-	-	-
vanadium	7440-62-2	-	-	-	-
vinyl acetate	108-05-4	0.0209	5.58		
vinyl chloride	75-01-4	1.14	21.7		
VPHs/VPHw/VHw6-10	-[3]	0.51	1,600	90	180
xylenes, total	1330-20-7	0.271	383	145	290
zinc	7440-66-6	-	-	-	-

[1] Substance properties based on benzo(b)fluoranthene.

[2] Sum of DDT (2,4' + 4,4' isomers), DDD (2,4' + 4,4' isomers) and DDE (2,4' + 4,4' isomers).

[3] No CAS number exists for this substance.

[4] Nonylphenol includes related nonylphenolic and octylphenolic compounds, including ethoxylates and ethoxycarboxylates. Consult the director for further advice.

- not applicable

Appendix A Table A-2

Table A-2 Substance properties (select chlorophenols)

Soil pH (-)	Organic Carbon Partitioning Coefficient Koc (L/kg)						
	chlorophenol, 2- (CAS#95-57-8)	dichlorophenol, 2,4- (CAS#120-83-2)	pentachlorophenol [PCP] (CAS#87-86-5)	tetrachlorophenol, 2,3,4,5- (CAS#4901-51-3)	tetrachlorophenol, 2,3,4,6- (CAS#58-90-2)	trichlorophenol, 2,4,5- (CAS#95-95-4)	trichlorophenol, 2,4,6- (CAS#88-06-2)
4.9	398	159	9,050	17,300	4,450	2,370	1,040
5.0	398	159	7,960	17,200	4,150	2,360	1,030
5.1	398	159	6,930	17,000	3,830	2,360	1,020
5.2	398	159	5,970	16,700	3,490	2,350	1,010
5.3	398	159	5,100	16,500	3,140	2,340	999
5.4	398	158	4,320	16,100	2,790	2,330	982
5.5	397	158	3,650	15,700	2,450	2,320	962
5.6	397	158	3,070	15,200	2,130	2,310	938
5.7	397	158	2,580	14,700	1,830	2,290	910
5.8	397	158	2,180	14,000	1,560	2,270	877
5.9	397	157	1,840	13,200	1,320	2,240	839
6.0	396	157	1,560	12,400	1,110	2,210	796
6.1	396	157	1,330	11,500	927	2,170	748
6.2	396	156	1,150	10,500	775	2,120	697
6.3	395	155	998	9,510	647	2,060	644
6.4	394	154	877	8,480	542	1,990	589
6.5	393	153	781	7,470	455	1,910	533
6.6	392	152	703	6,490	384	1,820	480
6.7	390	150	640	5,580	327	1,710	429
6.8	388	147	592	4,740	280	1,600	381
6.9	386	145	552	3,990	242	1,470	338
7.0	383	141	521	3,330	213	1,340	300
7.1	379	138	496	2,760	188	1,210	267
7.2	375	133	476	2,280	169	1,070	239
7.3	369	128	461	1,870	153	943	215
7.4	362	121	447	1,530	141	819	195
7.5	354	114	437	1,250	131	703	178
7.6	344	107	429	1,020	123	599	164
7.7	333	98.4	423	831	117	507	153
7.8	319	89.7	418	679	113	426	144

Soil pH (-)	**Organic Carbon Partitioning Coefficient Koc (L/kg)**						
	chlorophenol, 2- (CAS#95-57-8)	dichlorophenol, 2,4- (CAS#120-83-2)	pentachlorophenol [PCP] (CAS#87-86-5)	tetrachlorophenol, 2,3,4,5- (CAS#4901-51-3)	tetrachlorophenol, 2,3,4,6- (CAS#58-90-2)	trichlorophenol, 2,4,5- (CAS#95-95-4)	trichlorophenol, 2,4,6- (CAS#88-06-2)
7.9	304	80.7	414	556	108	357	137
8.0	286	71.7	410	458	105	298	131
8.1	267	63.0	408	379	103	249	126
8.2	246	54.7	406	316	101	208	122
8.3	224	47.0	404	265	99.1	175	119
8.4	202	40.0	403	225	97.8	148	117
8.5	180	33.8	402	192	96.8	126	115
8.6	158	28.4	401	167	96.1	108	113
8.7	137	23.8	400	146	95.4	93.4	112
8.8	118	19.9	400	130	94.9	81.9	111
8.9	100	16.6	400	117	94.5	72.6	110
9.0	84.7	13.9	399	107	94.2	65.1	109

Appendix A: Table A-3

Table A-3 Substance properties (inorganics) distribution coefficients Kd

Substance	Chemical Abstract Service # (CAS)	Kd (L/kg)
aluminum	7429-90-5	1,500
antimony	7440-36-0	45
arsenic	7440-38-2	*
barium	7440-39-3	100
beryllium	7440-41-7	*
boron	7440-42-8	3
cadmium	7440-43-9	*
chloride ion	16887-00-6	0.05
chromium, hexavalent	18540-29-9	*
chromium, trivalent	16065-83-1	*
cobalt	7440-48-4	45
copper	7440-50-8	*
cyanide	57-12-5	9.9
fluoride	16984-48-8	150
iron	7439-89-6	25
lead	7439-92-1	*
manganese	7439-96-5	65
mercury	7439-97-6	52
molybdenum	7439-98-7	20
nickel	7440-02-0	*
selenium	7782-49-2	*
silver	7440-22-4	*
sodium ion	17341-25-2	20
strontium	7440-24-6	35
thallium	7440-28-0	*
tin	7440-31-5	250
tungsten	7440-33-7	150
uranium	7440-61-1	450
vanadium	7440-62-2	1,000
zinc	7440-66-6	*

* varies by soil pH – determine in accordance with Protocol 28 or, for silver and thallium, see Table A-4.

