Phase II Environmental Site Assessment

Directive PNG033

May 2019

Governing Legislation:

Act:	*The Oil and Gas Conservation Act*
Regulation:	*The Oil and Gas Conservation Regulations, 2012*
Order:	127/19

Contents

1. Introduction

The purpose of this Directive is to outline the requirements for a Phase II Environmental Site Assessment and is intended to improve the consistency of reports submitted to the Ministry of Energy and Resources (ER). Information on Phase I Environmental Site Assessment requirements is provided in *Directive PNG016: Acknowledgement of Reclamation Requirements* (Directive PNG016).

This Directive applies to the environmental site assessment process as it relates to spills, incidents and historical contamination resulting from wells, facilities and flowlines as defined in *The Oil and Gas Conservation Regulations, 2012* (OGCR).

This Directive replaces the *Saskatchewan Petroleum Industry/Government Environmental Committee* (SPIGEC) *Guideline No. 4, Saskatchewan Upstream Petroleum Sites Remediation Guidelines* and SPIGEC *Guideline No. 5, Environmental Site Assessment Procedures for Upstream Petroleum Sites*. Users of this document are reminded that the extent of assessment and investigation needed to adequately understand the conditions at a given site should be commensurate with the complexity of the situation.

This Directive incorporates an approach for characterizing impacted sites using tiered endpoints, all of which are intended to be protective of human health and the environment. Assessors have the option to use the endpoint most appropriate for the site as long as compliance with the regulatory requirements is maintained.

Questions concerning the requirements set out in this Directive should be directed to the ER Service Desk at 1-855-219-9373 or email at ER.servicedesk@gov.sk.ca.

2. Abbreviations

BTEX	benzene, toluene, ethylbenzene, xylene
CCME	Canadian Council of Ministers of the Environment
CSA	Canadian Standards Association
EC	Electrical Conductivity
ENV	Saskatchewan Ministry of Environment
ESA	environmental site assessment
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
PHC	petroleum hydrocarbons
QA/QC	quality assurance/quality control
RPD	relative percent difference
SAR	sodium adsorption ratio
SOPC	substance of potential concern

3. Definitions

Administrative Control: As defined in ENV's *Endpoint Selection Standard*.

Acknowledgement of Reclamation (AOR): As defined in Directive PNG016.

Delineation: Means determining the volume (depth and areal extent) of a contamination plume in soil or groundwater.

Endpoint: (Tier 1, 2, or 3) as set out in ENV's *Endpoint Selection Standard.*

Environment: Includes the following:

- Air and the layers of the atmosphere;
- Land, including soil, subsoil, sediments, consolidated surficial deposits and rock;
- Water;
- Organic and inorganic matter and living organisms; and
- Interacting natural systems and ecological and climatic interrelationships that include the components listed above.

Exposure pathway: The route by which a receptor comes into contact with a contaminant.

Facility: As defined in the OGCR.

Flowline: As defined in the OGCR.

Groundwater: Water beneath the ground surface.

Investigation derived waste: Generated during the investigation of contaminated sites. Includes, but is not limited to:

- Soil Cuttings from drilling or hand augering;
- Soils removed via hydrovacuum;
- Drilling mud or water used for mud or water rotary drilling;
- Cleaning fluids such as spent solvents or wash water; and
- Purged water from groundwater monitoring wells.

Potable water aquifer: As defined in ENV's *Endpoint Selection Standard*.

Problem Site: The terminology used to describe sites that present potential or actual risk to the Orphan Fund due to environmental impacts from oil and gas operations.

Receptors: Living plants, animals, or humans that may be exposed to a substance.

Reclamation: As defined in the OGCR.

Remediation: Means decontamination, excavating, removing, sequestrating, encapsulating, immobilizing, attenuating, degrading, processing or treating the contaminants in the soil or

water in a manner so that, in the opinion of the minister, the contaminants no longer pose a threat or risk to human health, public safety, property or the environment.

Site: As defined in the OGCR.

Subsoil: Refers to all soil at depths greater than 1.5 m below ground surface.

Topsoil: Refers to all soil extending from the ground surface to 1.5 m below ground surface.

Well: As defined in the OGCR.

4. Governing Legislation

The requirements in this Directive are authorized under and supplemented by:

- *The Oil and Gas Conservation Act*
- The OGCR
- *Directive PNG031: Site Specific Liability Assessment* (Directive PNG031)

5. Adopted Standards

Standards adopted in this Directive are:

- *CAN/CSA-Z769-00 (R2013) – Phase II Environmental Site Assessment Standard*
- ENV – *Endpoint Selection Standard*
- ENV – *Saskatchewan Environmental Quality Guidelines* (SEQG)

These standards establish uniform specifications, procedures, criteria, methods, processes or practices and represent a minimum acceptable benchmark developed from widely accepted and proven principles, practices or guidelines for an ESA.

