Environment Protection Authority

Contamination assessment of service station sites

Minimum sampling requirements

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Contents

There are thousands of service station sites in NSW, and many of them are contaminated with a range of potentially harmful chemicals.

Proper assessment of these sites is crucial to ensure that human health and the environment are protected from potential impacts of contamination.

This technical note provides guidance on sampling requirements for assessing service station sites, to help ensure the quality of assessments is consistently high and fit for purpose.

1. Introduction

The NSW Environment Protection Authority (EPA) has prepared this technical note to help contaminated land consultants, site auditors, regulators and planning authorities who undertake or review assessments of service station sites. It provides guidance on the assessment process, the role of sampling within that process, and specifies where samples should be collected, the minimum number to collect and why.

1.1. Scope of this technical note

This document is not intended to provide stand-alone guidance, and it should be used in conjunction with other guidelines made by the EPA, most notably:

- Environment Protection Authority (EPA) 2020a, *Consultants reporting on contaminated land: contaminated land guidelines*, EPA 2020/P2233, NSW EPA, Parramatta.
- Environment Protection Authority (EPA) 2020b, *Guidelines for implementing the Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2019*, EPA 2020/P2700, NSW EPA, Parramatta.
- Environment Protection Authority (EPA) 2022, *Contaminated land guidelines: Sampling Design*, EPA 2022/P3915, NSW EPA, Parramatta.

EPA 2020a provides information to make sure reports prepared by consultants on the management of contaminated land, including service station sites, have the right information in a suitable format to inform and explain management decisions, document outcomes, and allow efficient review by regulators, site auditors and other interested parties.

EPA 2020b details the environmental requirements for operating underground petroleum storage systems (UPSS), such as those found at service stations, and summarises best-practice equipment and procedures in the fuel storage and delivery sector.

EPA 2022 provides detailed guidance on how to design sampling programs for contaminated sites, including service stations. It explains how to get data that is appropriately representative for the purposes of the sampling and the media being sampled, and how to carry out the subsequent analysis and interpretation of the collected data.

This technical note does not discuss applicable safety requirements for investigations at service station sites or other obligations under the *Work Health and Safety Act 2011* (WHS Act) and Work Health and Safety Regulation 2017. All site assessors should make sure their investigations are undertaken in accordance with the WHS Act and industry occupational health and safety procedures.

This document provides guidance for the assessment of service station sites but may be of use for the assessment of other sites at which UPSS have been installed.

This technical note replaces the EPA's previous guidance: *Technical note: Investigation of service station sites*, EPA 2014/0315.

1.2. Background

Over 2,000 service stations operate in NSW. Leaks from underground fuel tanks and pipework at service stations are a common source of soil and groundwater contamination.

Service stations make up the single largest sector of contaminated sites in NSW, and proper assessment of service station sites is crucial to making sure human health and the environment are protected from potential impacts of contamination.

In NSW, contaminated sites are regulated under the *Contaminated Land Management Act 1997* (the CLM Act), the *Protection of the Environment Operations Act 1997* (POEO Act) or the planning framework, depending on the significance of the contamination and how it will be managed.

Land that is significantly contaminated is generally regulated by the EPA under the CLM Act and Contaminated Land Management Regulation 2013. Land that is contaminated as a result of the illegal disposal of waste is generally regulated under the POEO Act and associated waste legislation.

Contaminated sites that do not pose an unacceptable risk under their current or approved use are generally regulated by planning authorities under the *Environmental Planning and Assessment Act 1979*, including the State Environmental Planning Policy (Resilience and Hazards) 2021 and the Managing Land Contamination - Planning Guidelines.

Assessment and management of contamination at service station sites is generally regulated either by the EPA or the local council, or both, depending on the circumstances. Service station sites may be investigated for a variety of reasons including redevelopment, following spills or other environmental incidents, community complaints, recorded fuel losses and regulatory action.

Assessment of site contamination is risk-based and should take a weight-of-evidence approach. A major objective of assessing service station sites is to determine the nature and extent of contamination, if any, by collecting representative samples for chemical analysis. The type of sampling carried out, and the methods used to analyse and interpret the resulting data, significantly influence the assessment's validity.