Appendix A; Table A-4

Table A-4 Substance properties (silver and thallium) distribution coefficients Kd

Soil pH (-)	Kd (L/kg)	
	silver CAS# 7440-22-4	thallium CAS# 7440-28-0
4.9	0.1	44
5.0	0.13	45
5.1	0.16	46
5.2	0.21	47
5.3	0.26	48
5.4	0.33	50
5.5	0.42	51
5.6	0.53	52
5.7	0.67	54
5.8	0.84	55
5.9	1.1	56
6.0	1.3	58
6.1	1.7	59
6.2	2.1	61
6.3	2.7	62
6.4	3.4	64
6.5	4.2	66
6.6	5.3	67
6.7	6.6	69
6.8	8.3	71
6.9	10	73
7.0	13	74
7.1	16	76
7.2	20	78
7.3	25	80
7.4	31	82
7.5	39	85
7.6	48	87
7.7	59	89
7.8	73	91
7.9	89	94
8.0 to 9.0	110	96

APPENDIX B

Habitat and Receptor Assessment
(Question TS-5 in SLRA Questionnaire)

This assessment evaluates whether the site contains suitable habitat for specific local species. This assessment may only be completed by a Registered Professional Biologist whose area of practice includes demonstrable experience in the identification of ecological receptors and assessment of ecological and sensitive habitat.

The potential for onsite terrestrial habitat to be used by specific receptor groups is evaluated in three steps: (1) determination of potential receptors; (2) selection of site-specific receptors; and, (3) assessment of habitat suitability. The procedure is a critical step in the problem formulation of an ecological or environmental risk assessment.

1.0 Determining potential receptors

Potential site receptor groups to be considered vary depending on land use and geographic location of the site. **Form B-1** indicates those wildlife receptors that must be considered on the basis of the different land uses (other receptors may be considered as deemed appropriate by the assessor). The assessor must also complete a site visit and check for the presence of terrestrial plant types on the site.

2.0 Selection of appropriate site-specific receptors

In this first step the potential presence of receptors at the site is assessesed based on what is observed and what would be anticipated if the site remained in its natural undisturbed condition. Using **Form B-1** as a reference, the assessor must complete **Form B-2**, which documents the land use and geographic location of the site along with observed receptor groups based on a site visit and interviews with local residents. The assessor must also indicate the potential for the presence of receptors which have not been observed during the site visit or indicated by local or onsite sources. The potential for a receptor's presence is evaluated on the basis of an office review of available information on potential receptor groups (biogeoclimatic zone lists, Committee on the Status of Endangered Wildlife in Canada [COSEWIC] lists, etc.). The receptor identification must be compliant with applicable rules in Protocol 1, "Detailed Risk Assessment" and Protocol 20, "Detailed Ecological Risk Assessment Requirements" for the applicable land use, and the Qualified Profesional must review and consider applicable ministry guidance in assessessing potential presence of receptors.

Finally, the assessor must indicate which receptor groups will be carried forward to the assessment of habitat suitability. Each of the selected receptor groups on **Form B-2** must be carrried forward and any COSEWIC-listed, or BC red-listed or blue-listed species that may be present in the vicinity of the site must be listed and considered individually. The following tools must be taken into consideration:

- identifying COSEWIC species and their geographic range is available at the following url: http://www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm.
- identifying red and blue-listed species and their geographic range is available at the following url: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/species-ecosystems-at-risk.

3.0 Assessment of habitat suitability

In this second step the site is assessed for habitat suitability for potential receptors identified in the first step. The undeveloped land onsite is evaluated in terms of habitat suitability for each of the selected receptor groups on **Form B-2**. The habitat suitability for each receptor group (including any i red/blue-listed species) is evaluated by completing the decision matrix in **Form B-3**. The decision matrix considers the following three factors:

- Habitat Size. This column considers whether the area of suitable habitat which is wholly or partly on the contaminated site is large enough to support the receptor in question. Factors such as the home range of the species should be considered while evaluating the size criterion. A "yes" answer indicates that the undeveloped land is large enough to support the receptor in question without connectivity or proximity to other suitable habitat, and a "no" indicates that the land is too small to support the receptor.

- *Connectivity of Fragments*. A "yes" answer indicates that the area of habitat identified above is sufficiently connected or in sufficient proximity of additional habitat features, and a "no" would indicate that the undeveloped land is isolated from any additional habitat requirements of the receptor.

- *Quality of the undeveloped land*. A "yes" answer indicated that the types of vegetation, presence of habitat features and percent cover are adequate to provide habitat for the receptor, and a "no" would indicate that the quality of the habitat is inadequate due to the absence of habitat features, degradation of the land or human disturbance. In determining whether the site has factors that affect its quality as habitat, such as: traffic; periodic use for storage (e.g. lumber, pipes, etc.); or maintenance requirements (for example, the Fire Code, clearing of rights of way) with vegetation controls.

