Background levels: Identifying naturally occurring chemical substances

Method and approach

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Contents

[1 Purpose 4](#_Toc110492076)

[1.1 How to use this guide 4](#_Toc110492077)

[1.2 Scope 6](#_Toc110492078)

[1.3 Status 6](#_Toc110492079)

[2 Overview of legislative framework 6](#_Toc110492080)

[3 Site data/information gathering 7](#_Toc110492081)

[3.1 Background reference sites 8](#_Toc110492082)

[3.2 Literature review – Geology and hydrogeology 9](#_Toc110492083)

[3.3 Literature review – Mineralogy 9](#_Toc110492084)

[3.4 Geological mapping 10](#_Toc110492085)

[4 Local Area Review 11](#_Toc110492086)

[4.1 Sampling and analytical data 11](#_Toc110492087)

[4.2 Soil background sampling 12](#_Toc110492088)

[4.3 Groundwater background sampling 13](#_Toc110492089)

[5 Analyse and draw conclusions 14](#_Toc110492090)

[5.1 Multiple lines of evidence 14](#_Toc110492091)

[5.2 Data analysis for soil assessment 15](#_Toc110492092)

[5.3 Data analysis for groundwater assessment 16](#_Toc110492093)

[5.4 Diffuse anthropogenic sources 17](#_Toc110492094)

[6 Case Studies 17](#_Toc110492095)

[6.1 Case study 1 - naturally occurring arsenic 17](#_Toc110492096)

[6.2 Case study 2 – arsenic above naturally occurring levels 17](#_Toc110492097)

[6.3 Case study 3 – natural PAHs 18](#_Toc110492098)

[6.4 Case study 4 – assessing background levels in groundwater 18](#_Toc110492099)

[6.5 Case study 5 – assessing background levels in soil 19](#_Toc110492100)

[7 Further resources 19](#_Toc110492101)

[8 Supporting materials 20](#_Toc110492102)

[9 Glossary of key terms 20](#_Toc110492103)

[10 Acronyms and abbreviations 23](#_Toc110492104)

# Purpose

This guidance sets out a method and approach for identifying background levels for naturally occurring chemical substances on or under the surface of land in the vicinity of the land, as described in Section 36(b) of the Environment Protection Act 2017 (the Act).

The method and approach set out in this guidance is one way that sufficient evidence can be gathered to confirm that a chemical substance is present at naturally occurring background levels.

If a person asserts the presence of chemical substance as naturally occurring in the vicinity of the land but its presence also exhibits qualities that may create a risk of harm, EPA will only accept it as naturally occurring within the meaning of section 36(b) where such an assertion is supported by sufficient evidence. This should be the best available evidence in the circumstances that is relevant and reliable.

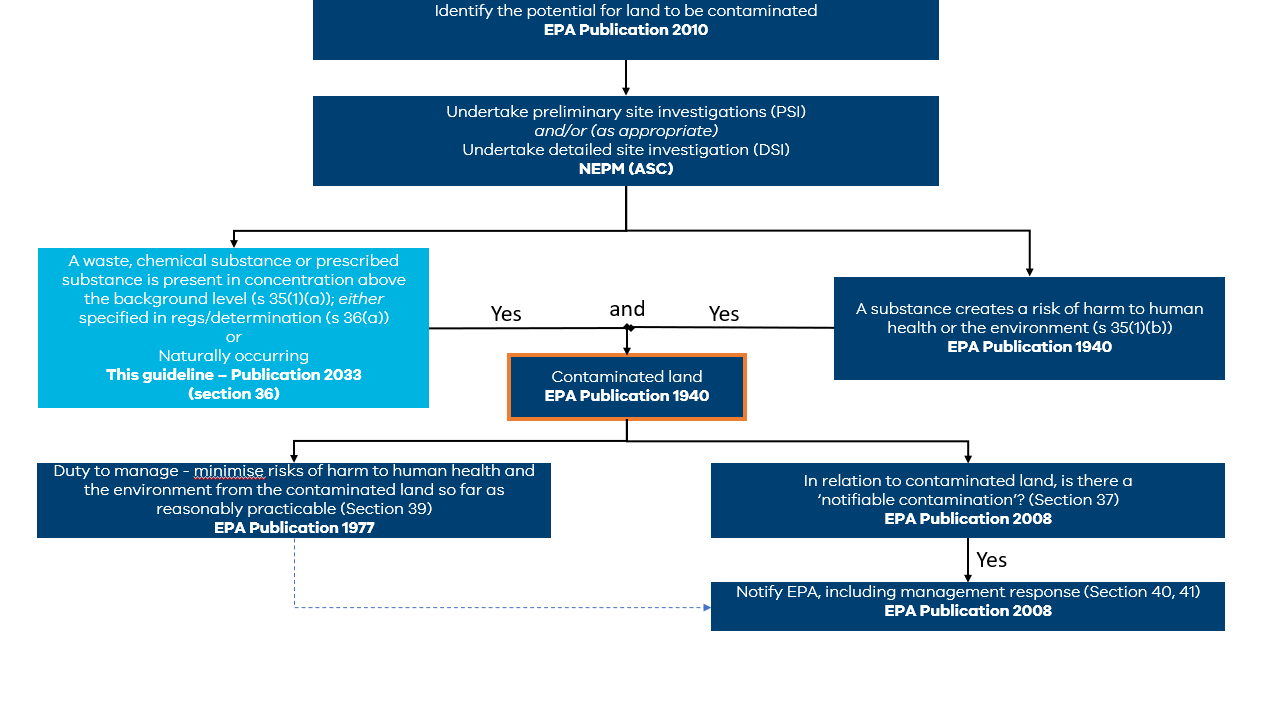
This guidance provides information to people in management or control of land. It also supports contaminated land consultants, EPA-appointed environmental auditors and environmental practitioners who are engaged to advise on land that is potentially contaminated. The guidance is drafted to a technical standard.