2. Assessing service station sites

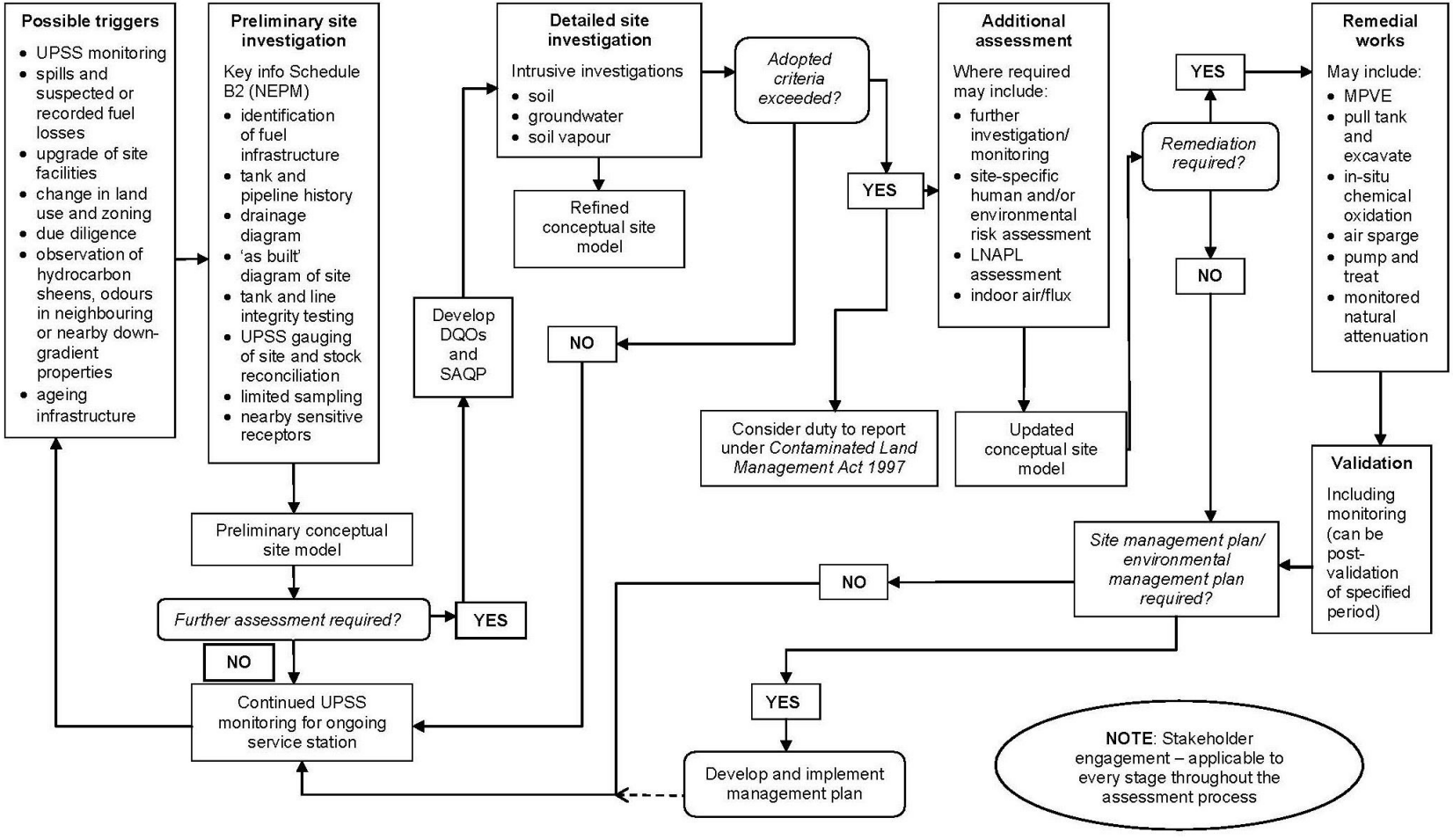
Assessments of service station sites should only be carried out by duly qualified persons as described in EPA 2020b and Schedule B9 of the *National Environment Protection (Assessment of Site Contamination) Measure* (NEPC 2013, B9).

NEPC 2013 recommends the use of a systematic planning process to define the objectives of a site assessment and develop a sampling plan for the collection and evaluation of representative data.

The assessment of service station sites generally includes sequential stages of assessment and management. These range from the trigger for the initial assessment through to remediation/validation (where required) and ongoing management. These stages are summarised in Figure 1 below.

Section 1 in EPA 2020a provides further details about each of the stages of contaminated land management.

Figure 1 Decision chart for the assessment of service station sites



Specialist studies may also be needed, for instance to provide data for human health or ecological risk assessments, to evaluate potential impacts on the broader environment, and as part of the remedial design. While the assessment is usually represented as sequential steps, the steps often consist of multiple, overlapping investigations. For example, UPSS groundwater monitoring can identify the need for soil sampling to help delineate the extent of contamination, which may then lead to vapour sampling or more groundwater sampling to close data gaps. See EPA 2020a for further guidance.

Sampling of materials must comply with any other relevant statutory requirements, including those set out in statutory instruments, and all works must comply with relevant local and state requirements for environmental management. Section 15 of NEPC 2013, B2 provides the minimum measures that should be adopted to ensure protection of the environment during site assessment.