The assessor must state if it is their professional opinion as to whether the vegetation or invertebrates at the site are stressed because of site contamination or whether the conditions are typical for that geographic area at the time of the site inspection.

Following consideration of the three factors above (size, degree of fragmentation, quality), the assessor should indicate whether or not the receptor in question is likely to use the undeveloped land as habitat.

- If "yes" for any receptor, then enter a "yes" response to Question TS-5 (the site does contain suitable habitat for specific local species).

- If “no” for all receptors, then enter a “no” response to Question TS-5 (there are no potential unacceptable risks to the terrestrial environment via direct exposure).

The assessor must provide rationale on **Form B-3** in support of any decisions made.

Forms B-1 through B-3 are included in the SLRA Questionnaire and Forms attachment.

Protocol 13

Screening Level Risk Assessment

Questionnaire and Forms

Screening Level Risk Assessment (SLRA) Questionnaire

		Yes	No	Note
GENERAL				
Complete problem formulation and conceptual site model.				
Check for requirements (Section 3.1)				
Check for precluding conditions (Section 3.2)				
Check for exemptions (Sections 3.3 and 6.0)				
Proceed sequentially through the following exposure scenarios.				0
HUMAN EXPOSURE SCENARIOS				
Exposure to Contaminated Soils (HS-1 to 3)				
HS-1	Do substance concentrations in soil exceed the applicable standards?	☐	☐	1,2
HS-2	Are contaminated soils located within, or may contaminants in soil migrate to within, 1 m of ground surface?	☐	☐	3
HS-3	Is the ground surface above contaminated soils uncovered?	☐	☐	4
Exposure to Contaminated Groundwater (HW-1 to 3)				
HW-1	Does drinking water use apply at the site?	☐	☐	5
HW-2	Do substance concentrations in soil or groundwater exceed the standards for the protection of drinking water?			6,2
HW-3	Is there the potential for soil leachate or contaminated groundwater to migrate to a water well used for drinking water on the parcel or to migrate beyond the parcel boundary, at concentrations greater than the drinking water standards?	☐	☐	7
ECOLOGICAL EXPOSURE SCENARIOS				
Terrestrial Exposure to Contaminated Soils (TS-1 to 5)				
TS-1	Do substance concentrations in soil exceed the applicable standards?	☐	☐	8,2
TS-2	Are contaminated soils located within, or may contaminants in soil migrate to within, 1 m of ground surface?	☐	☐	3
TS-3	Is the ground surface above contaminated soils uncovered?	☐	☐	4
TS-4	Is there *potential terrestrial habitat* present? [This question to be completed by a Registered Professional Biologist (RPBio)]	☐	☐	9
TS-5	Does the site contain suitable habitat for specific local species? [This question to be completed by a Registered Professional Biologist (RPBio)]	☐	☐	10
Exposure of aquatic biota to contaminated groundwater (AW-1 to 3)				
AW-1	Does aquatic life water use apply at the site?	☐	☐	5
AW-2	Do substance concentrations in soil or groundwater exceed the standards for the protection of aquatic life?	☐	☐	11,2
AW-3	Is there the potential for soil leachate or contaminated groundwater to migrate to a receiving environment on the parcel or to migrate beyond the parcel boundary, at concentrations greater than the Aquatic Life water standards?	☐	☐	7
Exposure of crops to contaminated groundwater (IW-1 to 3)				
IW-1	Does irrigation water use apply at the site?	☐	☐	5
IW-2	Do substance concentrations in soil or groundwater exceed the standards for the protection of irrigation?	☐	☐	12,2
IW-3	Is there the potential for soil leachate or contaminated groundwater to migrate to a water well used for irrigation on the parcel or to migrate beyond the parcel boundary, at concentrations greater than the irrigation water standards?	☐	☐	7

Screening Level Risk Assessment (SLRA) Questionnaire (Continued)

Exposure of livestock to contaminated groundwater (LW-1 to 3)				
LW-1	Does livestock water use apply at the site?	☐	☐	5
LW-2	Do substance concentrations in soil or groundwater exceed the standards for the protection of livestock watering?	☐	☐	13,2
LW-3	Is there the potential for soil leachate or contaminated groundwater to migrate to a water well used for livestock watering on the parcel or to migrate beyond the parcel boundary, at concentrations greater than the livestock watering water standards?	☐	☐	7
DEFAULT STANDARDS				
DF-1	Do VHw6-10 or EPHw10-19 concentrations in groundwater exceed the default generic numerical water standards for these substances?	☐	☐	
DF-2	Is there the potential for soil leachate or contaminated groundwater to migrate beyond the parcel boundary at concentrations greater than the VHw6-10 or EPHw10-19 water standards?	☐	☐	7