Criteria in the SEQG are to be used for comparing conditions at sites assessed under this Directive for all SOPCs with exception of soil salinity and sodicity. Soil remediation criteria for salinity and sodicity provided in Appendix 1 have been adapted from the former SPIGEC *Guideline No. 4, Saskatchewan Upstream Petroleum Sites Remediation Guidelines*. Environmental quality guidelines from other jurisdictions may be used in situations where SOPCs are not included in the SEQG.

6. Phase II Environmental Site Assessment Process

ESA is the process of evaluating the environmental condition of a site and includes:

- verification of the presence of contamination;
- identification of specific contaminants;
- understanding the effect and distribution of the contaminants in environmental media; and
- identifying risks contaminants may pose to ecological and human receptors.

The ESA process is often based on a phased approach that builds on lines of evidence developed in previous phases. The first step is to complete a Phase I ESA which consists of a non-intrusive

investigation that is intended to identify: actual and potential contamination; the types of contaminants; and area(s) of potential environmental concern at the site that may need to be investigated further. Actual and potential contamination identified in a Phase I ESA must be evaluated, characterized, and quantified through a Phase II ESA(s) that meets or exceeds CSA Z769-00. A Phase II ESA is an intrusive investigation, including physical testing and sampling of environmental media that is intended to confirm or deny the presence of SOPCs and to determine their spatial distribution. If existing ESA work does not meet these standards, assessors must conduct additional investigation or identify and evaluate the deficiency(ies).

The ESA process may begin and end with a Phase I ESA. However, the precept of source-pathway-receptor analysis is often based on a developmental process that may have to be done in several stages to gain an adequate understanding of the site, and provide the necessary lines of evidence to make informed remediation/risk management decisions. ESA reports should be designed to show the interrelation between contaminant sources (if present), pathways and receptors on a contaminated site (Rowe, 2001).

Viewing the ESA process in this way is an essential part of systematic planning and will:

- provide a better understanding of all potential sources, pathways and receptors in the impacted area;
- support the selection of sampling locations and establishing background concentrations;
- identify data gaps and uncertainties that can be addressed by sampling; and
- serve as a tool for summarizing and communicating the environmental state of the site.

The level of assessment and investigation needed to adequately understand the conditions at a given site depend on the complexity of the situation. The complexity of site-specific conditions will also dictate the number and depth of boreholes and the potential need for groundwater monitoring wells.

A Phase II ESA commissioned for an AOR application should be designed for the purpose of investigating the presence or absence of contamination and to compare the site conditions with the applicable criteria and background conditions. Where a Phase II ESA identifies contamination, but is not specific enough to evaluate certain pathways or receptors, it should be assumed that they are applicable at the site.

Phase II ESAs supporting the development of site specific liability assessment and/or site specific risk assessment reports should be designed to fully delineate contamination and assess all exposure pathways. Where contaminant concentrations exceed the applicable endpoints at the property or lease boundary (as determined by a professional land surveyor), delineation should be extended past the lease/property boundary where possible. Site specific liability assessment requirements can be found in Directive PNG031.

When using environmental information from Phase II ESAs for estimating site liabilities, the assessor must ensure that:

- all potential sources of contamination or surface disturbance are investigated according to the specified standards and standard industry practice;
- boundaries of plumes are established to a reasonable degree and the volumes of affected soil and unaffected soil overburden are estimated;

- groundwater impacts are appropriately quantified and, where possible temporal trends are determined; and
- contaminant issues are sufficiently quantified and characterized to permit development of remediation plans.

ER and the licensee may reserve the right to re-evaluate sites when new information becomes available, or if site activities or circumstances change whereby:

- changes in the concentration or extent of impacts are identified;
- changes in migration and exposure pathways or receptors are identified; and/or
- changes in site conditions are identified that may change the level of risk to the environment.

7. Phase II Environmental Site Assessment Requirements

The following sections outline requirements and provide guidance for Phase II ESAs to be submitted to ER.

7.1 Third Party Professional Qualifications

Third party professionals must be certified in their respective profession and familiar with applicable federal, provincial and municipal legislation and published guidelines and directives used to evaluate the presence of contamination on a property and to develop reclamation plans.

For the purposes of certifying the work and analysis carried out in the preparation of a Phase II ESA, the following qualifications are considered acceptable:

- licensed to engage in the practice of professional engineering/geoscience in Saskatchewan pursuant to *The Engineering and Geoscience Professions Act*;
- licensed to practice agrology in Saskatchewan pursuant to *The Agrologists Act*;
- licensed to practice as a biologist or chemist by professions legislation of a Canadian province or territory;
- licensed to practice as a forester or forest technologist in Saskatchewan pursuant to *The Forestry Professions Act;*
- certified as an applied science technologist in Saskatchewan, with 5 years of direct experience in ESAs pursuant to *The Saskatchewan Applied Science Technologist and Technicians Act;*
- designated by the minister.