People applying the method and approach should have suitable skills, knowledge, and experience in contaminated land assessment. The guidance is applicable when a qualified person has undertaken an assessment or has information that has identified the presence of a chemical substance and now needs to confirm whether it is present at a concentration above the naturally occurring background level.

The guidance is structured as a pathway to help the qualified person understand the nature and extent of the naturally occurring chemical substances for the site being investigated.

## How to use this guide

Figure 1 illustrates where this guidance applies within the contaminated land framework. A background level assessment can help determine whether a site has naturally enriched levels or is contaminated as defined by Section 35 of the Act.



**Figure 1** illustrates where confirming whether a chemical is present above background levels fits within contaminated land assessments.

Understanding the background concentrations of naturally occurring chemical substances at a site provides baseline information about chemical substances that are naturally present and those introduced by anthropogenic contamination sources.

This guidance should be read in conjunction with:

* [*Contaminated land policy*](https://www.epa.vic.gov.au/about-epa/publications/1915) (publication 1915)
* [*Contaminated land: Understanding section 35 of the Environment Protection Act 2017*](https://www.epa.vic.gov.au/about-epa/publications/1940)(publication 1940)

EPA has published guidance on how to [work with consultants](https://www.epa.vic.gov.au/for-business/find-a-topic/environmental-consultants) as part of engaging a qualified person to undertake an assessment.

The method and approach for assessing background levels can be followed to confirm if a chemical substance is present at concentrations either above or below naturally occurring background levels.

The method and approach outlined in this guidance is a multiple-lines-of-evidence approach that involves evaluating and assessing the quality of the data for each line of evidence applicable for the site.

The three steps of the method and approach, outlined in Figure 2, are:

* Step 1: Site data/information gathering
* Step 2: Local area information review
* Step 3: Analyse and draw conclusions from the information using the multiple-lines-of-evidence approach.

**Figure 2** represents the high-level steps of the method and approach to set out where it is reasonable to state that the chemical substance is naturally occurring, and the supporting documentation and results required during the assessment.

The steps are consistent with the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM ASC) and draw on standard practices that environmental consultants and EPA-appointed environmental auditors currently apply when undertaking a site assessment.

## Scope

The method and approach outlined in this guidance sets out a clear and consistent approach to identify whether a chemical substance is present at a naturally occurring concentration in soils and groundwater, or if it has been introduced due to point source contamination or diffuse anthropogenic contamination sources.

The guidance includes links to existing information published by EPA and other bodies that supports identification, assessment, and management of risks of harm from land and groundwater contamination.

The guidance also addresses situations when background level concentrations are site specific and rely on sampling results and statistical analysis for the site being investigated.

This method and approach is not applicable if the qualified person has determined that the concentrations of chemical substances identified are not likely to be naturally occurring, including placement of fill material where the fill is the likely source of the chemical substance. Further details on managing risk of harm are available in [*Contaminated Land: A guide to meeting the duty to manage for those in management or control of land*](https://www.epa.vic.gov.au/about-epa/publications/1977) [(publication 1977](https://www.epa.vic.gov.au/about-epa/publications/1977))

## Status

This guidance forms part of the state of knowledge available to those undertaking background level assessments of naturally occurring chemicals. It relates specifically to the assessment of background levels of naturally occurring chemical substances as per section 36(b) of the Act.

This guidance supersedes [*Proposed methodology for deriving background level concentration when assessing potentially contaminated land*](https://www.epa.vic.gov.au/about-epa/publications/1936) (publication 1936).

EPA may make a determination under regulation 5 of the *Environment Protection Regulations 2021* that sets out the background level (including the manner of deriving the background level) for the purpose of section 36(a). A determination can relate to waste or a type of waste, or a chemical substance or a class of chemical substance and be limited to a specific place or premises or class of place or premises. It can also be of specific or general application. A determination about a background level would take precedence over this guidance.

The method and approach set out in this guidance may also be relevant to whether EPA considers that a person ‘should reasonably have become aware of’ notifiable contamination for the purpose of section 40(3).

The method and approach is a practical and pragmatic means of identifying naturally occurring concentrations that are widespread and common in the environment. However, any such levels derived from the method and approach must also be consistent with the objectives and purposes of the Act.

# Overview of legislative framework

There are three key duties that address contaminated land risks:

1. the general environmental duty (GED) (section 25)
2. the duty to manage contaminated land (section 39)
3. the duty to notify of contaminated land (section 40).

These duties sit within a broader risk management and response scheme under the Act.

Section 35 of the Act defines contaminated land to be land where waste, a chemical substance or a prescribed substance is present on or under the surface of the land, and the waste, chemical substance or prescribed substance:

1. is present in a concentration above the background level; **and**
2. creates a risk of harm to human health or the environment.

In some cases, it may be simpler to first identify whether the measured concentration creates a risk of harm to human health or the environment rather than whether it is exceeding the background level.

Section 36 of the Act provides that the background level of waste, a chemical substance or a prescribed substance in relation to land is:

1. the background level specified in, or determined in accordance with, the regulations or an environment reference standard in relation to the waste, chemical substance or prescribed substance; or
2. if the regulations or an environment reference standard do not specify, or set out how to determine, a background level for the waste, chemical substance or prescribed substance – **the naturally occurring concentration of the waste, chemical substance or prescribed substance on or under the surface of land in the vicinity of the land.**

This guidance relates specifically to the assessment of naturally occurring chemical substance as described in section 36(b).

This guidance is relevant to the duty to manage contaminated land, in particular:

* the identification of any contamination that the person knows or ought reasonably to know of (section 39(2)(a))
* the duty to notify of contaminated land.

The GED applies to all persons engaging in an activity that may give rise to risks of harm to human health or the environment from pollution or waste. If a chemical substance is at a naturally occurring concentration, yet there is a risk of harm to human health or the environment, then the risk of harm may still need to be addressed under the GED. In this situation, even though the land does not meet the definition of contaminated land under section 35, the applicable ecological or health investigation level would inform whether there is a risk of harm.