In some cases, contamination at service station sites must be reported to the EPA. The *Guidelines on the duty to report contamination under the Contaminated Land Management Act 1997 (*EPA 2015) explain when and how contamination should be reported, based on the levels of contaminants in the land and other related factors, such as the potential for contamination to migrate off site.

2.1. Preliminary site investigation

The objective of the preliminary site investigation is to assess whether contamination has the potential to exist on the site and whether further investigation is needed. The approach can vary depending on the information initially available. It may be limited to a site inspection to verify desktop findings, or it may include targeted sampling to support results of UPSS monitoring.

Section 1.1 of EPA 2020a details the relevant considerations and processes associated with a preliminary site inspection.

Information of particular relevance to service station assessments includes:

- identification and location of all present and former tanks, lines, dispensers, vents and filling points, workshops and waste disposal locations
- tank and pipeline history, such as their method of construction, the age of tanks, details of cathodic protection and maintenance, and records of any product or waste spills and leaks
- evidence of past changes to property boundaries, in particular historical road widening - some older service stations operated curbside bowsers and underground storage tanks that may now be located under nearby roadways
- review of UPSS groundwater monitoring well data
- a review of the data held in the site's management and maintenance plans
- site and forecourt drainage and pollution control system diagrams which can include triple interceptor traps or above-ground coalescing plate interceptors (wired steel or plastic boxes); blind sumps (underground concrete ring tanks); and oil/water separators (including full retention oil/water separators which have 5,000–20,000 litre underground holding tanks)
- information on service trenches and infrastructure on and adjacent to the site, such as stormwater, sewer, gas, telecommunications and electrical easements which could represent pathways for contaminant migration
- as-built diagrams of the site
- historical aerial photographs to indicate changes and modifications
- records of previous incidents and equipment modifications
- details of any previous tank and line integrity testing
- data from leak detection systems, including details of any UPSS gauging at the site and review of stock reconciliation records, if available
- dangerous goods records.

The layout of a service station site may have changed over time, and the changes may mask historical areas of potential contamination. Any assessment should identify the potential for 'lost' underground infrastructure to be present on the site, and whether targeted investigations are needed to find this infrastructure.

Scarring of concrete surfaces and obvious changes in concrete colour or texture should be noted during site walkovers at the preliminary site investigation stage, as this may indicate a surface that has been repaired or replaced after disturbance. This can help in identifying locations of UPSS infrastructure and potential discrepancies between site plans and observed features.