7.2 Scope

In addition to confirming or denying the presence of contamination, the Phase II ESA should be designed to delineate contamination and evaluate the migration potential and exposure possibilities (where applicable). To this end, the following information should be considered:

- an overview of historical, current and planned future land uses;
- detailed description of the site and its physical setting to form hypotheses about the release and ultimate fate of contamination;
- information on climate and meteorological conditions that may influence contamination distribution and migration;
- soil texture;
- groundwater presence/absence or characterization;
- sources of contamination at the site and the media that may be affected;
- the distribution of chemicals within each medium, including information on the concentration;
- proximity of contamination to human and ecological receptors;
- how contaminants may be migrating from the sources, the media and pathways through which migration and exposure of potential human or environmental receptors could occur, and information needed to interpret contaminant migration (soil properties, geology, hydrogeology, hydrology and possible preferential pathways);
- where relevant, information pertinent to soil vapor intrusion into buildings, including construction features of buildings;
- presence of conditions warranting a Tier 2 approach as described in the ENV *Endpoint Selection Standard*; and
- presence of conditions requiring a Tier 3 approach as described in the ENV *Endpoint Selection Standard*.

7.3 General Records

Every person required to conduct an ESA must ensure records are kept and retained for at least seven years from the date the record was created.

7.4 Field Methodologies and Investigation Tools

All field sampling methodologies including field screening, borehole drilling, monitoring well construction, trenching and other activities used for soil, surface water, groundwater and sediment sampling must be identified.

7.5 Sampling Rationale and Design

Sampling plans should be tailored to accommodate specific objectives of the Phase II ESA and the site conditions to be investigated. Clear rationale must be provided for the media, and sampling locations. The location (and depth), number of samples, and suite of chemical analyses will depend upon site characteristics and must be sufficient to identify impacted areas and define the distribution of contaminants.

At a minimum, soil sampling and analysis must be included in the Phase II ESA. When SOPCs have entered, or are expected to enter groundwater a groundwater assessment should be conducted. In many cases where soil contamination exceeds Tier 1, 2 or 3 SEQG, the sampling and analysis of groundwater, as well as surface water and sediment if applicable may also be conducted if contaminant migration from soil to these media cannot be clearly excluded.

An adequately designed sampling plan will, at minimum contain the following:

- Sampling objectives;
- Justification for the proposed sampling strategy;
- Detail of investigative methods to be used (e.g. hand auger, boreholes, test pits);
- Consideration of ongoing monitoring locations (groundwater and/or gas monitoring);
- Location (survey site map, depth and frequency of sampling). An accurate site map should be used;
- Precautions to protect the environment, prevent cross contamination and prevent the creation of new adverse effects; and
- Health and safety considerations for the protection of assessors.

Table 1 provides guidance for determining the appropriate chemical parameters that should be tested for at upstream petroleum sites.

Table 1: SOPC at Upstream Petroleum Sites

Parameters		pH, EC, SAR	PHCs F1 – F4	BTEX	PCBs	Alcohols	Trace Metals	PAHs
Well Sites	**Well Head**	O	O	O				
	Storage Tank and Area	O	O	O				
	Flare Pit	O	O	O	▲			▲
	Emergency Earthen Pit (Brine)	O	▲	▲				
	Pits of Unknown Origin	O	O	O	O		O	
Batteries, Compressors, Treatment and Processing Facilities	**Flowline**	O	O	O				
	Gas Flowline	▲	O	O	▲			
	Blow Down Tank & Area	O	▲	▲	▲			
	Metering Equipment		▲	▲			Hg	
	Pig Trap (Flowline)	O	O	O				
	Treater and Separator	O	O	O				
	Dehydrator	▲	O	O		O		
	Salt Water Storage Tank	O	▲	▲				
	Crude Oil Storage Tank	O	O	O				
	Other Storage Tank	O	O	O	▲			
	Tankfarm Area	O	O	O				
	Refined Product Storage		O	O	▲	▲	O	
	Ecology Pit	O	O					
	Desand Tank	O	O	▲				
	Flare Knock Out Tank	O	O	O		▲	O	
	Flare Line	O	O	O				
	Flare Pit	O	O	O	▲		O	O
	Emergency Earthen Pit (Brine)	O	▲	▲				
	Pits of Unknown Origin	O	O	O	O	▲	O	
	Saltwater	O						
Spills	**Crude Oil**	▲	O	O				
	Emulsion	O	O	O				
	Condensate	▲	O	O				
	Refined Product(s)	▲	O	O	▲	▲	▲	

O - there is a very strong potential that the parameter is present and it should be tested

▲ - parameter should be tested only if evidence exits or it is strongly suspected, for example during pit excavation if electrical capacitors are found in the pit then PCB analysis must be carried out

Hg - means test for mercury if evidence exists or it is strongly suspected

7.6 Sampling and Analysis

The integrity of environmental samples relies on the sampler's use of sound sample collection techniques and equipment as well as accredited laboratory methods for analysis. The nature of the SOPCs, the equipment used to collect the samples, the use of substance-appropriate preservation methods and the sampling techniques of the sampler are all factors that affect the quality and reliability of sample results. Assessors are encouraged to consult with an accredited laboratory to ensure that substance-specific field protocols are used.

