Ministry for the Environment
Manatū Mō Te Taiao

Contaminated Land Management Guidelines No. 1

Reporting on Contaminated Sites in New Zealand (Revised 2011)

New Zealand Government

While every effort has been made to ensure that this guideline is as clear and accurate as possible, the Ministry for the Environment will not be held responsible for any action arising out of its use. This guideline should not be taken as providing a definitive statement for any particular user's circumstances. All users of these guidelines should satisfy themselves, and their client(s) concerning the application of these guidelines to their situation and in cases where there is uncertainty seek expert advice.

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Other councils that provided a significant contribution to the development of these guidelines were Environment Waikato, Environment Southland, Taranaki Regional Council, Tasman District Council, and Greater Wellington. The Ministry for the Environment published the guidelines in April 2001. The revised versions in 2003 and 2011 have been organised and published by the Ministry.

The checklist for reporting on the removal of petroleum underground storage tanks (given in Chapter 4) is based on an original developed by URS (NZ) Ltd, Wellington; permission to use this material is gratefully acknowledged.

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Executive Summary

This is the first of a series of documents on contaminated land management, published by the Ministry for the Environment under the auspices of the Regional Waste Officers' Forum. The guidelines are adapted from Australian guidelines as a best practice guide for use by regional councils, territorial and unitary authorities, and environmental consultants. They cover reporting practice only, and do not show how to conduct investigations, to make assessments, or to suggest remediation.

How this document can be used

The purpose of this document is to ensure consistency of reporting on the investigation, assessment and remediation of contaminated sites in New Zealand. It will assist council and local authority staff, site auditors, members of the public, and other interested parties to evaluate the effects on the environment such contaminated sites may cause.

Five reporting stages are described:

- preliminary site investigation report
- detailed site investigation report
- site remedial action plan
- site validation report
- ongoing monitoring and management plan.

This document presents a detailed checklist covering these five reporting stages. The checklist will help to achieve a uniform approach to reporting on contaminated sites and ensure that local authorities receive the information they need to address the relevant environmental issues. Report stages may be presented separately, as is often the case with complex sites, or they can be combined. In any case, each report must contain all the necessary information to enable a full review.

Consultants' reports normally address these stages. Reports may be prepared for sale or purchase agreements, or for permit applications, as well as for documenting contamination and describing clean-up procedures.

The main checklist is not appropriate for reports prepared following the removal of petroleum underground storage tanks, and for this reason a separate checklist on this topic is given.

An extended list of references is provided, showing information available from selected sources in New Zealand, Australia and the United States.

Responsibilities of users of these guidelines

Compliance with these guidelines does not in any way authorise any person, including consultants, to access land for the purpose of undertaking investigations other than on land owned or leased by them, without the express permission of the owner or lessee of the land or their rightfully appointed agents.

Compliance with these guidelines does not in any way release any person, including consultants, from additional requirements (including permits required by various legislation) that may be imposed by local authorities. Where documentation required for such additional requirements satisfies part or all of these guidelines, this should be included in reporting and clearly identified as doing so.

Consultants (and their clients) should be aware of the duty to avoid, remedy or mitigate adverse effects on the environment as specified in s.17 of the Resource Management Act 1991.

Changes from the 2001 version

An earlier version of this document was produced in 2001. At that time the draft of the guidelines was circulated to local government, environmental consultants and key industries, and the final document was revised on the basis of the comments received.

The document was first updated in November 2003 with changes to the following sections:

- 2.1 – Reference has been made to the risk-screening system, and information should be provided in a preliminary site investigation report to allow a risk screening to be undertaken on a site.
- 2.5 – The need for annual reporting on site management plans has been highlighted. Management plans are becoming more common as a way of reducing risk by controlling behaviour on a site. However, to have confidence that the risk continues to be managed, the implementation and effectiveness of any plan needs to be reported on.

Further updates have been made in the current edition of these guidelines (October 2011) to the following:

- website URLs
- references to other documents
- references to the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (to take effect on 1 January 2012).

Various minor changes have also been made to the text and tables to make them consistent with other contaminated land management guideline documents.

The guidelines are available on http://www.mfe.govt.nz and on the Quality Planning website (http://www.qualityplanning.org.nz/index.php).

1 Introduction

This is the first of an intended series of documents on contaminated site management to be produced by the Ministry for the Environment.

Their purpose is to ensure that reports prepared by consultants and others on the investigation, assessment, remediation and any subsequent monitoring of contaminated land contain sufficient and appropriate information to enable efficient review and appropriate action by regulators, site auditors, members of the public and other interested parties. Chapters 2 and 3 of these guidelines provide the minimum requirements for the contents of reports related to contaminated land. Chapter 4 lists guidelines for dealing with underground petroleum storage tanks. Adoption and use of these guidelines should result in enhanced environmental awareness of the issues at contaminated sites and promote outcomes in accord with the principles of the Resource Management Act 1991 (RMA).