SLRA Questionnaire Notes

0. If a “no” response is provided to a given question within a series, then the remaining questions in that series need not be answered.
1. Use the applicable land use soil standards in Schedule 3.1 Part 1 (Intake of contaminated soil) and Schedule 3.1 Part 2 or background soil concentrations established under Protocol 4.
2. Any applicable directors’ interim standards or criteria must also be applied.
3. This question includes evaluation of the potential for wicking of contaminants into the upper 1 m of soil due to capillary action. Cross-sections showing the vertical extent of soil contamination must be provided to support a “no” response to this question.
4. This question evaluates if there is a permanent barrier (for example, pavement or concrete) at ground surface, above the contaminated soils, to prevent potential exposure to contaminants. A scaled plan map showing the lateral extent of contaminated soils, barriers present, and absence of bare or vegetated soil at ground surface must be provided to support a “no” response to this question.
5. For evaluation of water uses, see Protocol 21, “Water Use Determination”.
6. For soils, use the applicable land use soil standards in Schedule 3.1 Part 1 (Groundwater used for drinking water) and Schedule 3.1 Part 2, background soil concentrations established under Protocol 4, or the site-specific numerical soil standards developed under Protocol 2 for the “Groundwater used for drinking water” site-specific factor. For groundwater, use the water standards in Schedule 3.2 (Column 6 Drinking Water) or background groundwater concentrations established under Protocol 9.
7. This question is answered by evaluating: (a) soil leachate concentrations (**Form A-1**); and (b) contaminant transport along a groundwater flow path to the respective receptor (**Form A-2**). The forms, and details on how to complete them, are provided in **Appendix A**. Provide completed forms (**Form A-1 and A-2**) to support a “no” response to this question. See Figure 3 for graphical depiction of the soil leachate and groundwater transport assessment process.
8. Use the applicable land use soil standards in Schedule 3.1 Part 1 (Toxicity to soil invertebrates and plants, Livestock ingesting soil and fodder or Major microbial functional impairment) and Schedule 3.1 Part 3 or background soil concentrations established under Protocol 4.
9. See definition for *potential terrestrial habitat* and Figure 4 for graphical depiction of the potential terrestrial habitat evaluation process.
10. This question is answered by: (1) determining possible site receptors based on land use (**Form B-1**); (2) selecting appropriate receptors (**Form B-2**); and (3) assessing habitat suitability for each receptor (**Form B-3**). The forms, and details on how to complete them, are provided in **Appendix B**. Provide completed forms (**Form B-1 through B-3**) to support a “no” response to this question.
11. For soils, use the applicable land use soil standards in Schedule 3.1 Part 1 (Groundwater flow to surface water used by aquatic life) and Schedule 3.1 Part 3, background soil concentrations established under Protocol 4, or the site-specific numerical soil standards developed under Protocol 2 for the “Groundwater flow to surface water used by aquatic life” site-specific factor. For groundwater, use the water standards in Schedule 3.2 (Column 3 Aquatic Life) and, as applicable, Protocol 10, or background groundwater concentrations established under Protocol 9.
12. For soils, use the applicable land use standards in Schedule 3.1 Part 1 (Groundwater used for irrigation) and Schedule 3.1 Part 3, background soil concentrations established under Protocol 4, or the site-specific numerical soil standards developed under Protocol 2 for the “Groundwater used for irrigation” site-specific factor. For groundwater, use the water standards in Schedule 3.2 (Column 4 Irrigation) or background groundwater concentrations established under Protocol 9.
13. For soils, use the applicable land use standards in Schedule 3.1 Part 1 (Groundwater used for livestock watering) and Schedule 3.1 Part 3, background soil concentrations established under Protocol 4, or the site-specific numerical soil standards developed under Protocol 2 for the “Groundwater used for livestock watering” site-specific factor. For groundwater, use the water standards in Schedule 3.2 (Column 5 Livestock) or background groundwater concentrations established under Protocol 9.

Form A-1. Soil Leachate Concentrations, Transport and Mixing

Question being answered (for example, AW-3): ______ **Applicable CSR Water Standard (circle):** **DW** **AW** **LW** **IW**

Parameter	Units	Default Value	Site-Specific Value	Minimum Value
Water-filled porosity, n_w	-	0.119		
Air-filled porosity, n_a	-	0.241		
Dry bulk density of soil, ρ_b	g/cm^3	1.7		
Fraction of organic carbon, f_{oc}	-	0.005		
Depth to water table, d	m			
Source depth, Z	m			
Source length, X	m			
Aquifer thickness, d_a	m			
Infiltration rate, I	m/yr			0.08
Darcy flux, V (=K*i)	m/yr			

Soil Sample Locations/ ID	**Contaminant**	**C_S** Soil concentration at source (µg/g)	**C_L** Leachate concentration at source[1] (µg/L)	**C_z** Leachate concentration at water table (Eqn A-2) (µg/L)	**d_m[2]** Mixing zone thickness (Eqn A-4) (m)	**DF[3]** Dilution Factor	**$C_{gw'}$** Predicted groundwater concentration below source (Eqn A-3) (µg/L)	**CSR Water Standard[4]** (µg/L)

[1] Include specification of calculation method (Appendix A Sections 1.1, 1.2 or 1.3).

[2] If mixing thickness is greater than the aquifer thickness, enter $d_m = d_a$.

[3] If the soil contamination source extends below the water table, enter DF=1.

[4] Use CSR numerical water standards listed in Schedule 3.2, Protocol 10, as applicable, or background groundwater concentrations established under Protocol 9, for the pathway being assessed (DW, AW, LW, IW).