The volatile fractions of hydrocarbons in PHC impacted soils are subject to a substantial decrease in concentration during sample collection. In some cases, samples collected and capped can lose between 70 to 90 per cent of the volatile fractions F1 and BTEX within 5 days of sampling (Curran, 2005). When collecting environmental samples for PHC volatile fractions analysis, the assessor must collect, preserve, store and handle samples in accordance with a method approved by a standards-setting organization.

Methanol extraction in soil for PHC volatile fractions is a sampling requirement. For further information on sampling for PHC volatile fractions analysis, refer to: *Guidance for Environmental Site Characterizations in Support of Environmental and Human Health Risk Assessment* (CCME, 2016).

7.7 Groundwater Monitoring Wells

Where groundwater impacts are known or suspected, monitoring wells should be installed and used to characterize conditions. Groundwater monitoring wells can be used to (ENV, 2015):

- determine the predominant direction of groundwater flow;
- quantify the physical and transport properties of the soils and contaminants (e.g. hydraulic conductivity, dispersion coefficient); and
- monitor the concentration of contaminants in groundwater.

Monitoring well locations should be chosen to facilitate effective monitoring and evaluation of groundwater conditions at the site. The following principles are considerations for the best placement of monitoring well locations (ENV, 2015):

- a minimum of three monitoring wells are required to approximate groundwater flow direction;
- a minimum of one well should be placed up-gradient to establish background water quality conditions;
- where a contaminant plume exists, a sufficient number of wells must be installed to delineate the plume boundaries;
- sufficient number of wells should be placed to monitor down-gradient transport;
- where vertical migration is a concern, an evaluation of vertical hydraulic gradient and transport properties should be conducted; and
- monitor well installation must avoid creating a conduit for contamination migration between multiple water-bearing strata. This includes both saturated and unsaturated soil strata.

A discussion of monitoring well design considerations must be included where groundwater investigations are conducted. To justify the number and location of groundwater monitoring wells, a systematic method similar to that used for soil sample collection may be used (CCME, 1993).

For further information, refer to *Standard Practice for Design and Installation of Groundwater Monitoring Wells* (ASTM, 2010), *Standard Guide for Sampling Groundwater Monitoring Wells* (ASTM, 2013) and *Design and Installation of Monitoring Wells* (USEPA, 2008).

7.8 Establishing Background Conditions

The remediation criteria are to be applied within the context of the intended land use following remediation. The specific contaminant must be within or less than the specified range of the criteria. If the remediation criteria are lower than the background levels (levels in similar soil series that has not been impacted by upstream petroleum activities), then the background levels must be considered as the primary remediation criteria. Background criteria may not need to be established if remediation is intended to meet Tier 1 criteria and/or the soil salinity and sodicity criteria for unconditional use (Appendix 1).

To gain a good understanding of background conditions at a site, it is necessary to take a sufficient number of representative samples from soils with similar characteristics to the affected site but which are taken from outside the area affected by contamination. For the purpose of this Directive, background means locations that have not been influenced by discharges or activities from the site under investigation and represent the baseline conditions for the area in question. Background samples are often necessary to provide a baseline for comparison of site data; and they are used to demonstrate whether the site conditions are truly different from the baseline condition.

Background samples should be collected (ENV, 2015):

- prior to impacted site samples to avoid cross contamination from the sampling site;
- under similar ambient conditions as the environmental test samples; and
- from each stratum (or soil-type variation within a strata), that correlates to the strata in which impacts occur. For example, if multiple soil types or soil horizons correlate to the zone where impacts are identified, then each should have a background established separately.

Additional considerations:

- background sample locations should not have any anthropogenic impacts;
- sample locations should be upstream; and
- up-gradient or cross-gradient of groundwater flow (if possible).

Following the above recommendation will help normalize effects such as matrix interference on analysis and impart an acceptable degree of certainty to the analyses (CCME, 1993). It is preferable to select background sampling location(s) near the impacted site under investigation. The close proximity will improve similarity between the sites. However, when a suitable local background sampling location is not available a regional site can be used for background sample collection. In the latter case, background samples from other investigations in the region may

be used if similarities exist between the media being tested, but site-specific background samples are preferable (ENV, 2015).