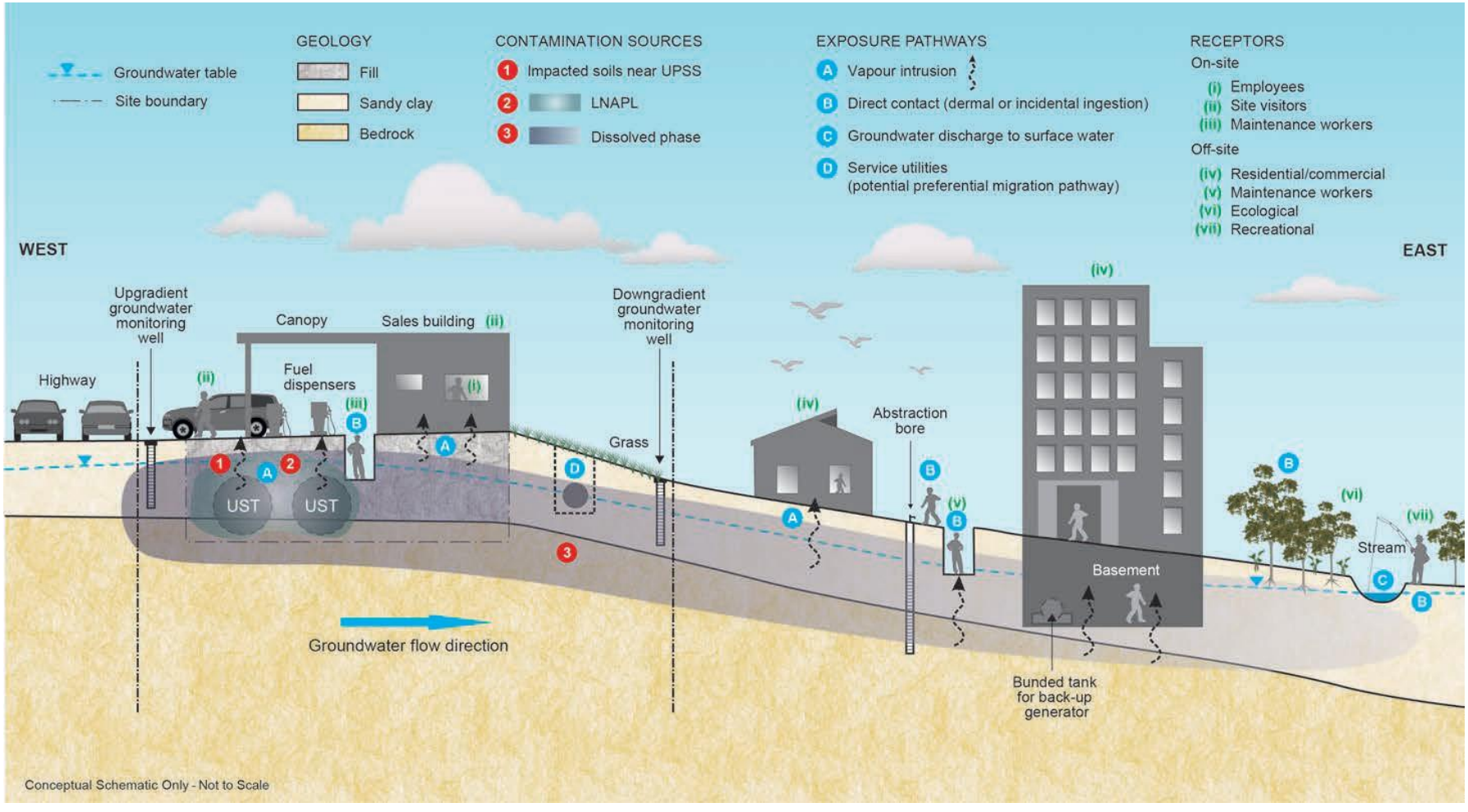
2.2. Conceptual site model

A conceptual site model is an essential part of all stages of site assessment including the preliminary site investigation. It provides the framework for identifying sources of contamination, contaminant migration pathways, receptors and exposure mechanisms. The complexity of the conceptual site model should match the scale and complexity of the known or potential contamination impacts.

The preliminary conceptual site model will allow data gaps for site characterisation to be identified, and the data quality objectives to be established (see section 2.3). The preliminary conceptual site model and any identified data gaps should inform development of a sampling analysis and quality plan, and allow identification of the mechanisms that could have resulted in contamination, the contaminants of potential concern and the target media for the investigation.

Guidance on developing conceptual site models is provided in section 1.1 of EPA 2020a and section 2.1 of EPA 2022. An example schematic of a conceptual site model for a service station site is provided at Figure 2.

Figure 2 Schematic conceptual site model of service station site



2.3. Sampling and analysis quality plan and data quality objectives

The objective of a sampling and analysis quality plan is to provide the context, justification and details of the proposed sampling and analysis approach for investigating the data gaps identified in the preliminary conceptual site model. Data quality objectives are performance and acceptance criteria developed during the planning of a site assessment. They are used to evaluate whether there is enough quality data to support decision making. See section 1.2 of EPA 2020a and section 2.3 of EPA 2022 for guidance on how to develop a sampling and analysis quality plan and data quality objectives.

2.4. Contaminants of potential concern

Primary contaminants of potential concern typically associated with the handling and storage of fuels at service stations include:

- petroleum hydrocarbon fractions ranging from C6 to C40 (analysed as total recoverable hydrocarbons)
- benzene, toluene, ethylbenzene and xylenes (BTEX)
- naphthalene
- fuel additives, such as ethanol, methyl tertiary-butyl ether (MTBE) (See CRC CARE 2016)
- lead, for sites with older infrastructure (leaded fuel was phased out in Australia in 2002)
- other volatile organic compounds such as hexane, heptane, cyclohexane and trimethylbenzene.

Secondary contaminants that may be associated with other activities carried out on service station sites include:

- polycyclic aromatic hydrocarbons (PAHs) and phenols (such as from waste oil kerosene or diesel tanks)
- leak detection fluids used with fibreglass underground storage tanks
- acids (such as from storage of spent batteries)
- asbestos
- heavy metals and chlorinated solvents (as used in workshops)
- per- and poly-fluoroalkyl substances (PFAS) from fire-fighting equipment
- phosphates, oil and grease (such as from car washes).

The potential for fill materials of unknown origin to be found at a service station site should be assessed, as it is not uncommon for imported fill to be used to grade different parts of a site throughout its history, or to backfill old tank pits. Contaminants of potential concern in fill may include metals (lead, cadmium, chromium, zinc, copper, mercury, arsenic and asbestos), TRHs, BTEX, organochlorine pesticides and polychlorinated biphenyls.

The contaminants discussed above are not a complete list, and analytical testing suites should always be based on the conceptual site model and sampling and analysis quality plan for the site.

2.5. Detailed site investigation

A detailed site investigation typically uses intrusive investigations to establish whether potential source-pathway-receptor linkages are complete or incomplete, and helps refine the conceptual site model by assessing and testing data gaps and uncertainties identified in the preliminary conceptual site model.