Other or additional reporting requirements may apply in certain cases. Where land is subject to specific planning, building or zoning requirements related to the actual or likely presence of hazardous contaminants, additional information may be requested. The appropriate planning authority should be consulted for details. Also, the relevant authority should be contacted when a site[1] is subject to:

- an investigation by the authority
- an enforcement action by the authority
- a resource consent application, or
- where the site has previously been granted a resource consent.

Reports and reporting related to contaminated sites may be used by local authorities or the Ministry for the Environment to monitor environmental impacts associated with contaminated sites, their management, and relevant policy.

There are already New Zealand guidelines on the investigation, assessment, remediation, and monitoring for some types of land uses, specifically gasworks, petroleum hydrocarbon contaminated sites, timber treatment sites and sheep-dip sites. These are available from the Ministry for the Environment, and are listed on the Ministry's website: http://www.mfe.govt.nz/publications/hazardous/.

A number of contaminant types and land-use activities are not yet addressed in guidelines, nor are a number of associated issues, such as the representativeness of sampling, assessing natural attenuation, requisite auditing procedures, and the competency of personnel involved in site investigations, audit and monitoring. A list of New Zealand and international reference documents (Chapter 5) has been compiled, which may provide assistance in these matters when reporting on contaminated sites.

[1] For the purposes of this document, 'site' means an area of land, as defined by legal descriptions or part of a legal description, which is under investigation.

2 Investigating and Reporting

Contaminated site management can be broadly classified into the following reporting stages, which track the site investigation process from inception to remediation or long-term management:

- preliminary site investigation report
- detailed site investigation report
- site remedial action plan
- site validation report
- ongoing monitoring and management plan.

Consultants' reports normally address these stages. Reports may be prepared to satisfy the requirements of sale and purchase agreements, permit applications or for other purposes in addition to documenting the investigation and clean-up procedures considered and adopted.

Report stages may be presented separately, usually where large and complex sites are being considered, or they can be combined. However, each report must stand alone and have enough information to be clearly and readily understood by the appropriate persons reviewing it.

If there is already information prepared on a site, and that information is still available, a summary of that information should suffice in subsequent reports. If there is already a relevant report about a site (eg, at a local authority on an identified file), who holds this file and its location should be disclosed in the report.

Where the report(s) being prepared will be used for a resource consent, the appropriate additional information required by s.88 and the Fourth Schedule of the RMA may be included in the report or attached to it. Note that some local authorities require permit application information to be presented on specified forms.

The following five stages may contribute to a report. Not all stages may be necessary, although any exclusion should be clearly justified in the report. Chapter 3 provides a detailed checklist of what should be included, as a minimum, for each stage. Note particularly the single-page summary checklist, which *should be the first page of your report*. The summary checklist will serve as a quick guide to the contents and completeness of the report.

2.1 Stage 1 – Preliminary site investigation report

The purpose of the preliminary site investigation report is to present the site history. It should:

- identify any known local information providing baseline data on soil and groundwater quality near the site
- list in order all past and present activities at the site that involved the storage, production, use, treatment or disposal of materials that could contaminate the site
- identify the types of materials that could contaminate the site and where such contamination could have occurred
- describe the current site condition, and the contents and results of any known previous assessments
- cite any records from relevant authorities detailing site condition, including the data and results of any risk-screening (see *Contaminated Land Management Guidelines No. 3: Risk Screening System*, Ministry for the Environment, 2004) or other assessments undertaken
- identify the likelihood of contamination
- make a preliminary assessment of that site's contamination based on the qualitative and quantitative information available
- assess the need for further investigation at the site, specifically with reference to the current and/or proposed land uses and/or the potential environmental impact.

The risk-screening system is a useful method to assess potential risk, and while mainly employed by local government should also be considered as a tool for use by environmental consultants. Input values sufficient to allow a risk screening to be undertaken should be included in the preliminary site inspection.

The site history is fundamental to the preliminary assessment, and may be used to assess the likelihood of the site having become contaminated. It is important to review and assess all relevant information about the site, including information obtained during a site inspection. If a complete site history clearly demonstrates that site activities have been non-contaminating, there may be no need for further investigation or sampling.

However, if contaminating activities have or may have occurred, or if the site history is incomplete, it may be necessary to undertake a preliminary sampling and analysis programme. The results of such an investigation should be included in the preliminary site investigation report as part of the basis for assessing the need for a further, more detailed, site investigation.