An appropriate number of samples must be collect to effectively establish background conditions. More samples may be needed due to natural constituent occurrences and inherent variability within each distinctive soil horizon. Based on the SOPC, potential mobility and soil type, an estimate of contamination depth should be made and background samples taken at comparable depths for the particular soil type. The background concentration can be taken as the upper 95th confidence limit for the samples obtained, assuming a lognormal distribution (ENV, 2015).

7.9 Laboratory Analysis

Sample collection, preservation, and other handling practices should be described and appropriate techniques must be used in order to minimize any changes to sample composition or concentration prior to analysis.

The handling and analysis of samples must be done in accordance with standard chain-of-custody procedures to ensure that the samples are properly handled, shipped and analyzed for the appropriate parameters; received by the laboratory; and analyzed within the prescribed holding times.

Samples submitted for laboratory analysis must be analyzed by a laboratory accredited pursuant to the requirements of the Canadian Association for Laboratory Accreditation.

7.10 Quality Assurance/Quality Control

Quality assurance (QA) consists of measures or checks that are put in place to confirm that the quality control (QC) activities are effective. A QA/QC program is described as the overall "management system" that ensures defined standards of quality are met within a stated level of confidence. QC consists of the day-to-day activities (in the field or laboratory) used to control the quality of the product or service so that the needs of the users are met.

Effective QA/QC principles and practices should be used throughout the major stages of the Phase II ESA and should address all aspects of the project, including:

- Project management responsibilities and resources;
- Data quality objectives;
- Sampling and analysis plans;
- Data collection protocols;
- Data quality control plans;
- Data assessment procedures and requirements; and
- Project quality output.

A QA/QC program should be developed to commensurate with the scope of ESA and site conditions.

A high quality sampling program benefits from the use of field-duplicate samples. Field duplicates are collected and submitted to assess the potential for laboratory data inconsistency and the adequacy of the sampling and handling procedures.

The results of the duplicate sampling may be used to assess the adequacy of the field sampling, the heterogeneity of the sample matrix and the laboratory analytical precision.

Precision is a QC measure that can be evaluated using duplicate environmental samples. It can be applied to field duplicates to assess the consistency of samples collected in the field, or to laboratory duplicates to assess the precision of the laboratory analysis. The Relative Percent Difference (RPD) should be assessed with the characteristics of the analytical method and instrumentation used to determine laboratory concentrations, that is, with respect to the method detection limit (MDL) for the specific substance of concern (ENV, 2015).

When evaluating sample duplicates precision may be considered poor if RPD values are outside of a reasonable range, even with sample heterogeneity considered. Various values are proposed in literature for acceptable values of RPD. Some reference manuals designate analyte specific values for acceptable RPD. It is possible to establish a program specific value of RPD by collecting a sufficient number of duplicate samples, and each laboratory will have its own RPD acceptability values. As a general rule, RPD values of less than 20 per cent indicate good correlation where the concentrations are greater than five times the MDL. Data yielding RPD values greater than 20 per cent should be viewed with caution and RPD values of 50 per cent indicate a lack of sample representativeness (ENV, 2015).

7.11 Data Validation and Interpretation

All findings, including nil findings, resulting from the investigations performed must be included in the report. The report must also include the sampling dates.

The assessor must interpret the data in a clear and logical manner. Data must be compared to the applicable guidelines and/or background conditions. Contaminant concentrations exceeding Tier 1, Tier 2 or background conditions must be highlighted and discussed. Data should be presented both in tabular format and on detailed site plans, photo mosaic, or aerial photographs at 1:5,000 scale or finer resolution, if available. The report must include a discussion on the QA/QC procedures and identify and discuss any anomalies in the data.

Hydrogeological reporting (where applicable) must include a discussion and interpretation of the hydrogeological site setting, including a description of local aquifers, local groundwater flow direction (vertical and horizontal) gradient, velocity and groundwater quality. The potential for off-site contaminant migration through any pathway must be assessed and discussed.

In some cases, sampling and/or laboratory analyses of samples may indicate other impacts from potential off-site contaminants originating from a site other than the one under investigation. In these situations, the extent of possible off-site impacts must be identified and described in the Phase II ESA report, and the report must clearly identify how the potential off-site source is shown to be distinct from sources on site. Where evidence does not clearly show the site

impacts are distinct from an off-site impact, the report can only identify the possibility of an off-site source.

7.12 Existing and Potential Uses of Ground and Surface Water

The Phase II ESA must document potential uses of groundwater and surface water, including their general locations. The distance beyond which water uses are not significant or relevant depends on site specific conditions but typically water uses within 300 m of the site must be identified. If the direction of groundwater flow has been reliably determined by site specific groundwater monitoring, documentation of water uses can be limited to 100 m up gradient and 300 m down gradient to the site. Flood risk areas should be taken into account when considering distance to surface water receptors if the site will not be remediated to Tier 1 criteria.