# Site data/information gathering

The first step in a background assessment is to conduct preliminary site investigation (PSI) and review all available data (that is, a multiple-lines-of-evidence approach) to understand the chemical substances that have the potential to occur on the land. The common approach for assessing background levels of a chemical substance in soil involves reviewing the geological map for the local area and comparing the data to publicly available environmental audit reports or other environmental data sources the consultant may have access to, such as the [Victorian Background Soil Database](https://rmit.figshare.com/articles/online_resource/Soil_Explorer_Victorian_Background_Soil_Database/12356411).

The site data and information gathering should identify characteristics including, as a minimum:

* site location
* geological setting
* historical land uses
* former and current activities at the site.

A chemical substance may be identified during the sampling and analysis stage of a site assessment. The qualified person may not necessarily spend time researching naturally occurring concentrations of all naturally occurring chemical substances at the PSI stage, especially if during the sampling assessment there is no chemical substance concentration result that indicates the need for further assessment.

The qualified person may need to understand naturally occurring concentrations of a chemical substance when they have site results that need to be interpreted. This may not be until most of the way through the detailed site investigation (DSI) stage.

## Background reference sites

A background reference site is an area with the same physical, chemical, geological, and biological characteristics as the site being investigated, but that is free from anthropogenic inputs of the chemical or waste that is the subject of the assessment, so far as reasonably practicable.

Data may already be available for the background site, or samples can be collected for comparison with the samples collected on the site. For some sites it may not be possible to find a non-impacted area on the site being assessed and offsite reference site samples should be obtained.

A background reference site can be applied for land and groundwater and should:

* be located as close as possible to the site being assessed and should have the same geology
* be up-gradient (topographical or hydraulic) of the site to minimise the risk that surface runoff or shallow groundwater flow may have transported contaminated material to the reference site (the location of a reference site could be down-gradient if no pathway is present between the two areas)
* not be impacted by local, diffuse or regional inputs of the chemical substance, with sufficient historical information provided to demonstrate that the reference site has not been affected by land uses carried out during the assessment or any other potentially contaminating activity
* be a site with the same parent material of comparable soil type and textural classification (such as collected using the same sampling equipment and technique as those used to collect samples during the site assessment). This approach is essential in areas where there are high naturally occurring background levels, such as mineralised areas.

It may be appropriate to use a reference site for the collection of soil samples from a comparable soil stratum. If a single, ideal reference site does not exist, it may be necessary to select more than one reference site.

In some scenarios, reference sites may not have the same land use to provide representative background concentrations, as long as potential sources of contamination for the element of concern at the reference site are considered. For example, a residential property could be an applicable background reference site for assessment of nickel concentrations for an industrial property from a similar area/geochemical domain.

## Literature review – Geology and hydrogeology

A literature review of local geology and hydrogeology should aim to provide a greater understanding of the chemical substances that may arise during site assessment that may be attributed to geological formations/processes.

Understanding what chemical substances could be on the land involves undertaking a literature review which should include, but is not limited to:

* current published studies, especially studies focusing on background levels of chemicals in land in Victoria
* environmental audit reports[[1]](#footnote-2) within the local area
* groundwater monitoring reports within the local area
* soil bore data
* geological mapping
* geochemical setting
* mineralogy landforms
* geomorphology data.

The literature review and data analysis may identify a potential reference site that could be used for collection of samples from a comparable groundwater aquifer or soil stratum. Where an appropriate reference site is not available, published data on background metal or metalloid concentrations for the relevant soil unit may be used.

## Literature review – Mineralogy

Mineralogy is the study of the characteristics of minerals, such as their formation, their physical and chemical properties, and their environmental properties. Physical and chemical weathering have the potential to change the availability and potential concentration of a naturally occurring chemical substance. Factors that can influence the weathering process are:

* parent lithology, which dictates the mineralogy
* climate, subdivided into precipitation and temperature
* topography
* age, which controls the length of time exposed to weathering.

[Research by Mikkonen et al. (2018)](https://researchrepository.rmit.edu.au/esploro/outputs/doctoral/Environmental-and-anthropogenic-influences-on-ambient-background-concentrations-of-potentially-toxic-elements-in-soils-of-Victoria-Australia/9921864287801341), suggested that weathering is also a key driver of variability in background concentrations. Results from the Victorian Background Soil Survey indicated that weathering was the predominant driver of variability in natural concentrations of elements within soils overlying Silurian siltstone/sandstone and tertiary sediments and the third most predominant factor in variability in soils overlying basalt.

[Research by Reimann and Caritat, (2017)](https://doi.org/10.1016/j.scitotenv.2016.11.010), focused on the geochemical background variation and threshold values, in particular the focus on weathering and pedogenesis may provide different compositions in different soil horizons. The study noted that exploration geochemistry is most often based on the detection of naturally high concentrations derived from the existence of mineral deposits in an area. Even unmineralised rock types can cause enriched natural concentrations. The study outlined that there may be instances where the difference between geogenic and anthropogenic chemical substance derivation is important, for example, industrial or brownfield sites and mining areas that are commissioned for shutdown. In these cases, the chemical substance concentration for the area undergoing restoration requires remediation or cleanup prior to the duty holder leaving the site. An assessment of the readily defined source of the high element concentrations exists and the spatial scale of contamination may be established by geochemical mapping.

## Geological mapping

Victoria's geology can be divided into three major episodes:

* Neoproterozoic to Early Carboniferous
* Late Carboniferous to Mid-Mesozoic
* Mid-Mesozoic to the present day.

Earth Resources has [more information about Victoria’s geology](https://earthresources.vic.gov.au/geology-exploration/maps-reports-data).

Geology is inherently variable in its make-up, and this can make the process of assessing naturally occurring levels quite complex. Chemical substances have the potential to occur naturally at high concentrations, which is, by definition, not contamination.[[2]](#footnote-3) These chemical substances are commonly mineralogical based, such as metals and metalloids, and are generally associated with soils and groundwater. For example, geology-hosting lead gossans will have naturally occurring high levels of lead and other sulfide-based elements and would not be regarded as lead contamination.