2.2 Stage 2 – Detailed site investigation report

This should give comprehensive information on:

- issues raised in the preliminary inspection
- the type, extent and level of contamination anticipated
- the nature of samples collected and the sampling procedures followed, including quality assurance / quality control requirements
- the analyses undertaken, methodologies used and laboratory quality assurance / quality control procedures.

The site investigation report should also assess:

- the actual extent and concentrations of contaminants in all appropriate media at the site
- any likely dispersal in air, surface water, groundwater, soil and dust from the detected contaminants
- where applicable, the location and magnitude of any on-site or off-site impacts on soil, water, sediment and biota
- any potential effects of contaminants on public health, the environment and structures
- the adequacy and completeness of all information used in decisions on remedial options
- if clean-up, management or ongoing monitoring is intended at the site.

Any investigation undertaken should comply with *Contaminated Land Management Guidelines No. 5: Site Investigation and Analysis of Soils (Revised 2011) (*Ministry for the Environment, 2004).

The results of chemical analysis of the soil sampled are to be compared with appropriate soil contaminant standards or soil guideline values. Soil contaminant standards have been derived for a group of priority contaminants and a set of scenarios that are legally binding as gazetted under the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health.

Where soil contaminant standards are not applicable, soil guideline values may be derived in accordance with the methods and guidance on site-specific risk assessment provided in the *Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health (Ministry for the Environment, 2011a).* Alternatively, generic soil guideline values (such as those in the industry-based guidelines published by the Ministry for the Environment) may be applied. The assumptions on which those guidelines are based must be shown to apply to the site and surrounding conditions under investigation.

There are computer tools that can help to assess risk to human health and ecology. Where these are used, describe them in the site investigation report (including what they are designed to do) and detail what data was used, what scenarios were examined and the underlying algorithms. Sufficient information should be provided so that the report reviewer is able to replicate the risk assessments.

If the results of the detailed site investigation indicate that the site poses unacceptable risks to human health or the environment – on-site or off-site, and under either the present or proposed land use – then a remedial action plan needs to be prepared and implemented.

Note that all areas of interest to the local authority, the consultant or their client(s) may not lie within the property boundary. In this case, the boundaries of interest (the area of contamination) should be clearly defined. Any investigation should extend so as to clearly bound the contamination related to the source(s) or site in question. If contamination extraneous to the site being investigated is found, the appropriate local authority should be advised. This can be done either via the site investigation report or, if immediate adverse effects are detected or anticipated, as soon as practicable.

2.3 Stage 3 – Site remedial action plan

Once the site has been identified as requiring remediation or management, the remedial action plan should be prepared as follows.

- Set remediation or management goals that ensure the site and any relevant additional land contaminated by site activities will be suitable for its current or proposed land use and will pose no unacceptable risk to human health or the environment, either on-site or off-site.
- Document in detail all risk-reducing procedures and plans to be implemented to achieve an acceptable level of risk for the current or proposed site's land use.
- Establish a recording mechanism to ensure activities proceed as detailed in the remedial action plan.
- Establish the environmental safeguards required to complete the remediation in an environmentally acceptable manner.
- Identify and include proof of the necessary approvals, permits or licences required by regulatory authorities to undertake remediation.

Where site-specific clean-up levels are to be developed by applying proprietary risk assessment methods, the consultant must consult the relevant regional council or unitary authority to discuss appropriate procedures. Guidance on when it is appropriate to carry out a site-specific assessment and how to derive site-specific soil guideline values is given in *Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health (Ministry for the Environment, 2011a)*.

Systematic and clear plans should be made of remedial work to be undertaken, ensuring among, other things that dates, quantities, sampling, excavation and disposal locations will be recorded. Local background conditions should be verified within the remedial action plan. Such data and any management or regulatory decisions made during or following the remedial process will be required for reporting stages 4 or 5 (or both).

2.4 Stage 4 – Site validation report

After remedial or management action, the conditions at the site must be assessed to validate that the objectives stated in the remedial action plan have been achieved. A site validation report detailing the application of the remedial action plan, any variances from the proposed plan and the results of validation is required. The application of the remedial action plan should be assessed both in terms of the management and remedial goals established, and how remediation was undertaken.

This will vary according to:

- the degree of contamination originally present and the remediation goals set for the site
- the type and extent of remedial processes that have been carried out
- the current or proposed land use.

Validation must confirm statistically that the remediated site complies with the clean-up criteria set for the site in the remedial action plan. For further guidance on statistical sampling and confirmation, we recommend that consultants see the New South Wales Environment Protection Authority's *Contaminated Sites: Sampling Design Guidelines* (1995). The United States Environmental Protection Agency's *Methods for Evaluating the Attainment of Cleanup Standards* (1989) is also useful.

A number of computer tools can also assist with sample planning and the assessment of statistics related to sampling. As in the site investigation, the report should give details of the programme and enough information to let the reviewer replicate the assessment.