Form A-2. Groundwater Transport

Question being answered (for example, AW-3): ________ **Applicable CSR Water Standard (circle): DW AW LW IW**

Parameter	Units	Default Value	Site-Specific Value	Minimum Value
Total porosity, n	-	0.36		
Effective porosity, n_e	-	0.25		
Dry bulk density of soil, ρ_b		1.7		
Fraction of organic carbon, f_{oc}	-	0.005		
Source width[1], Y	m			
Average linear groundwater velocity, $v=K*i/n_e$	m/yr			5

Soil or Groundwater Sample Locations/ID	**Contaminant**	**$C_{gw'}$** Predicted groundwater concentration below source (from Form A-1) (µg/L)	**C_{gwmax}** Maximum measured groundwater concentration below source (µg/L)	**C_{gw}** Groundwater concentration below source[2] (µg/L)	**x** Distance to point of compliance[3] (m)	**C_x** Predicted groundwater concentration at point of compliance (Eqn A-5) (µg/L)	**CSR Water Standard[4]** (µg/L)

[1] Maximum extent of contaminated groundwater in the source zone perpendicular to the groundwater flow direction.

[2] Enter the maximum measured groundwater concentration based on site investigation data (C_{gwmax}) or groundwater concentration predicted from soil leaching ($C_{gw'}$), whichever is greatest.

[3] See Appendix A Section 4.0 for allowable distance values. Maximum allowable value is 500 m.

[4] Use CSR numerical water standards listed in Schedule 3.2, Protocol 10, as applicable, or background groundwater concentrations established under Protocol 9, for the pathway being assessed (DW, AW, LW, IW).

Form B-1. Minimum Required Receptors Based on Current Land Use

Wildlife receptors	**Industrial**	**Commercial**	**Residential**[1]	**Agricultural**	**Urban Park / Wildlands**[2]
Terrestrial salamanders	Yes	Yes	Yes	Yes	Yes
Frogs/Toads	Yes	Yes	Yes	Yes	Yes
Reptiles	Yes	Yes	Yes	Yes	Yes
Waterfowl	If adjacent to water	If adjacent to water	If adjacent to water	Yes	If adjacent to water
Marsh birds/Waders	If adjacent to water	If adjacent to water	If adjacent to water	If adjacent to water	If adjacent to water
Upland game birds	No	No	No	Yes	Yes
Raptors	Yes	Yes	Yes	Yes	Yes
Shorebirds	If adjacent to water	If adjacent to water	If adjacent to water	Yes	If adjacent to water
Songbirds	Yes	Yes	Yes	Yes	Yes
Insectivorous mammals	Yes	Yes	Yes	Yes	Yes
Small herbivorous mammals	Yes	Yes	Yes	Yes	Yes
Bats	Yes	Yes	Yes	Yes	Yes
Small/medium carnivores	No	No	Yes	Yes	Yes
Large carnivores	No	No	No	Yes	Yes
Ungulates	No	No	No	Yes	Yes
COSEWIC/red/blue-listed species (evaluate individually)	Yes	Yes	Yes	Yes	Yes
Soil invertebrates	Yes	Yes	Yes	Yes	Yes
Terrestrial plants: check those that apply (found onsite during site visit)					
Trees: coniferous					
Trees: deciduous					
Shrubs					
Herbs: forbs					
Herbs: grasses					
Mosses, liverworts					
Lichens					
Fungi					
COSEWIC/red/blue-listed species	Yes	Yes	Yes	Yes	Yes

[1] Residential includes both Residential (Low Density) and Residential (High Density) land uses.

[2] Urban Park / Wildlands includes: Urban Park, Wildlands (Natural) and Wildlands (Reverted) land uses.

Date of site visit(s): ____

Form B-2. Selection of Appropriate Site-Specific Receptors

Land use: ______________________________

Location of site: ______________________________

Wildlife receptors	Based on land use[1]	Observed[2] (by assessor)	Observed (other sources)	Not observed[3]	Professional opinion regarding presence of receptor
Terrestrial salamanders					
Frogs/Toads					
Reptiles					
Waterfowl					
Marsh birds/Waders					
Upland game birds					
Raptors (eagles, hawks, falcons, owls)					
Shorebirds					
Songbirds					
Insectivorous mammals					
Small herbivorous mammals					
Bats					
Small/medium carnivores					
Large carnivores					
Ungulates					
Shrubs					
Grasses					
Ornamentals					
Trees: coniferous					
Trees: deciduous					
Herbs and forbs					
Mosses, lichens and fungi					
Other					
Red- or blue-listed species (B.C. Conservation Data Centre)					
COSEWIC-listed species (evaluate as individuals)					

[1] Receptors chosen based on current land use (from **Form B-1**).

[2] Specify date of observation/site visit.

[3] Receptor not observed. Indicate potential (“Nil”, “Low” or “High”) that receptor will actually be present at the site based on office review of available information.

Form B-3. Habitat Suitability

(to be completed for each receptor selected from **Form B-2**)

Receptor: ____

Observed onsite or potential for presence onsite: Yes ________   No ________

(Assessor may answer No where site specific information such as lack of aquatic environment for an aquatic species allows the assessor to determine that a receptor would not be present. If “No” form need not be completed.)