[The RMIT background soil database](https://rmit.figshare.com/articles/online_resource/Soil_Explorer_Victorian_Background_Soil_Database/12356411) could be used to understand the background concentrations of particular metals.

The concentrations of naturally occurring chemical substances are dependent on and/or influenced by:

* topography
* parent material of the soil
* geography
* physical, biological and chemical properties in the natural environment.

# Local Area Review

Step 2 is to review available reports, sampling results and local studies on background chemicals undertaken in the area, and identify data gaps, addressing these gaps where possible.

The use of environmental audits/site assessments completed for surrounding sites (where available) is beneficial for the comparison of soil type data and chemical substance concentrations. Ideally, data should only be adopted from sources that are from the same or similar study area including soil horizon, sampling method and approach, spatial distribution, and analytical method.

Comparing site environmental sampling data with that from an up-gradient location is the standard approach for assessing naturally occurring levels of a chemical substance in groundwater. It is noted that the up-gradient location cannot be influenced by activities that cause material change of background level.

This is a simple approach that can only be achieved if local or regional environmental audit reports are readily available, and sufficient data is available to allow a robust conclusion to be made based on the professional judgement of the assessor. Care must be taken to ensure that the data adopted from an environmental audit is relevant to assessing background levels, as most soil bores and groundwater wells installed at audit sites will be targeting contamination.

## Sampling and analytical data

Sampling should be undertaken in accordance with the NEPM ASC for design, sampling depth and frequency where insufficient soil data is available to characterise the chemical substance

The collection of background samples is usually necessary if:

* the literature review is inadequate to identify concentrations of naturally occurring chemical substances
* the site contains contaminated soil
* historical data is unavailable or insufficient
* the substance of interest is widely spread over the site.

Soil or groundwater sampling may be required if there are no readily available reference sampling results. *Schedule B2 – Guideline on Site Characterisation* of the NEPM (ASC) can be used as a guide to conduct a site investigation where sampling is required.

Site sampling objectives and locations are site-specific so this guidance is not a prescriptive sampling design. The location and number of background samples depends on the chemical substance(s) of interest at the site and their expected concentrations, and may also be influenced by:

* availability and quality of existing information and analytical data
* site hypotheses to be tested
* media variability
* size of the site, number and type of sources
* pathway-specific considerations such as geologic formations, types of surface water bodies
* other potential sources of contamination in the vicinity of the site.

One approach is to determine where potential alternative sources of contamination exist and where they could possibly interfere with naturally occurring chemical substance samples, and therefore may not be considered background samples. For example, industrial areas are typically affected by increased levels of contaminants and greater local variability, so additional background samples may be required to establish offsite conditions. The sampling design should incorporate the collection of sufficient samples between the site and all other potential sources of contamination to attribute the increase to the site.

An integrated sampling strategy should be considered when determining naturally occurring concentrations. This will need to be site-specific. For example, sampling the bedrock itself or sampling subsurface soils, that is > 30 cm in undisturbed areas.

Robust background analytical data must consider the consistency and comparability in the elements of the background samples with site data, especially background samples collected specifically for the study and data gathered from published sources. Site and background samples should be collected and analysed in the same way and according to relevant standards and guidance.

## Soil background sampling

When undertaking soil sampling, the sampling strategy should be based on accurate and reliable site-specific information.

When seeking to measure naturally occurring concentrations, soil samples should be collected from areas that:

* have the same soil type and geology (parent material)
* have similar physical, chemical, geological, and biological characteristics/properties
* are likely to be free from the influence of nearby point sources (including legacy ones)
* are visually free from anthropogenic disturbance
* are unlikely to be significantly impacted by ambient or diffuse influences (for example roadside soils).

Where possible, samples should also be collected from the same soil horizon layer (and depth) using the same sampling technique. Particular care should be taken when collecting surface samples as they may have different parent material compared to subsurface samples due to aeolian, alluvial and soil formation processes (Mikkonen, 2018).

Where suitable sampling locations cannot be identified, it may not be possible to measure naturally occurring concentrations because the absence of anthropogenic influences will be difficult to substantiate. In this situation, a qualified person would assess whether a risk of harm is created rather than undertake further assessment of naturally occurring concentrations.

Examples of indicators that can be used to demonstrate that measured concentrations reflect naturally occurring concentrations include statistical approaches, geochemical indices and calculation of enrichment factors.

Where a statistical appraisal of sampling results indicates measured concentrations are not consistent with those encountered on the site, a qualified person would assess whether a risk of harm is created rather than undertake further assessment of naturally occurring concentrations.

## Groundwater background sampling

When selecting data against which to compare site groundwater conditions, it is important to ensure that the data selected is from a groundwater system that is the same, or comparable, to that below the site itself. *Hydrogeological assessment (groundwater quality) guidelines*  [(publication 668](https://www.epa.vic.gov.au/about-epa/publications/668)) provides guidance on how to assess hydrogeological conditions.

To adopt groundwater data (whether from offsite or onsite) as being background, it will need to be demonstrated that the data is relevant to the groundwater system below the site. The information required for this may include:

* A description of the current and historical site uses/surrounding uses near the data source (for example, up-hydraulic gradient of the data source) to show that groundwater would not be impacted by activities on the site, or by the same activities as undertaken near the site (see also Section 5 for details on reference sites).
* A description of the geology and hydrogeology for the data source to show that the hydrogeology is the same as that for the site.
* Information regarding the groundwater quality parameters (for example, electrical conductivity (and TDS), pH, dissolved oxygen, redox, temperature) from the data source (this may include major anion and cation data where practicable) to enable discussion on the potential geochemical differences in the groundwater and to account for potential dilution effects.
* Site plans and conceptual models of surface water systems and groundwater to facilitate an understanding of the overall system and interactions that are subject to assessment.