The site validation report must assess the results of the post-remediation testing against the clean-up criteria stated in the remedial action plan. Where targets have not been achieved, the reasons for this must be stated and additional site work proposed to achieve the specified remedial action plan objectives should be listed. If any contingency plans were detailed in earlier reports, they should have been implemented before the site validation report is submitted.

The site validation report should also include, where possible, information confirming that all the requirements of regional council, unitary and territorial authority or other planning authority licences or permits have been met. In particular, documentary evidence should be included to show that any disposal of contaminated material off-site has been done or will be done in accordance with the remedial action plan, and with the requirements of the disposal site and the relevant local authority.

2.5 Stage 5 – Ongoing monitoring and management plan

The requirements for an ongoing monitoring and management plan for the site should be assessed where:

- full clean-up is not possible or preferable
- monitored natural attenuation is selected as the preferred remedial option
- on-site containment of contamination is proposed.

Where remedial goals are achieved in accordance with the remedial action plan, as confirmed by the site validation report, there may still be a requirement to provide an ongoing monitoring and management plan. In accordance with s.15 of the RMA, this may be required as supporting information for an application for a discharge permit, if this is required to authorise contaminants that remain on-site or off-site. In this case, the appropriate requirements of s.88 and the Fourth Schedule of the RMA should also be included. The relevant regional council or unitary authority should be contacted to confirm the requirements in each area.

A monitoring programme should detail the proposed monitoring strategy, what will be monitored, the location and frequency of monitoring, and the reporting requirements (format, content and frequency). It should also state the proposed period for reviewing the monitoring and management plan.

Reporting of the results of monitoring falls outside the scope of these guidelines. Where ongoing monitoring or site management is required to be reported as a condition of a resource consent, the reporting requirements will be in accordance with those set down by the consent. However, the requirements proposed in the monitoring and management plan are likely to form the basis for proposing conditions of any ongoing reporting under a resource consent. Where monitoring or management is governed by a non-statutory instrument, any additional requirements will be as stated in that instrument.

Where a management plan is used as the primary means of reducing risk, its application and effectiveness must be reported on, no less than annually, to the relevant local authorities. Without such reporting, it will not be possible for the local authorities to be confident that the risk from the contamination is being managed.

3 Checklist of Reporting Requirements

The following checklist is provided to help achieve a uniform approach to reporting on contaminated sites, and to ensure that the environmental issues of relevance to the regional council or unitary authority are being addressed to their satisfaction. The aim is not to require identical reporting from consultants, but to ensure the comprehensiveness of information provided. The headings given in the checklist may be used for report section headings.

If a report has to deviate from the checklist, the reasons for this should be clearly stated. Include in the main text of the report all information needed to satisfy any guideline criteria that are applied to the site. If some conclusions need to be supported by large or unwieldy amounts of detail, such detail can be included as a separate appendix to the report, but this fact must be mentioned in the main text.

3.1 Summary checklist

Always include the summary checklist as the first page of your report. It provides the reader with a succinct overview of the full report, the type of information included in each section, and the degree of completeness of the information given. The main checklist and the summary page both use the abbreviations set out in Section 3.2.

3.2 How to use the checklist

The checklist links with stages 1 through 5 of reporting, discussed in Chapter 2. The aim is to provide a logical and sequential list ensuring that each section of a report covers the required data. The listings are indicative and not directive – include additional relevant topics and headings where site details or contaminant issues warrant this.

The first column lists report headings to be included and principal subjects to be covered under each heading. The other columns refer to the principal reporting stages of contaminated site studies, using the following abbreviations:

PSI preliminary site investigation report
SIR detailed site investigation report
RAP site remedial action plan
SVR site validation report
MMP ongoing monitoring and management plan.

The following abbreviations indicate the information requirements:

R the corresponding heading and details are required
A readily available information should be included
S a summary of this section's details will be adequate if detailed information has been included in an available referenced report
N include only if no further site investigation is to be undertaken
X not applicable and may be omitted.