Habitat size	Connectivity of fragments	Quality	Move to detailed risk assessment
Yes	Yes	Not applicable	**Yes**
		Not applicable	**Yes**
	No	Yes	**Yes**
		No	**No**
No	Yes	Yes	**Yes**
		No	**No**
	No	Not applicable	**No**
		Not applicable	**No**

Note: “Yes” indicates that the habitat or habitat characteristic is favourable for a species.

Does sensitive habitat (as defined in Protocol 13) exist? Yes________   No_______

Detailed risk assessment required? Yes________   No_______

Visible signs of impacts on plants or invertebrates? Yes________   No_______

Comments:

Professional opinion regarding habitat quality:

Form C. Professional Statements and Signatures

Form C Professional Statements and Signatures. To be completed by Qualified Professional(s) – Part 1

Part 1 (to be completed by QPs responsible for overall SLRA) I the undersigned certify as follows:

1. I am a qualified professional.
2. The SLRA that is the subject of this report has been prepared in accordance with all requirements in the *Environmental Management Act*, the Contaminated Site Regulation, Protocol 13 and any other protocols relevant to the SLRA.
3. The SLRA has been prepared in conformity with ministry approved methods, procedures and guidance, and standards of professional practice.
4. A DSI for the contaminated site that is the subject to this SLRA has been prepared in conformity with Section 59 of the CSR and any Protocols relevant to the DSI.
5. The DSI has been prepared in conformity with ministry approved methods, procedures and guidances, and standards of professional practice.
6. I have demonstrable experience in remediation of the type of contamination at the site and am familiar with the remediation carried out on the site.
7. The responses provided in the attached SLRA Questionnaire are true and accurate based on current knowledge as of the date completed.

Print Name	Signature	Professional Designation	Date completed (yyyy-mm-dd)

Apply professional society stamp
(if applicable)

If multiple Part 1 signatories, add additional Form C's as needed.

Form C Professional Statements and Signatures. To be completed by Qualified Professional(s) – Part 2

Part 2 (to be completed by QPs responsible for Habitat Assessment) I the undersigned certify as follows:

8. I am a qualified professional.
9. I am a Registered Professional Biologist (RPBio) and have demonstrable experience in, and my area of practice includes, the assessment of ecological habitat.
10. The habitat assessment done as part of the SLRA was completed, and the parts of the SLRA report dealing with the habitat assessment were prepared, in accordance with Protocol 13 and any other protocols relevant to the habitat assessment.
    The responses provided in the attached SLRA Questionnaire dealing with habitat are true and accurate based on current knowledge as of the date completed.

______________________	______________________	______________________	______________________
Print Name	Signature	Professional Designation	Date completed (yyyy-mm-dd)

Apply professional society stamp
(if applicable)

If multiple Part 2 signatories, add additional Form C's as needed.

Form C Professional Statements and Signatures. To be completed by Qualified Professional(s) – Part 3

Part 3 (to be completed by QPs responsible for Plume Stability Assessment) I the undersigned certify as follows:

11. I am a qualified professional.
12. I have demonstrable experience in (a) assessment of groundwater flow, contaminant fate and transport, and aqueous geochemistry, and (b) trend analysis.

Print Name	Signature	Professional Designation	Date completed (yyyy-mm-dd)

Apply professional society stamp
(if applicable)

If multiple Part 3 signatories, add additional Form C's as needed.

FIGURE 1. Screening Level Risk Assessment Flowchart.
(Note: This flowchart is provided for illustrative purposes only. The questionnaire included in SLRA must be completed and takes precedence over this flowchart).