The number of groundwater samples (including frequency of sampling) and locations required will depend on the site being assessed and the quality of the supporting data (and lines of evidence) able to be obtained. For example, a single bore, monitored quarterly over a single year may provide sufficient information to be confident that the background levels are understood. Nevertheless, longer periods of baseline monitoring may be required to assess natural variability as groundwater typically moves slower than surface water meaning that it takes longer for groundwater to show changes at a specific location. If there is seasonal variation and low velocity of groundwater flow then a longer sampling duration is likely to be appropriate if the person in management or control of land is seeking to assert that the chemical is present at naturally occurring levels. The sampling design is tailored to the site being assessed.

Background groundwater locations for site assessments tend to be positioned up-hydraulic gradient of the site but may also be positioned laterally (sideways with respect to the groundwater flow direction), or even down-hydraulic gradient from the site, noting that it may be difficult to satisfactorily demonstrate that groundwater down-gradient of the site is not actually impacted by the site itself. The key aspect is demonstrating that the background groundwater location has not been impacted by contamination the same as, or similar to the site.

In many environments it will not be possible to report natural background in groundwater, as up-gradient wells will also be impacted, representing baseline rather than background conditions. In this situation a background assessment is not applicable, and the assessor would typically go straight to risk assessment of harm (which will likely take into consideration baseline conditions).

# Analyse and draw conclusions

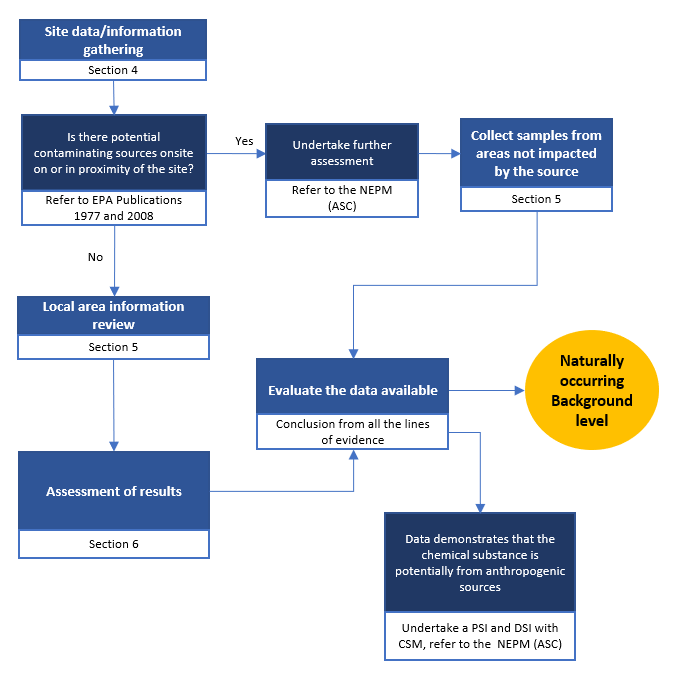
## Multiple lines of evidence

A multiple-lines-of-evidence approach involves using many and diverse sources of information which converge to support and justify the conclusions. It is regularly used in the assessment of site contamination. Multiple lines of evidence should be considered wherever possible.

Multiple lines of evidence can be undertaken in accordance with the ANZG 2018, ‘Weight of evidence’ type of assessment, which describes the process of collecting, analysing, and evaluating a combination of different qualitative, semi-quantitative or quantitative lines of evidence to make an overall assessment of the naturally occurring chemical substance or contamination. Applying a weight-of-evidence process incorporates judgements about the quality, quantity, relevance, and similarity of the data contained in the different lines of evidence.

Applying this approach enables a robust and scientifically supportable understanding of the nature and extent of the chemical substance(s) associated with a site and whether they are present at concentrations above the background level. The approach of comparing background levels to site data can be scaled according to the availability of data (both site and background).

Figure 3 indicates the various lines of evidence that may be used for understanding whether the concentration of a chemical substance(s) is naturally occurring. This diagram outlines the decisions required, and associated reference boxes, for the method and approach to be adopted when assessing whether the concentrations of a chemical substance are naturally occurring.



**Figure 3.** The flow chart represents multiple lines of evidence that can be applied to identifying whether the chemical substance located at the site is naturally occurring.

## Data analysis for soil assessment

Schedule B2 of the NEPM (ASC) states that the data quality should be evaluated prior to carrying out any processing or statistical analysis of the data set. This schedule provides further details on data and statistical analysis that should be considered when undertaking an assessment.

Chapter 4 of the *Guidance for comparing background and chemical concentrations in soil for CERCLA Sites* (US EPA, 2002) provides guidance for preliminary data analysis using graphs and distributions of the data.

The data analysis may depend on the:

* quality of existing site and background data
* quantitative analysis used to establish background concentration, which may involve a combination of comparative statistical analysis and graphical methods.

The preliminary data analysis is an integral part of choosing the methods for making statistically valid comparisons of site and background concentrations.

When comparing background data for a site they may be divided into several major categories, which may include:

* data ranking and plotting
* descriptive summaries
* simple comparisons
* parametric tests
* nonparametric tests.

Various graphical methods may be used to represent the background data, including histogram, box and whisker plot and probability plot. Further guidance on statistical approaches for comparing site data to background data can be found in Chapter 5 of the *Guidance for comparing background and chemical concentrations in soil for CERCLA Sites* (US EPA, 2002).

## Data analysis for groundwater assessment

Groundwater quality data for all monitoring bores including the dates of sampling, number of samples, and range of indicators should be presented in addition to summary statistics (for example 5th, 20th, 50th, 80th and 95th percentile, minimum and maximum at each monitoring bore). Graphs provide a powerful evaluation tool by visually summarising data characteristics of groundwater. If major cation and anion data are available, a Piper diagram (or an equivalent means of representing ion composition) may be produced.