In some cases, the detailed site investigation and preliminary site investigation stages may be combined into a single investigation.

The detailed site investigation should identify the nature of the contamination and delineate its lateral and vertical extent enough to allow an appropriate level of risk assessment to be undertaken. If necessary, it may provide the basis for development of an appropriate remediation or management strategy (See section 2.2 of NEPC 2013, B2).

Methods used at the detailed site investigation stage can include drilling of boreholes and the installation of soil vapour monitoring wells and additional groundwater wells, and the digging of test pits. This stage may require statutory approvals, including licences for monitoring well installation and permission from the local council for any investigations on public land.

More detailed guidance on how to complete a detailed site investigation is provided in section 1.3 of EPA 2020a.

3. Sampling at service station sites

For assessment of service station sites, multiple lines of evidence and weight of evidence approaches must be used to synthesise the physical and numerical information that characterises the site and its surroundings. The conceptual site model and the associated data-gap analysis are the key tools for this synthesis. In following this process, it's important the reporting includes all available physical and numerical datasets, and methodologies are documented and explained, including any assumptions and associated limitations.

The types of environmental sampling typically conducted at each stage of the management of contamination at service station sites are shown in Table 1.

Table 1 Site assessment investigation stages and associated sampling for service station sites

Investigation stage	Type of sampling
Preliminary site investigation	Usually includes sampling of any existing UPSS monitoring wells. Additional sampling is not always required at this stage, and if performed is generally limited to targeted sampling of soil, fill, and/or surface water. The preliminary site investigation should usually include a site inspection with field observations to verify desktop findings.
Detailed site investigation	Both targeted and probabilistic sampling are performed, commonly of soil, fill and groundwater, but sometimes also of soil gas, indoor air, ambient air and surface water.
Implementation of the remedial action plan	Includes sampling for compliance monitoring and waste classification, from in-situ media and/or stockpiles. Also includes investigations of unexpected finds uncovered during the physical works.
Validation investigation	Conducted using probabilistic sampling for broad areas and targeted sampling for validating hotspots, beneath former structures or within excavations, tank pits, trenches, etc. Can also include validation of continuous or batch remedial processes.

Investigation stage	Type of sampling
Ongoing monitoring (if required)	Targeted to specific locations such as sentinel groundwater wells or air monitoring in basements, as the extent and magnitude of contamination has been identified in a previous assessment stage. Any site-specific ongoing monitoring program is developed with consideration to the conceptual site model and any regulatory requirements, including groundwater well monitoring required under the UPSS Regulation.

Notes

- See section 3 of EPA 2022 for sampling considerations, including the difference between field and analytical samples. Section 4 of EPA 2022 provides information about sampling programs and objectives.
- See section 5 of EPA 2022 for how to develop an appropriate sampling strategy for any given site, including service stations.

3.1. Specific sampling considerations for service station sites

Known locations of current and former UPSS infrastructure and site utilities (such as fill points, tanks, feed lines, dispensers, pits and utility trenches) should be early targets for assessment. Other identified potential sources of contamination, such as fill of unknown origin, workshop areas, above-ground storage tanks and waste oil tanks should also be sampled.

The potential for unidentified infrastructure (such as old tanks and lines or unmarked drainage and service trenches) to be present must be considered when designing any sampling program for service station sites.

Where identified, potentially contaminated areas, including contaminant source locations, should be sampled and analysed for all relevant contaminants of potential concern listed in section 2.4.

3.1.1. Underground storage tanks

Underground storage tanks may have concrete anchors or caps, particularly in areas with a high water table, and cathodic protection may also be installed. These aspects should be considered when determining sampling locations.

As a general rule, the majority of older steel underground storage tanks are commonly located between 600 and 700 mm below ground surface.

Modern fibreglass underground storage tanks have a minimum burial depth depending on surface pavement and trafficability. The top of these tanks are typically located between 450 and 600 mm below ground surface. For more information, refer to Standards Australia 2008.

3.2. Soil sampling at service station sites

The conceptual site model should guide the development of an appropriate sampling density.

Table 2 summarises the minimum recommended protocols for soil sampling at potential locations of concern at service station sites. This not a complete list, and how these protocols are applied should be based on the site history, the stage of investigation or validation and access and safety constraints.