The absence of existing potable water wells is not sufficient by itself to justify the elimination of the potable water aquifer pathway, as potential future groundwater use must always be considered.

7.13 Investigation Derived Waste

Investigation derived waste stored onsite should not pose additional risks and will be addressed at the time of site remediation.

7.14 Sealing Abandoned Monitoring Wells and Boreholes

Best management practices should be followed when sealing abandoned monitoring wells and boreholes. For example, sealing water-bearing intervals when abandoning a borehole or monitoring well with bentonite grout.

For more information on Monitoring Well abandonment, refer to *Monitoring Well Decommissioning Model* (Environment Canada, 2002) and *Design and Installation of Monitoring Wells* (USEPA, 2008).

8. Phase II Environmental Site Assessment Report Format

The level of assessment will vary depending on the complexity of the site but the report should describe all aspects of the Phase II ESA program. Table 2 summarizes the format and content preferred by ER.

Table 2: Contents to Include in the Phase II ESA Report

Section	Content
Title Page	• Identify report type • Well/facility licence number, UWI, and land location • Company contact information
Executive Summary	• Provide an overview of the report, key findings, and conclusions
Introduction	• Provide background information • Reference any regulatory requirements or directives given by ER • Describe regional and local site characteristics, including a description of historical, current and anticipated land-users, a description of current and historical infrastructure, topography, preliminary site geology and hydrogeology • Provide a detailed site plan, photo mosaic, and/or aerial photograph indicating major facility areas including flare pits, holding tanks, well head, relevant surface features, etc. • Describe objectives and scope of work
Methodology	• Provide the basis for choosing the applicable soil and groundwater (where applicable) remediation standards • Describe all field methods employed including: equipment used, methods of sample collection, field screening techniques, sampling method and analytical suite for each sampling location • Provide rational for sampling locations and frequency • Describe quality assurance/quality control protocol followed for sampling and handling soil and groundwater (where applicable) • Include details of any new non-standard method that was employed
Results	• Identify sensitive receptors and pathways for soil and water • Provide information on contaminants discovered at the site, their concentrations and spatial extent, and include a description of potential for, or known, off-site migration of contamination • Provide summary of all findings, including nil findings, resulting from the investigation • Provide sampling dates for all field and analytical results • Present analytical results including: tables with values that exceed guidelines highlighted; scaled figures showing site location, bore hole/monitor well locations, groundwater elevation and flow direction (where applicable), stratigraphy, zones of contamination, etc. • Provide a summary of hydrogeological information and supporting survey information • Provide a detailed site plan showing estimated extents of soil/groundwater contamination where contaminant concentrations are equal to or greater than applicable criteria • Discuss analytical results as compared to applicable criteria, including consideration of the source, pathway, receptor precept • Discuss anomalous data • Discuss laboratory and field QA/QC results, including inconsistencies or anomalies in the data

Conclusions and Recommendations	• Summarize the soil textures encountered • Identify contaminants and conclude whether they are present at concentrations exceeding the applicable criteria • Describe the known physical extent of contaminants that are above applicable guidelines/standards • Provide conclusions on whether impacts have rendered, or have the potential to render groundwater unsuitable for irrigation, livestock water, or for potable consumption • Provide conclusions on whether the contaminants have, or have the potential to affect any other receptors in the vicinity of the site

Certification of Work	• Provide professional third party sign-off, including:
	  • signature(s)
	  • registration/member number(s) or stamp(s)
	  • date of signing

Limitations	• Identify parties authorized to use information in the report • Provide information regarding limitations to liability and disclosure
References and Supporting Documents	• Provide applicable citations for methods used • Provide documentation and key exhibits to support findings and conclusions, including published works and guidelines • Include all borehole logs • Include laboratory data-sheets • Site Photographs

9. References

ASTM International 2010. Standard Practice for Design and Installation of Groundwater Monitoring Wells (D5092 - 16).

CAN/CSA 2013. (Z769-00) Phase II Environmental Site Assessment. Canadian Standards Association (CSA International), Toronto, Ont.

CCME 1993. Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites, Volume 1 Main Report. CCME, Winnipeg, MB, p. 89.

CCME 2016. Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment. Vol. I: PN 1551

Curran, J.C. 2005. Rationale for Preservation of Soil and Sediment Samples for Determination of Volatile Organic Compounds. State of Connecticut Govt., Hartford, CT.

Environment Canada 2002. Monitoring Well Decommissioning Model. National Water Research Institute.

Meridian Environmental Inc. 2008. PN 1398 Canada-Wide Standards for Petroleum Hydrocarbons (PHCs) in Soil: User Guidance. Canadian Council of Ministers of the Environment, Winnipeg.

Rowe, R.K. 2001. Geotechnical and Geoenvironmental Engineering Handbook. Kluwer Academic.