Piper diagrams and time series plots could also provide a rapid way to identify whether there is a difference (or similarity) between groundwater bores. If a difference is suspected, a test of statistical difference (such as Student’s t-test or Mann-Whitney U Test) could be performed to determine the significance of the difference.

Time series plots are an excellent tool for examining the behaviour of one or more indicators over time, as they provide an initial indication of temporal dependence and can highlight where one or more locations are varying over time. The time series data should also be analysed for trends. If a concentration trend, either upward or downward is detected then the groundwater may be being impacted. A Mann-Kendall Test may be used to identify the presence of a significantly increasing or decreasing trend at a compliance bore or any trend in background data sets.

Box plots provide a graphical summary of data concentration and give an indication of spatial variability across multiple bore locations by presenting the central tendency, dispersion, and unequal variances in the data at each bore. The box part of the box plot can represent the median, 20th and 80th percentile or quartiles (25th and 75th percentiles), and the whiskers can represent either the minimum and maximum for each bore or the 1.5 times the interquartile range.

## Diffuse anthropogenic sources

Diffuse pollution occurs when a chemical substance, which is not concentrated, is spread out over a large area. Examples of diffuse pollution are:

* the use of fertiliser in agriculture and forestry
* pesticide use from a wide range of activities
* contaminants from roads and paved areas
* atmospheric deposition of contaminants arising from industry.

Sources of atmospheric deposition of particulate matter include those that are natural, such as bushfires, wind erosion and sea spray. Industrial emissions and diffuse anthropogenic sources include motor vehicles, wood stoves and lawn mowers. For more information on atmospheric deposition, refer to draft *Guidelines for assessing and minimising air pollution in Victoria* ([publication 1961)](https://engage.vic.gov.au/new-environmental-laws/guideline-assessing-and-minimising-air-pollution-victoria) .

Diffuse anthropogenic contamination continues to impact the environment because of global industrialisation. The current approach is to consider if anthropogenically sourced contaminants create a risk of harm. If they do, contaminated land duties apply and the site needs to be managed according to *Contaminated Land: A guide to meeting the duty to manage for those in management or control of land*  ([publication 1977](https://www.epa.vic.gov.au/about-epa/publications/1977)) or to the GED.

# Case Studies

## Case study 1 - naturally occurring arsenic

A soil assessment identified the presence of arsenic in shallow natural soils (between 1 and 5 m below ground) across the southern part of a site. The qualified person noted that the samples were collected from an area of the site that had not been used for commercial or industrial purposes.

The geology for all those samples was Brighton Group sediments. A review of nearby environmental audit reports indicated a similar trend in concentrations in samples from Brighton Group sediments, but not from the overlying quaternary sediments as found in other areas of the site. A literature review identified a peer-reviewed study which highlighted a statically significant higher concentration of arsenic in Brighton Group sediments and that the concentration range reported matched that identified at the site.

A review of the RMIT University (RMIT) soils database indicated that this was a trend typical of Brighton Group sediments across the region and a similar concentration range was recorded. The qualified person identified a nearby park, which a historical review indicated had been used for open space purposes since records and aerial photos began. A check sample collected from Brighton Group sediments below the park also reported a similar arsenic concentration range.

All the lines of evidence supported a conclusion that the arsenic detected in Brighton Group sediments below the site was at naturally occurring levels.

## Case study 2 – arsenic above naturally occurring levels

A site is currently undergoing an environmental audit. One contaminant of concern identified was arsenic. The assessor compares chemical concentrations in the soil with the RMIT database for the type of geology; reviews audit report data for nearby sites; and considers the surrounding site history and potential sources of contamination.

The assessor also reviews analytes in groundwater up-gradient verses down-gradient of the site to assess whether similar compounds are present and whether concentrations are higher, lower, or similar.

The results show that the geology below the site is the same up-gradient, and it is likely that there is only one aquifer. The geology, a sedimentary rock, has been shown to have naturally enriched levels of arsenic. There were no potentially contaminating activities identified up-gradient of the site, and nearby audits indicated that the concentration of arsenic was similar to that detected up-gradient of the site, but much lower than that detected below the site.

It was concluded that the concentration of arsenic in groundwater below the site was not naturally occurring.

## Case study 3 – natural PAHs

An assessment of a regional site identified the presence of polycyclic aromatic hydrocarbon (PAHs) compounds. A review of site history indicated that there were no obvious potential sources of PAHs onsite but did identify that there had been a bushfire as a result of lightning strikes in the area in the recent past.

A review of the literature did not indicate that geological sources would explain the presence of PAHs, however, there were studies that demonstrated that naturally occurring bushfires could cause the presence of PAHs.

## Case study 4 – assessing background levels in groundwater

A suitable groundwater reference monitoring bore was identified to the north-east of the site. Groundwater flows to the south. The site activities may have led to groundwater being impacted by metals (chromium, copper and nickel). A desktop review has indicated that there have not been any activities near the reference monitoring bore that would lead to metal contamination in groundwater. However, it was noted that nitrate contamination was present due to a former fertiliser plant in that area.

The reference monitoring bore was installed 15 mbgs into a new volcanic basaltic aquifer. Groundwater below the site is slightly deeper, but consistent with the groundwater gradient. Only two rounds of data were collected from the reference monitoring bore, but the data were collected from the wettest and driest times of the year so would represent the extremes in variability. Assessment of major ion chemistry using a Piper plot indicated that groundwater from both areas has very similar geochemistry and also a similar TDS which suggests that the groundwater has undergone similar processes and there has not been significant dilution. Furthermore, the seasonal variation was minimal.

The concentrations of copper and nickel are slightly higher in groundwater from the reference bore than from groundwater below the site. However, the concentration of chromium was 10 times greater in groundwater from below the site.

It was therefore concluded that the concentrations of copper and nickel in groundwater from below the site were consistent with background levels. It was concluded that the concentration of chromium in groundwater below the site was not consistent with background levels. The concentrations of chromium are reported above the criteria for maintaining/achieving relevant environmental values. As such, the site is considered ’contaminated land’ with respect to chromium.