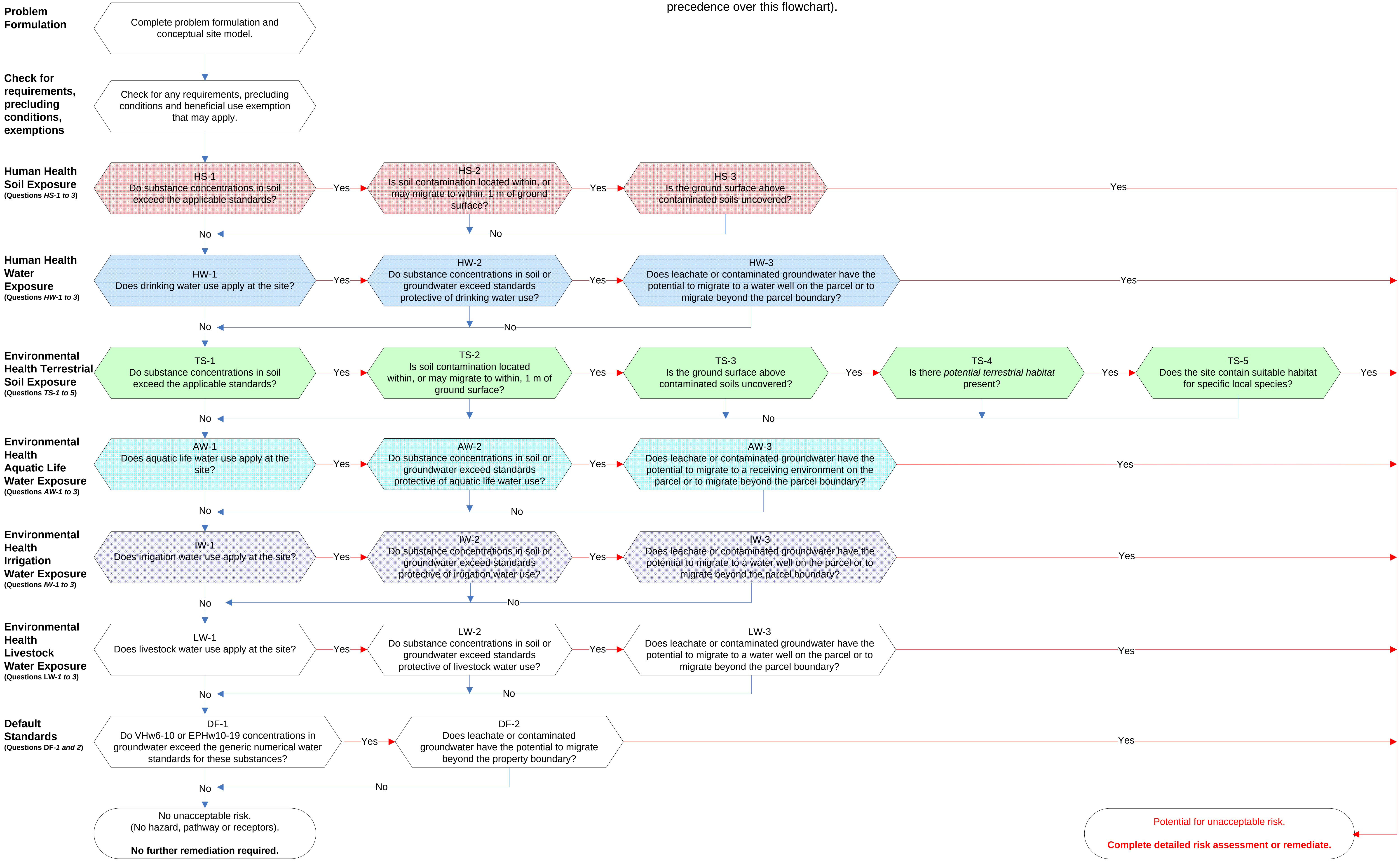
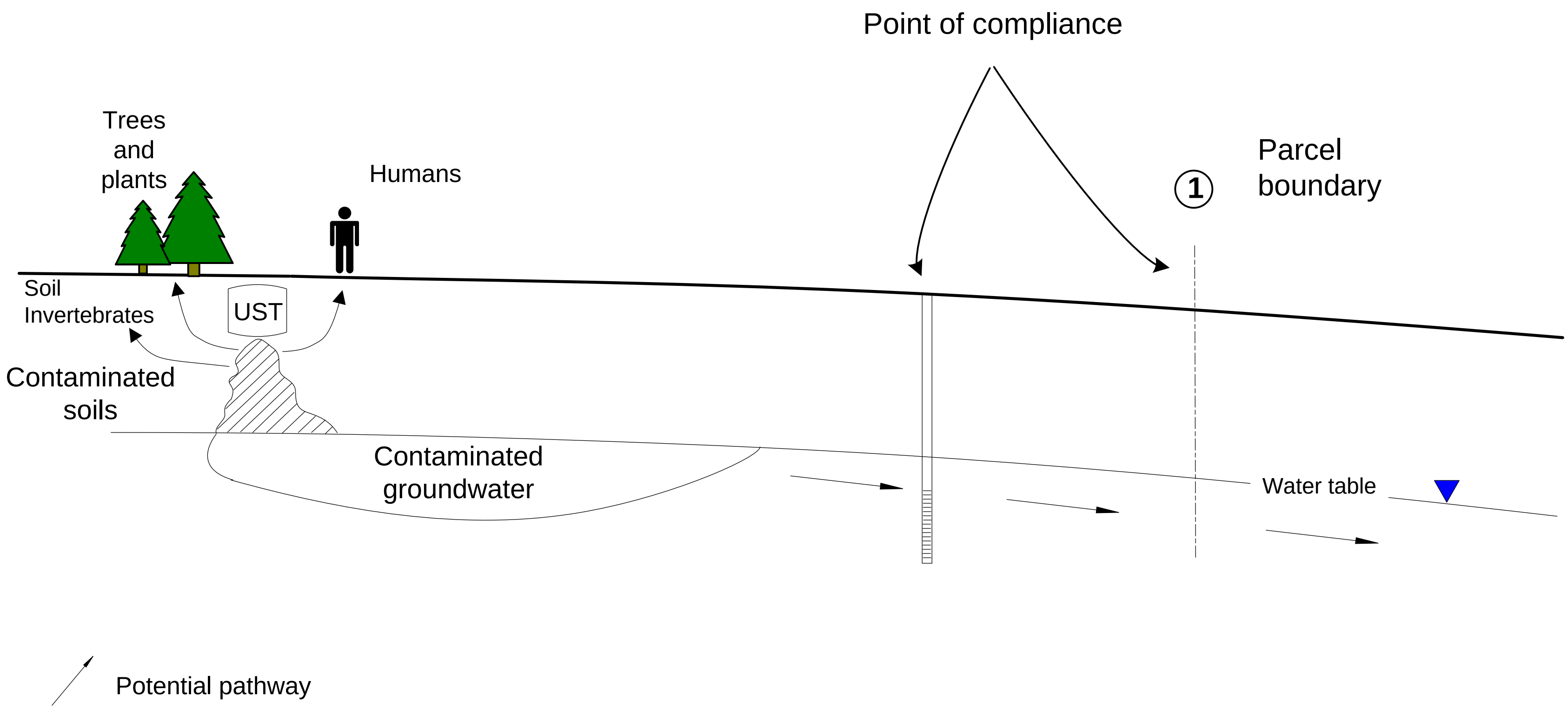


FIGURE 2. Conceptual Site Model (example).