Table 2 Minimum recommended soil sampling at service station sites

Potential area of concern	Minimum no. of samples/ locations	Action
Underground storage tank	Tank length < 4 m: one sample from beneath the centre of each tank, and one sample from each of the four walls Tank length 4–10 m: one sample from beneath each end of each tank, and two samples from each of the four walls Tank length > 10 m: one sample from beneath each end of each tank, and three samples from each of the four walls	Collect samples if tank is to remain in place or during excavation and tank removal. Samples should be taken at or below the base of the tanks.
Underground storage tank pit natural soils and backfill sands	Two samples	Samples between 0–200 mm into surrounding soil. Recommended to be at or below the base of the tank.
Underground storage tank pit water	One sample	Sample if there is water present and backfill sands or natural soils appear contaminated.
Fuel dispensers	One sample per dispenser backfill and, if required, one per natural soil	Sample area adjacent to line and dispenser junction, taking representative sample of backfill during excavation and removal of the dispenser. If contamination apparent, sample 0–200 mm into natural soils.
Fuel feed lines to dispensers	One sample every 5 m of line	Take representative sample of backfill sands and, if it appears contaminated, sample 0–200 mm into natural soils. Pay extra attention changes of line direction and the depth of burial of the line.
Remote fill points	One sample per fill point	Representative sample from backfill sands and, if it appears contaminated, sample 0–200 mm into natural soils.
Above-ground fuel storage (drum/tank)	One sample per 25 m^2	Collect samples in areas of spills, otherwise collect samples below storage area at depth intervals of 0– 200 mm and 200–500 mm.
Below-ground waste oil/wastewater tank	Two samples per tank	Collect samples if tank is to remain in place or collect samples during excavation and tank removal.
Spent battery storage	One sample per 25 m^2	Take representative auger samples in the 0–200 mm layer.

Potential area of concern	Minimum no. of samples/ locations	Action
Waste disposal areas (including wastewater disposal on site)	One sample per 25 m^2	Collect samples at the site of contamination or within the disposal area in the 0–200 mm layer.
Fill materials of unknown origin	Adopt sampling density in accordance with section 5 of EPA 2022, and consider sections 6 and 7 of NEPC 2013, B2	Collect representative auger/ borehole samples from surface to natural ground level.
Workshop (current or historical)	Dependent on conceptual site model and site observations	Collect samples at the site of contamination at depth intervals of 0– 200 mm and 200–500 mm. Where pits or hoists are present, sampling should extend below the base of the structure.
Carwash	Dependent on conceptual site model and site observations	Take representative samples in the 0– 200 mm layer.

These are recommended minimums. Samples selected for analysis should be biased towards 'representative worst case' samples, based on field indications of contamination.

Extra sampling will probably be needed if the sampling of potential contamination sources listed in Table 2 indicates that contamination has occurred.

Changes in lithology may mean extra sampling is needed, where relevant to the distribution of the tank pits and fuel lines (e.g. increased permeability of soils under a section of a tank or pipe).

Any deviation from the protocols in Table 2 should be justified in the sampling and analysis quality plan. For example, the site history or visual or olfactory field observations may indicate that an alternative sampling strategy is more appropriate. Alternative sampling locations should be identified using appropriate screening (such as visual inspection and photos, Photoionization detector screening, reference to conceptual site model, and the sampling methodology and decision criteria must be explained.

Samples must be collected in accordance with relevant Australian Standards and NEPC 2013, B2.

3.3. Groundwater monitoring and assessment

The *Contaminated sites: Guidelines for the assessment and management of groundwater contamination* (DEC 2007) outlines the framework for assessing and managing contaminated groundwater in NSW.

The Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2019 ('UPSS Regulation') requires all sites with operating UPSS, including service stations, to install at least three groundwater monitoring wells positioned to detect leaks from underground infrastructure. These must be monitored at six monthly intervals. Some sites may be exempted or use alternative systems to monitor for leaks.

On their own, groundwater monitoring wells installed on a site as required by the UPSS Regulation may not be enough to characterise the nature and extent of contamination from a leaking UPSS. Comprehensive groundwater assessment therefore needs a staged approach. The initial investigation should be targeted around known or suspected source areas while subsequent investigations may be needed to delineate and characterise the extent of the impact. Off-site wells may be needed where it is suspected that the impact on groundwater has extended beyond site boundaries. Installing wells off-site may be subject to landowner and other approvals.

Contamination may be confined to the tank pit where site-specific geology limits the impact of leaks on groundwater. In these situations, monitoring wells additional to those installed under the UPSS Regulation may not be needed. Any such decision should be justified by a robust conceptual site model which supports a low likelihood of hydraulic connection between the base of the tank pit and the groundwater surface. However, where this appears likely, the EPA recommends confirming this by installation of at least one down-gradient well to intersect the upper aquifer.

When designing a groundwater investigation, the potential for off-site sources of contamination should be considered in the conceptual site model. Service station sites can often be located in clusters or adjacent to other light industrial/commercial operations with their own potential sources of groundwater contamination.

NEPC 2013, B2 provides further guidance on groundwater assessment.