Summary contaminated sites report checklist					
Indicate the reports contained in this document	☐	☐	☐	☐	☐
Report section(s) and information to be presented	**PSI**	**SIR**	**RAP**	**SVR**	**MMP**
Executive summary	R ☐	R ☐	R ☐	R ☐	R ☐
Scope of work	R ☐	R ☐	R ☐	R ☐	R ☐
Site identification	R ☐	R ☐	R ☐	R ☐	R ☐
Site history	R ☐	S ☐	S ☐	S ☐	S ☐
Site condition and surrounding environment	R ☐	S ☐	S ☐	S ☐	S ☐
Geology and hydrology	A ☐	R ☐	S ☐	S ☐	S ☐
Sampling and analysis plan and sampling methodology	A ☐	R ☐	X	R ☐	R ☐
Field quality assurance and quality control (QA/QC)	N ☐	R ☐	X	R ☐	S ☐
Laboratory QA/QC	N ☐	R ☐	X	R ☐	X
QA/QC data evaluation	N ☐	R ☐	X	R ☐	X
Basis for guideline values	R ☐	R ☐	R ☐	R ☐	R ☐
Results	A ☐	R ☐	R ☐	R ☐	S ☐
Site characterisation	R ☐	R ☐	R ☐	R ☐	R ☐
Remedial actions	X	X	R ☐	S ☐	S ☐
Validation	X	X	X	R ☐	S ☐
Site management plan	X	X	R ☐	S ☐	S ☐
Ongoing site monitoring	X	X	X	N ☐	R ☐
Conclusions and recommendations	R ☐	R ☐	R ☐	R ☐	R ☐

Minimum information requirements for each of the five stages

Report section(s) and information to be included	PSI	SIR	RAP	SVR	MMP
Executive summary • Background • Objectives of the investigation stage(s) being reported • Scope of work to be, or which has been, undertaken • Summary of conclusions and recommendations	**R**	**R**	**R**	**R**	**R**
Scope of work • A clear statement of the scope of work to be, or which has been, undertaken	**R**	**R**	**R**	**R**	**R**
Site identification • Street number, street name, suburb and town/city • Legal description with lot, deposited plan and certificate of title number(s) • Geographic co-ordinates as per NZ Map Series 260 when dealing with a small part of a larger site • Current site plan with scale bar showing north direction, local water drainage and other locally significant features on-site and immediately off-site. The plan should also show the historical location of structures that may have affected the distribution of contamination (eg, buildings, underground storage tanks, treatment baths, etc) • Locality map	**R**	**R**	**R**	**R**	**R**

Report section(s) and information to be included	PSI	SIR	RAP	SVR	MMP
Site history • Chronological list of site ownership and uses (including the relevant HAIL[2] codes for those uses) indicating information gaps, unoccupied periods and, if relevant, proposed uses • An outline of those contaminants commonly associated with each land use based on Contaminated Land Management Guidelines Schedule B, ANZSIC (1993) codes and AS4482.1/2 (1997 and 1999), and/or from site-specific information • Zoning – previous, present and, if relevant, proposed, with summary of reasons for changes to zoning that have occurred • Details of relevant building and related permits, licences, resource consents, approvals and trade waste agreements with records of compliance • Local usage of ground and surface water resources, including presence, rate and location of abstractions (current and historical) • Site layout plans showing present and past industrial processes • Sewer and services plans identifying active and abandoned services • Historical uses of adjacent land • Relevant complaint history • Local knowledge of site by staff and residents – present and former • Summary of literature relating to the site, including newspaper articles • Review of aerial and site photography with date and location (including direction of photography) indicated on site maps • Description of manufacturing processes • Inventory of materials and waste products associated with site use and their on-site storage and/or disposal locations • Details and locations of current and former underground and aboveground storage tanks with details of integrity testing • Product spill and loss history • Recorded discharges to land, water and air (authorised and unauthorised) • On-site and off-site disposal locations • Contaminant source areas and pathways on-site and off-site • Integrity assessment (assessment of the accuracy of the information)	R	S	S	S	S
Site condition and surrounding environment • Topography, means of measurement and site map • Condition of buildings and roadways • Presence of drums, wastes and fill materials • Odours • Visual or quantified details of surface water quality • Flood potential described or mapped • Conditions at site boundary such as type and condition of fencing, soil stability, erosion, and storm water discharge • Visible signs of contamination such as identifiable waste products, discoloration or staining of soil, bare soil patches – on-site and at site boundary • Visible signs of plant stress • Details of any relevant local sensitive environment – rivers, lakes, creeks, wetlands, local habitat areas, endangered flora and fauna	R	S	S	S	S

[2] Hazardous Activities and Industries List (Ministry for the Environment, 2011b).