Notes

1. See Section 3.2 for restrictions on screening of drinking water, aquatic life, irrigation, livestock watering and default pathways where contaminated groundwater has migrated beyond the parcel boundary (at sites where DW, AW, IW or LW standards are applicable).

FIGURE 3. Soil Leachate and Groundwater Transport Assessment Flowchart. (Note: This flowchart is provided for illustrative purposes only. The process description in Appendix A take precedence over this flowchart).

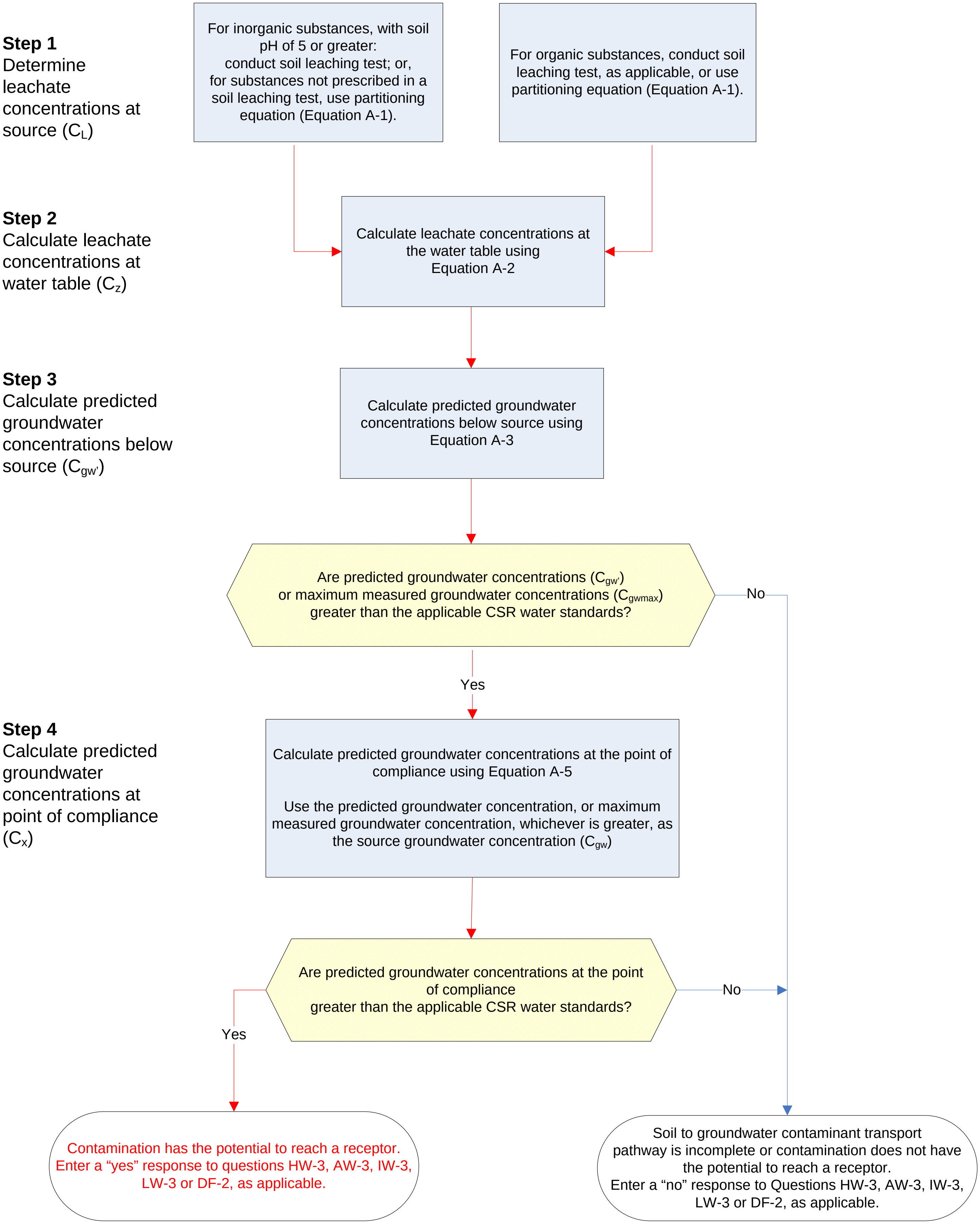


FIGURE 4. Potential Terrestrial Habitat Evaluation Flowchart.
(Note: This flowchart is provided for illustrative purposes only. The definitions and questionnaire in SLRA take precedence over this flowchart).