3.3.1. Groundwater well installation

The conceptual site model should be used to guide groundwater well installation, including the number of wells, their location and depth, and screen intervals. Wells should be located so that the nature and extent of any contamination of groundwater can be established with confidence, and the direction and velocity of groundwater flow confirmed.

Groundwater flow direction may not always be confirmed prior to the installation of monitoring wells. In these instances, information from the PSI should be used to infer likely flow directions, taking into account geology, local topography and local surface water features.

Consideration should be given to the depth of wells and whether more than one water-bearing formation needs to be investigated. To minimise the potential for vertical flow between aquifers via the well, the monitoring well screen must not be installed across different geological units, water-bearing zones or aquitards and aquicludes.

Groundwater assessments generally include installation of monitoring wells up-gradient, lateral to and down-gradient of contamination sources. Analytical testing suites for groundwater should include relevant contaminants of potential concern - see section 2.4. Additional parameters to be considered may include:

Physico-chemical

- redox
- pH
- electrical conductivity
- dissolved oxygen
- temperature

Monitored natural attenuation

- nitrate
- ferrous iron
- dissolved methane
- manganese
- sulphate

Table 3 outlines recommended minimum groundwater investigation protocols for service station sites. Any deviations from these protocols should be recorded and justified.

Table 3 Indicative groundwater investigation protocols for service station sites

Well locations	Minimum no. of wells
Background: Up-gradient of each contamination source – either off-site (preferred, but consent and approvals may be required) or adjacent to site perimeter	One well per contamination source, subject to site layout and access limitations
AND	**AND**
Lateral delineation: Adjacent to any contamination sources on-site	One well each side (i.e. cross-gradient) of each contamination source on site, subject to size and proximity of sources
AND	**AND**
Source zone: Within the plume	One well within or immediately downgradient of each contamination source on site, subject to size and proximity of sources
AND	**AND**
Migration: Down-gradient of the leading edge of each plume - either off-site (preferred, but consent and approvals may be required) or adjacent to site perimeter	One well per contamination source, subject to site layout and access limitations

Groundwater investigation bores should be:

- installed in accordance with *Minimum Construction Requirements for Water Bores in Australia* (NUDLC 2020)
- installed with similar construction techniques to minimise sources of variation and uncertainty in the data
- where appropriate, screened across the upper aquifer to locate any light non-aqueous phase liquids and identify contamination that's come primarily from surface spills and leaching.

The size of a plume depends on source characteristics and local hydrogeology, and well spacing should be site-specific and informed by the conceptual site model. As a minimum, for plumes estimated to be less than 200 m long, wells should generally be spaced 10–20 m apart in the direction of groundwater flow and 5–10 m apart perpendicular to flow. For larger plumes, over 200 m long, well spacing should generally be double this. Well spacing should generally be less than 10 m for the delineation of source zones (Sundaram et al. 2009). The sampling depth will be dictated by local hydrogeological conditions.

Groundwater sampling procedures are discussed in detail in section 8.2.4 of NEPC 2013, B2. Consistent methods should be used each time the wells are purged and sampled to avoid introducing sampling method-related uncertainties to the analytical data (DEC 2007).

A report detailing monitoring well installation must be prepared for each well in accordance with industry standards. This may be needed to supplement licence applications to the NSW Office of Water.

See also section 3 of EPA Victoria's *Groundwater sampling guidelines* (EPA Victoria 2022).

3.3.2. Light non-aqueous phase liquids

The presence of light non-aqueous phase liquids (free phase) can affect the groundwater elevation measured at a monitoring well. Due to the uncertainties involved, corrected groundwater elevations from wells affected by light non-aqueous phase liquids should not be used to determine the direction of groundwater flow. However sampling and characterising light non-aqueous phase liquids may be useful in determining the composition, age, weathering and potential source of the contamination.

Natural degradation of petroleum hydrocarbons in the environment may mitigate the impacts of contamination and play a part in the remedial approach to groundwater contamination. To demonstrate whether natural attenuation is occurring, recording and analysis of physico-chemical parameters is needed. Section 3.3.1 lists key parameters but others may also be needed. For further information on monitored natural attenuation, refer to Beck & Mann 2010 and Clements et al. 2009.

Fingerprint analysis of light non-aqueous phase liquids may provide information on the specific type (unleaded, E10, premium) and age of the product. Bail-down testing of light non-aqueous phase liquids provides information on the potential mobility and recoverability of the liquids in the immediate surroundings of the monitoring well, for example to help determine if light non-aqueous phase liquid extraction is a viable remedial option. More information can be found at Clements et al. (2009) and ASTM (2013).

See *Technical note: light non-aqueous phase liquid assessment and remediation* (EPA 2015b) for information on the assessment and remediation of light non-aqueous phase liquid in line with relevant legislation and policies.