Report section(s) and information to be included	PSI	SIR	RAP	SVR	MMP
Geology and hydrology • Background groundwater and surface water quality • Summary of local meteorology • Detailed map and description of location, design and construction of on-site wells, boreholes and pits • Site borehole logs / test pit logs showing stratigraphy using a recognised classification system and depth to groundwater table • Reported range of water table depths below ground surface • Description and location of springs and wells in the vicinity • Location, depth and extent of imported and locally derived fill • Direction(s) and rate of groundwater flow including, where applicable, groundwater levels surveyed to a common datum • Direction(s) of surface water run-off and identification of ponding areas • Preferential flow paths (surface and groundwater)	**A**	**R**	**S**	**S**	**S**
Sampling and analysis plan and sampling methodology • Sampling and analysis data quality objectives • Rationale for the selection of: – sampling pattern, locations and depths (as shown on site maps) – sampling density, including estimated size of the residual hotspots that may remain undetected and statistical confidence in the estimate – which samples are/were submitted for analysis and which samples are/were not analysed – the analytes for each sample and the analytical methods used • Detailed description of the sampling methods including: – sampling devices and equipment type – sampling containers and the type of seal used – sample preservation methods and reference to recognised protocols eg, APHA (1988) or US EPA SW846 (1992) – sample handling procedures – equipment decontamination procedures • Detailed description of any field-screening protocols, methods and equipment, and their calibration	**A**	**R**	**X**	**R**	**R**
Field quality assurance and quality control (QA/QC) • Details of the sampling team, identifying unique initials for each member • Statement of intended duplicate and blank frequency • Records for each sample collected, including date, time and location, samplers' initials, duplicate/blank location and type, analyses to be performed, site observations and weather conditions • Chain of custody, identifying for each sample: sampler, nature of the sample, collection date, analyses to be performed, sample preservation method, departure time from site, dispatch courier used • Background sample, field blank, trip blank, and rinsate sample results and laboratory-prepared trip spike results for volatile analytes • Decontamination procedures carried out between sampling events • Sample-splitting techniques and field instrument calibrations (where used)	**N**	**R**	**X**	**R**	**S**
Laboratory QA/QC • Signed laboratory receipt of signed chain of custody form identifying date/time of receipt and identity of samples included in shipment	**N**	**R**	**X**	**R**	**X**

Report section(s) and information to be included	PSI	SIR	RAP	SVR	MMP
• Record of holding times where not consistent with method specifications • Analytical methods used by laboratory and laboratory accreditation for analytical methods used • Inter-laboratory comparisons for analytical methods used (where available) • Description of spikes and surrogates used, with percent recoveries • Instrument, method detection and practical quantification limits • Standard solution, reference sample and check sample (including daily) results • Laboratory duplicate, blank and standard results					
QA/QC data evaluation • Evaluation of all field and laboratory QA/QC information listed above against the stated data quality objectives, including a discussion of: – documentation and data completeness – data representativeness – precision and accuracy for both sampling and analysis for each analyte in each environmental matrix informing data users of the reliability, unreliability or qualitative value of the data • Data comparability checks, which should include bias assessment arising from various sources, including: – collection and analysis of samples by different personnel – collection and analysis by the same personnel using the same methods but at different times (including seasonal for long-running projects) – use of different sampling or analytical methodologies from those stipulated in guideline documents – spatial and temporal changes (because of environmental dynamics) • Relative percent differences for inter- and intra-laboratory duplicates	**N**	**R**	**X**	**R**	**X**
Basis for guideline values • Table listing all selected guideline values, with references • Demonstration that selection of guideline values is consistent with the principles of *Contaminated Land Management Guidelines No. 2: Hierarchy and Application in New Zealand of Environmental Guideline Values (Revised 2011) (Ministry for the Environment, 2003)* or the *Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health (Ministry for the Environment, 2011)* • Assumptions and limitations of guideline values used	**R**	**R**	**R**	**R**	**R**
Results • Summary of previous results (where applicable) • Site plan(s) showing all samples and sampling locations, giving sample identification numbers and sample depth • Summary of all results in tabular form: – identifying essential details such as sample identification numbers and sample depth – showing comparison with relevant guideline values – highlighting every result exceeding the guideline values • A summary table of results containing the following statistics: minimum, maximum, arithmetic average and 95% upper confidence limit on the arithmetic average for each analyte • Site plan showing the extent of soil and/or groundwater contamination exceeding the relevant guideline values for the medium, location and sample depth	**A**	**R**	**R**	**R**	**S**