## Case study 5 – assessing background levels in soil

A site in the suburbs of Melbourne is being redeveloped from industrial to residential land use. The site has a layer of fill across it and, due to years of industrial use, the fill is impacted with various metal concentrations above investigation level guidelines. Soil sampling has indicated that the natural soil beneath the fill is not impacted to the same degree as the surface soil metals, but has some chemical substances present at levels that are approaching investigation level guidelines.

To confirm the background nature of the underlying soil, a reference site is chosen 250 m up hydraulic gradient from the site at a greenfields site that has not been developed. Soil sampling using the same techniques and from the same geology, soil profile, and depth as the site is performed. The soil lithology is characterised with respect to the potential for localised mineralisation by a qualified person and some mineralisation is identified.

The leachability of the soil from both sites is assessed and found to be within the same order of magnitude. The soil sampling data is assessed using statistical analysis and the soil at depth from the two sites is considered similar in metals concentrations.

Based on the comparison of the soil lithology, minerology and soil sampling data (multiple lines of evidence) of the industrial site to the greenfields site, the natural soil beneath the industrial site is considered to contain natural background levels of metals.

# Further resources

The following references help inform the state of knowledge on background assessments:

* [ANZG 2018. Australian and New Zealand Governments and Australian State and Territory Governments, 2018, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*](https://www.waterquality.gov.au/guidelines/anz-fresh-marine)
* DES (2021). Using monitoring data to assess groundwater quality and potential environmental impacts. Version 2. Department of Environment and Science (DES), Queensland Government, Brisbane.
* EPA Victoria, 2021, [*Contaminated land: Understanding section 35 of the Environment Protection Act 2017*](https://www.epa.vic.gov.au/about-epa/publications/1940) (publication 1940).
* EPA Victoria, 2006, [*Hydrogeological assessment (groundwater quality)*](https://www.epa.vic.gov.au/about-epa/publications/668) (publication 668).
* EPA Victoria, 2000, [*Groundwater sampling guidelines*](https://www.epa.vic.gov.au/about-epa/publications/669) (publication 669).
* EPA Victoria, 2021, [*Assessing and controlling risks of harm from contaminated land: a guide to meeting the duty to manage for those in management or control of land*](file:///C:/Users/russelh/Downloads/•%09https:/www.epa.vic.gov.au/about-epa/publications/1977) (publication 1977).
* EPA Victoria, 2021, [*Guide to the Environment Reference Standard*](https://www.epa.vic.gov.au/about-epa/publications/1992) (publication 1992).
* Mikkonen, H. G., 2018. [*Environmental and anthropogenic influences on ambient background concentrations of potentially toxic elements in the soils of Victoria, Australia*](https://researchrepository.rmit.edu.au/esploro/outputs/doctoral/Environmental-and-anthropogenic-influences-on-ambient-background-concentrations-of-potentially-toxic-elements-in-soils-of-Victoria-Australia/9921864287801341)*.* Doctor of Philosophy. RMIT University, Melbourne.
* [National Environment Protection (Assessment of Site Contamination) Measure 1999 (Commonwealth)](https://www.legislation.gov.au/Details/F2013C00288)
  + [Schedule B1 Guideline on Investigation Levels for Soil and Groundwater](file:///C:/Users/russelh/Downloads/legislation.gov.au/Details/F2013C00288/Html/Volume_2). x
  + [Schedule 4, Guideline on Site-Specific Health Risk Assessment Method and approach](file:///C:/Users/russelh/Downloads/o%09legislation.gov.au/Details/F2013C00288/Html/Volume_5).
  + [Schedule B5b Guideline on Method and approach to Derive Ecological Investigation](https://www.legislation.gov.au/Details/F2013C00288/Html/Volume_7)

[Levels in Contaminated Soils](https://www.legislation.gov.au/Details/F2013C00288/Html/Volume_7).

* Reimann, C., de Caritat, P., 2017. [*Establishing geochemical background variation and threshold values for 59 elements in Australian surface soil*](https://doi.org/10.1016/j.scitotenv.2016.11.010). Sci. Total Environ. 578, 633–648.
* US EPA, 2002, [*Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*](https://www.epa.gov/sites/default/files/2015-11/documents/background.pdf) - EPA 540-R-01-003, OSWER 9285.7-41.

# Supporting materials

The following resources help inform the state of knowledge on background assessments:

* EPA Victoria, 2021, [*Contaminated Land Policy*](http://www.epa.vic.gov.au/aboutepa/publications/1915) (publication 1915).
* EPA SA, 2018. *Site contamination guideline: Assessment of background concentrations. Environment Protection Authority South Australia.* Document Ref EPA 838/18. July 2018.
* Mikkonen, H.G., Clarke, B.O., Dasika, R., Wallis, C.J., Reichman, S.M., 2017. *Assessment of ambient background concentrations of elements in soil using combined survey and open-source data,* Science of the Total Environment 580(2017):1410–1420.
* WA DER, 2014. *Assessment and management of contaminated sites, Contaminated sites guidelines*. Government of Western Australia, Department of Environment Regulation. December 2014.
* State Government of Victoria, 2021, [Environment Reference Standard](http://www.gazette.vic.gov.au/gazette/Gazettes2021/GG2021S245.pdf).
* State Government of Victoria, 2021, [Environment Protection Regulations](https://www.legislation.vic.gov.au/as-made/statutory-rules/environment-protection-regulations2021).