3.4. Soil vapour assessment

A well-developed conceptual site model incorporating vapour risk is essential for understanding current site conditions, determining potential vapour behaviour (including possible variation in soil vapour concentration) and, as part of the data quality objectives process, for identifying data gaps and uncertainties and priorities for investigation (NEPC 2013, B2).

The conceptual site model should also help identify vapour intrusion pathways to potential receptors and whether a vapour assessment is needed. If it is, details on the location and number of sampling points, depth (soil vapour) and frequency of sampling events should be included in the sampling and analysis quality plan. Where a soil vapour risk is not considered to be significant, the detailed site investigation should show why pathways and vapour intrusion are unlikely to be present.

Vapour sampling should be undertaken with reference to *Assessment and management of hazardous ground gases: contaminated land guidelines* (EPA 2020c), NEPC 2013, EPA 2020a and CRC Care 2013. See also section 5.10 of EPA 2022.

4. Remediating service station sites

Remediation, including removal and repair of fuel infrastructure, tanks and lines, must be undertaken by duly qualified persons in accordance with NSW legislation and guidance, relevant Australian Standards, and applicable work health and safety legislation.

Regulatory requirements may include a notice issued by the EPA under the CLM Act such as a management order, and licences and/or development consent conditions issued by a regulatory or consent authority.

A remedial action plan should be used to define remediation objectives and methodologies, and must be prepared according to the requirements of EPA 2020a.

Remediation options that could typically be considered for service station sites following appropriate removal of redundant infrastructure include:

- on-site in-situ remediation of soil and groundwater, such as multi-phase vacuum extraction, air sparging with or without soil vapour extraction, and injections to enhance site-specific naturally occurring degradation processes
- on-site ex-situ treatment and remediation of soil and groundwater, such as enclosed bioremediation cells and pump and treat systems with emission controls
- on-site treatment, using enhanced bioremediation (with appropriate odour and stormwater controls), where high concentrations of volatile organic compounds are present, or passive bioremediation without the addition of organic matter at sites where the soils are contaminated with low concentrations of volatiles. Removing volatile fractions through exposure of the mass to atmosphere is not considered a legitimate form of bioremediation: refer to *Best practice note: Landfarming* (EPA 2014a) and *EPA Guidelines: Soil bioremediation*, (SA EPA 2005).
- off-site controlled soil treatment
- off-site controlled remediation of soil at a licensed waste facility and subsequent use as cover material
- off-site disposal to a licensed waste facility as contaminated soil as per the *Waste classification guidelines* (EPA 2014b)
- 'cap and contain' strategy with human health/ecological risk assessment to confirm remediation is appropriate: refer to ANZECC 1999
- monitored natural attenuation.

See section 1.6 of EPA 2020a for advice about decommissioning UPSS.

5. Validating service station sites

Completed remediation must be validated to make sure the objectives stated in the remedial action plan have been met.

The extent of validation needed will depend on the degree of contamination originally present, the type of remediation carried out, the current and proposed land use and any other regulatory requirements. For example, regarding a management order issued by the EPA under the CLM Act.

Validation generally requires a report that provides independent verification using objective and measurable criteria that a service station site is free of unacceptable levels of contamination, all necessary remediation works have been successfully carried out, and the site is suitable for the proposed use.

If needed, a site auditor accredited under the CLM Act may independently review remediation and validation reports to make sure the methods and interpretation of data are consistent with EPA guidance.

See section 1.6 of EPA 2020a for further details on site validation reporting and section 5.5 of EPA 2022 for validation sampling requirements.

6. Reporting

Competent reporting is crucial at all stages of the assessment and management of service station sites. The reporting process may be separated into the following stages:

- preliminary site investigation
- sampling and analysis quality plan
- detailed site investigation
- remedial action plan/options assessment
- site management plan
- remediation and validation report.

Reports must be prepared as detailed in EPA 2020a, and to a standard described in section 14 of NEPC 2013, B2. Appendix 6 of EPA 2020b provides a checklist for reporting following the decommissioning, removal or replacement of a UPSS.

7. References and further reading

7.1. References

ANZECC 1999, *Guidelines for the Assessment of On-site Containment of Contaminated Soil*, Australian and New Zealand Environment and Conservation Council, Canberra; available at www.scew.gov.au/system/files/resources/378b7018- 8f2a-8174-3928-2056b44bf9b0/files/anzecc-gl-assessment-site-containment- contaminated-soil.pdf

ASTM 2013, *E2856–13: Standard Guide for Estimation of LNAPL Transmissivity*, ASTM International, Pennsylvania; available at www.astm.org/Standards/E2856.htm

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7.2. Further reading

Inclusion of these extra reading sources may help in meeting EPA requirements:

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