Report section(s) and information to be included	PSI	SIR	RAP	SVR	MMP
Site characterisation • Assessment of the type of all environmental contamination, particularly in soil and groundwater • Assessment of the extent of soil and groundwater contamination, including identifiable off-site contamination that may cause environmental effects • Assessment of the potential for chemical degradation or interaction products • Assessment of possible exposure routes and risk to exposed populations (human and ecological risk)	**R**	**R**	**R**	**R**	**R**
Remedial actions • Remediation goal(s) • Discussion of the remedial options available, including the status quo, identifying the means of risk reduction proposed in each • Rationale for selection of the recommended remedial option • Discussion of the extent of remediation required to achieve the remedial goal(s) • Identification of regulatory requirements such as permits, licences and approvals • Pre-remediation site management plan (eg, fencing, warning signs, stormwater diversion, etc) • Names and phone numbers of appropriate personnel to contact during remediation • Demonstration of the disposal route for any material to be disposed off-site • Remediation schedule, including proposed hours of operation • Proposed testing to validate the site during and on completion of the remedial activities • Contingency plan if remedial strategy fails to reach the remediation goals • Staged progress reporting (for long-running projects)	**X**	**X**	**R**	**S**	**S**
Site management plan • Operational remediation site management plan including (where applicable): – community relations – stormwater and soil management – noise and odour control – dust control (including wheel wash) – contingency plans to respond to site incidents to obviate potential effects on the surrounding environment and community – proposed long-term site management – occupational safety and health issues and measures	**X**	**X**	**R**	**S**	**S**
Validation • Rationale and justification for the validation strategy, including: – clean-up criteria selected – statistically based decision-making methodology – validation sampling and analysis plan • Details of statistical analysis of validation results and evaluation against the clean-up criteria • Verification of compliance with regulatory requirements set by all relevant local authorities • Documentation demonstrating that any material moved off-site has been received at point of disposal	**X**	**X**	**X**	**R**	**S**

Report section(s) and information to be included	PSI	SIR	RAP	SVR	MMP
Ongoing site monitoring • Proposed ongoing site monitoring requirements (if any), including monitoring locations, parameters and frequency • Results of monitoring analyses, including all relevant QA/QC requirements stated above • Ongoing site or plant maintenance (eg, containment cap integrity, etc) or contingency plans • Details of those responsible for the maintenance/ monitoring programme(s) • Details to be included in the annual MMP report, including: – any changes to site owner or occupier – any changes to activities undertaken on-site – any changes to the physical layout of the site – any incidents where the management plan has had to be implemented (subsurface works, site development, etc)	**X**	**X**	**X**	**N**	**R**
Conclusions and recommendations • Brief summary of all relevant findings • Assumptions used in making conclusions • Extent of uncertainties in the results • Where remedial action has been taken, a list summarising the activities and the physical changes to the site • A clear statement that the consultant considers the site to be suitable for the current and, where applicable, the proposed use • A statement detailing all limitations and constraints on the use of the site (where applicable) • Recommendations for further work, if appropriate	**R**	**R**	**R**	**R**	**R**

4 Petroleum Underground Storage Tanks

The reporting requirements outlined in Chapter 3 are not necessarily appropriate for reports prepared following the removal of petroleum underground storage tanks. Therefore this chapter gives a checklist to be completed following the removal of underground storage tanks. The checklist has been amended from an original developed by URS (NZ) Ltd, Wellington.

The purpose of the checklist is to ensure consistent and thorough reporting of the removal of underground storage tanks in New Zealand, and is for works and investigations generally in accordance with the following nationally accepted documents:

- *Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand (Revised 2011)* (Ministry for the Environment, 1999)
- *Code of Practice for the Design, Installation, and Operation of Underground Petroleum Storage Systems* (Department of Labour, 1992).

The checklist provides the minimum information required to be provided to regional councils or unitary authorities when underground storage tanks are removed or replaced for Tier 1 investigations. If hydrocarbon impact on groundwater is detected and/or where soil remaining on-site exceeds appropriate Tier 1 soil acceptance criteria, a Tier 2 investigation should be undertaken in accordance with the Ministry for the Environment's *Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand (Revised 2011)* (Ministry for the Environment, 1999) and should be reported in accordance with this guideline.

This checklist is also available electronically at www.mfe.govt.nz/publications/hazardous.

It is not appropriate for this checklist to be used in place of a full site investigation should there be, or have been, other activities or land uses on the site that could cause contamination. It is only intended to be used following the decommissioning of (an) underground storage tank(s) and associated systems (lines, bowsers, fill points, etc). Where there are other potential sources of contamination, a full investigation in accordance with Chapters 2 and 3 of these guidelines should be undertaken.

Report form for the removal and replacement of petroleum underground storage tanks and underground equipment

Checklist	
☐ Company information	☐ Site plan and locality diagram
☐ Site information	☐ Bore/pit logs
☐ Contaminant information	☐ Analytical result sheets / chain of custody
☐ Interpretation	☐ Photographs

Company information			
Oil company name:			
Company representative/ agent:			
Date(s) on-site:			
Ownership:	☐ Company	☐ Operator	☐ Third party
Owner's details (trading name and postal address):			
Current site use:	☐ Service station ☐ Truckstop	☐ Workshop ☐ Other (describe)	☐ Commercial
Reason for removal:	☐ Replacement ☐ Transfer	☐ Partial removal ☐ Other	☐ Complete

Site information			
Name:			
Address:			
Legal description:			
City/district council area:			
City/district council zoning	Site:		
	Adjacent:		
All HAIL activities undertaken on site:			
Dangerous goods officer responsible:			
DGI notified on:		DGI on-site at (*date/time*):	
Number of tankpits:		Number of tanks removed:	