Saskatchewan Ministry of Environment 2015. Guidance Document: Impacted Sites.

USEPA 2013. Design and Installation of Monitoring Wells.

Appendix 1: Salinity and Sodicity Remediation Criteria

Figure 1: Topsoil Salinity and Sodicity Remediation Criteria

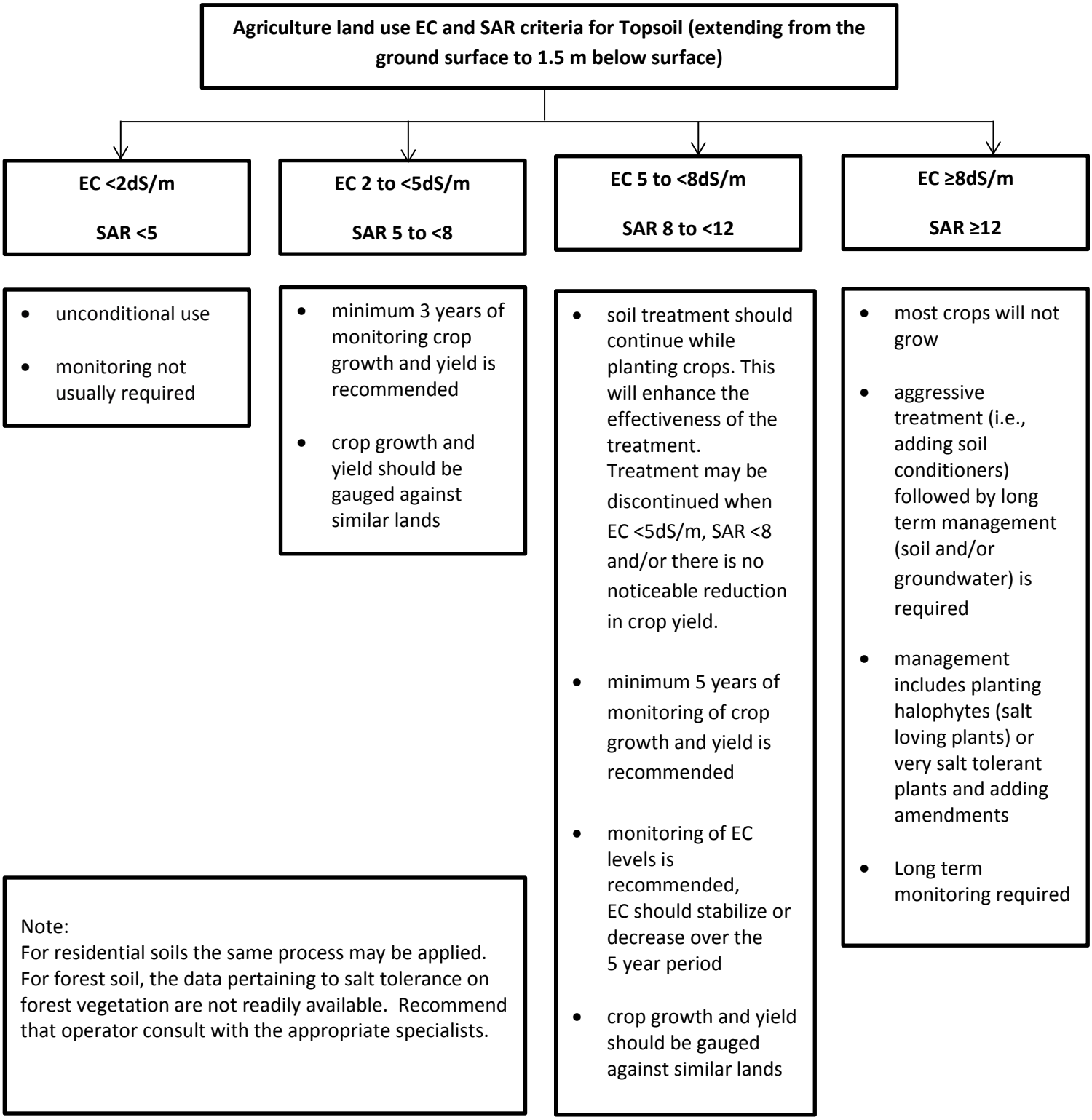
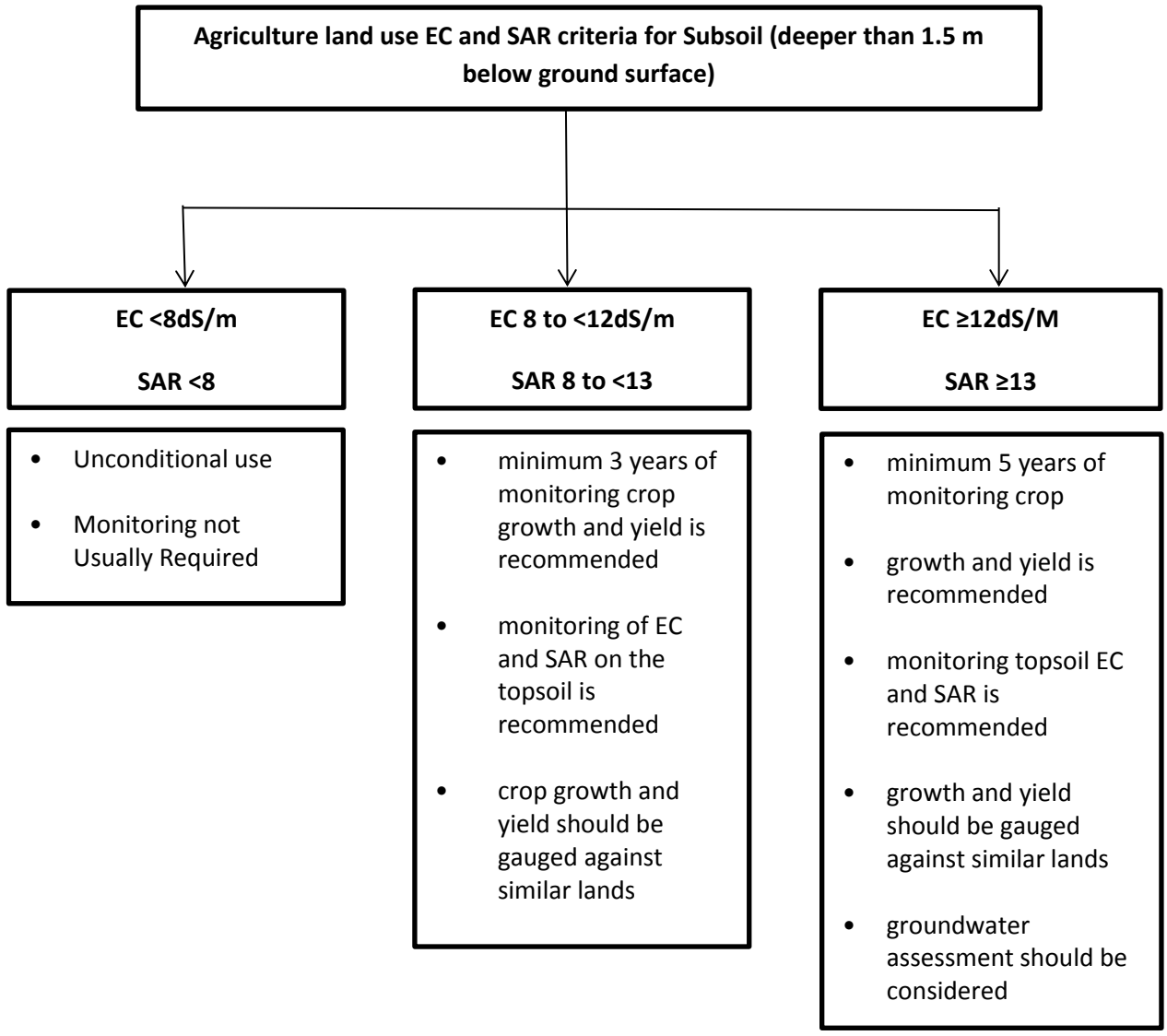