# Glossary of key terms

|  |  |  |
| --- | --- | --- |
| Term | Summary | Section in the Act |
| ***the Act*** | [The *Environment Protection Act 2017*](https://www.legislation.vic.gov.au/in-force/acts/environment-protection-act-2017/005) | N/A |
| ***Aquifer*** | Aquifer has the same meaning as in the Water Act 1989;  Note Aquifer in the Water Act 1989 means a geological structure or formation or an artificial land fill permeated or capable of being permeated permanently or intermittently with water.. | N/A |
| ***Background level*** | Section 36 of the Act defines the background level of waste, a chemical substance or a prescribed substance in relation to land is:   * the background level specified in, or determined in accordance with, the regulations or an environment reference standard in relation to the waste, chemical substance or prescribed substance; or * if the regulations or an environment reference standard do not specify, or set out how to determine, a background level for the waste, chemical substance or prescribed substance – the naturally occurring concentration of the waste, chemical substance or prescribed substance on or under the surface of land in the vicinity of the land. | 36 |
| ***Contaminated land*** | Land where waste, a chemical substance or a prescribed substance is present on or under the surface of the land, and the waste, chemical substance or prescribed substance—  (a) is present in a concentration above the background level; and  (b) creates a risk of harm to human health or the environment.  Land is not contaminated—  (a) merely because waste, a chemical substance, or a prescribed substance is present in a concentration above the background level in water that is on or above the surface of the land; or  (b) if any prescribed circumstances apply.  See [Contaminated land: understanding section 35 of the Environment Protection Act 2017](https://www.epa.vic.gov.au/about-epa/publications/1940) (<https://www.epa.vic.gov.au/about-epa/publications/1940>) for information on this definition. | 35 |
| ***Environment*** | The physical factors of the surroundings of human beings including the land, waters, atmosphere, climate, sound, odours and tastes; and the biological factors of animals and plants; and the social factor of aesthetics.. | 3 |
| ***Environment Reference Standard*** | The Environment Reference Standard (ERS) is an environmental benchmark. It brings together a collection of environmental values, indicators and objectives that describe environmental and human health outcomes to be achieved or maintained in the whole or in parts of Victoria.  See *Guide to the Environment Reference Standard (publication1992)* <https://www.epa.vic.gov.au/about-epa/publications/1992> for more information. | N/A |
| ***Groundwater***  (part of the definition of ‘land’) | Any water contained in or occurring in a geological structure or formation or an artificial landfill below the surface of land.  (As set out in clause 13(2) of the Environment Reference Standard, environmental values do not apply to water within a landfill cell). | 6 |
| ***Harm*** | An adverse effect on human health or the environment (of whatever degree or duration) and includes:  (a) an adverse effect on the amenity of a place or premises that unreasonably interferes with or is likely to interfere with enjoyment of the place or premises;  (b) a change to the condition of the environment so as to make it offensive to the senses of human beings; or  (c) anything prescribed to be harm for the purposes of the Act or Regulations.  Harm may arise as a result of the cumulative effect of harm arising from an activity combined with harm arising from other activities or factors. | 4 |
| ***Health investigation levels*** | Health investigation level (HILs) are a nationally set level that has been developed for a broad range of metals and organic substances. The HILs are applicable for assessing human health risk via all relevant pathways of exposure. | N/A |
| ***Human health*** | Defined to include psychological health. | 3 |
| ***Land*** | Any land, whether publicly or privately owned, and includes any buildings or other structures permanently affixed to the land; and groundwater. | 3 |
| ***Naturally occurring chemical substance*** | A chemical substance or element that is found in the environment that has not been influenced by human activity. | N/A |
| ***Non-point source*** | Non-point sources of pollution are often termed ‘diffuse’ pollution. They refer to inputs and impacts which occur over a wide area and are not easily attributed to a single source. They are often associated with particular land uses, as opposed to individual point source discharges. | N/A |
| ***Pathway*** | A route through which contamination could spread. This means how people or the environment come into contact with the contamination. For example, chemicals leaking into groundwater, vapour emissions through soil or air or both, or exposed contaminated soil. | N/A |
| ***Point source*** | A point source is a single, identifiable source of pollution, such as a pipe or a drain. Industrial wastes are commonly discharged to rivers and the sea in this way. | N/A |
| ***Qualified person*** | An environmental auditor appointed under the Act, or a person with the qualifications, experience, knowledge, or abilities required to undertake environmental assessments or contaminated land assessments. | N/A |
| ***Reference site*** | A site with the same physical, chemical, geological, and biological characteristics as the site being investigated, but that is free from anthropogenic inputs of the chemical or waste that is the subject of the assessment, so far as reasonably practicable. | N/A |
| ***Regulations*** | The Environment Protection Regulations 2021:  <https://www.legislation.vic.gov.au/in-force/statutory-rules/environment-protection-regulations-2021/003> | N/A |
| ***Source*** | Where the contamination comes from. For example, a leaking oil drum or a landfill site. The original source may no longer be present, but the contaminant could still be. | N/A |

# Acronyms and abbreviations

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| --- | --- |
| Acronym or abbreviation | Explanation |
| **ANZG** | [Australian and New Zealand guidelines for fresh and marine water quality](https://www.waterquality.gov.au/guidelines/anz-fresh-marine) |
| **CSM** | Conceptual site model |
| **DQO** | Data quality objectives |
| **DSI** | Detailed site investigation |
| **DtM** | Duty to manage contaminated land |
| **DtN** | Duty to notify of contaminated land |
| **ERS** | Environment Reference Standard |
| **GED** | General environmental duty |
| **MBGS** | Metres below ground surface |
| **NEPM (ASC)** | [National Environment Protection (Assessment of Site Contamination) Measure 1999](https://www.legislation.gov.au/Details/F2013C00288) |
| **PSI** | Preliminary site investigation |
| **TDS** | Total dissolved solids |

1. Cautionary note: Care needs to be taken to ensure that the conclusions provided in audit reports are consistent with the definition of background level under the Act. In the past, ’background’ may have referred to what is now considered to be ’ambient’ levels and not limited to natural processes (for example, nitrate from a leaky sewer up-gradient of a site may have been considered to be ’background’ levels, would now be considered to be ‘ambient’). [↑](#footnote-ref-2)
2. Naturally occurring chemical substances may still pose a risk of harm to human health. [↑](#footnote-ref-3)