Figure 2: Subsoil Salinity and Sodicity Remediation Criteria



Note:
The remediation goal is to ensure salts do not migrate back up to the topsoil or contaminate groundwater, livestock or irrigation water, or surface water.

Table 3: Saskatchewan Upstream Petroleum Sites Soil Salinity and Sodicity Remediation Criteria Summary

SOIL REMEDATION CRITERIA						
PARAMETERS		Agriculture	Residential	Forest	Subsoil	
pH		6 to 8	6 to 8	4 to 7	6 to 8	
EC (dS/m)	unconditional use	<2	<2	<2	<8	
	moderately tolerant crops	2[A] to <5[A]	2[A] to <5[A]	2[A] to <5[A]	8[A] to <12[A]	≥12[B]
	tolerant crop	5[B] to <8[B]	5[B] to <8[B]	5[B] to <8[B]		
	aggressive treatment required	≥8	≥8	≥8	--	--
SAR	unconditional use	<5	<5	<5	<8	
	moderately tolerant crops	5[A] to <8[A]	5[A] to <8[A]	5[A] to <8[A]	8[A] to <13 [A]	≥13[B]
	tolerant crop	8[B] to <12[B]	8[B] to <12[B]	8[B] to <12[B]		
	aggressive treatment required	≥12	≥12	≥12	--	--

[A] must monitor crop growth and crop yield for a minimum of three years see figure 1 or 2

[B] must monitor crop growth and crop yield for a minimum of five years and for subsoil exceedances a groundwater assessment should be considered see figure 1 or 2