Removed/replaced tank information

Tank/ pit ID	Capacity (*litres*)	Contents (*product*)	Remove/ replace	Age (*yr*)	Material	Holed (*y/n*)	Condition	Pit construction/ condition

Site environment				
Neighbouring land uses *(indicate on site plan)*	North	☐ Industrial/commercial	☐ Residential	☐ Agricultural
	South	☐ Industrial/commercial	☐ Residential	☐ Agricultural
	East	☐ Industrial/commercial	☐ Residential	☐ Agricultural
	West	☐ Industrial/commercial	☐ Residential	☐ Agricultural
Topography:		☐ Sloping	☐ Gently sloping	☐ Flat
Surface covering (*show on plan*):		☐ Unsealed	☐ Mixed seal/gravel	☐ Sealed
Surface drainage/runoff (*show on plan*):		☐ Drains	☐ Soakholes	☐ Interceptor
Underground services (*show on plan*):		☐ Present	☐ Distant	☐ Absent
Could services affect migration?		☐ Yes (to what extent?)		☐ No
Nearest surface water body:		☐ > 100 metres	☐ < 100 metres (*show on plan*)	
Surface water use:		☐ Recreation	☐ Drinking	☐ Irrigation
		☐ Aquaculture	☐ Industry	☐ Shipping
		☐ Not utilised	☐ Not known	

Site soil type log (*lithology if known*): Include anomalous or unusual soil characteristics	Depth (*m*)	Description (*eg, brown silty clay*)

Was groundwater encountered?	☐ No	☐ Yes	Depth (*m bgl*)
Was sheen or free product visible?	☐ No	☐ Yes	If yes, describe and reference photo
Have on-site wells been sampled?	☐ No	☐ Yes	
Checked for separate phase?	☐ No	☐ Yes	

Off-site wells (check with Regional Council):

Well number	Distance from site	Direction from site	Depth (*m*)	Use

Local groundwater flow direction (*if more than one aquifer comment on each aquifer individually*):	

Contaminant information								
Hydrocarbon impact assessment								
Location	Visual inspection		PID reading		Samples taken		Evidence of contamination (*staining, odour, etc*)	Justification for why no samples taken if there was evidence of contamination
	Yes	No	Yes	No	Yes	No		
Tank pit walls	☐	☐	☐	☐	☐	☐		
Pit bedding material	☐	☐	☐	☐	☐	☐		
Under pumps	☐	☐	☐	☐	☐	☐		
Dispensing lines	☐	☐	☐	☐	☐	☐		
Remote fills	☐	☐	☐	☐	☐	☐		
Fill lines	☐	☐	☐	☐	☐	☐		
Vent lines	☐	☐	☐	☐	☐	☐		
Other (*services, etc*)	☐	☐	☐	☐	☐	☐		
Surface soils (*show on plan*)	☐	☐	☐	☐	☐	☐		

Vegetation/soil removal		
Site and near-site vegetation condition:	☐ Good	☐ Poor
Was impacted soil/bedding removed from site?	☐ Yes	☐ No
If yes, how much, where on the site did it come from, and where was it disposed?		

Sampling (*locations shown on plan*) (*ensure sample numbers are same as those represented on site plan*)

Sample	Date sampled	Location	Depth (*m*)	Soil type	Odour?		Remaining/ removed
					Yes	No	
					☐	☐	
					☐	☐	
					☐	☐	
					☐	☐	
					☐	☐	
					☐	☐	
					☐	☐	
					☐	☐	
					☐	☐	
					☐	☐	
					☐	☐	
					☐	☐	
					☐	☐	

Interpretation				
Current site use:	☐ Petroleum use	☐ Industrial/commercial	☐ Residential	☐ Agricultural
Future site use:	☐ Petroleum use	☐ Industrial/commercial	☐ Residential	☐ Agricultural
Adjoining land use:	☐ Petroleum use	☐ Industrial/commercial	☐ Residential	☐ Agricultural
Groundwater use:	☐ Potable	☐ Irrigation	☐ Stock	☐ Not used ☐ Not known
Soil type: * *Considered for groundwater inhalation risk only*	☐ SAND, sandy loams, silty sands ☐ SANDY SILT, silt, silty loam, clay sand ☐ SILTY CLAY, clay loam, sandy clay ☐ CLAY		☐ PUMICE ☐ GRAVELS* ☐ FRACTURED BASALT* ☐ PEAT/ORGANIC SOIL	
Depth to contamination:	☐ < 1 metre	☐ 1–4 metres	☐ > 4 metres	
Depth to groundwater:	☐ 2 metres	☐ 4 metres	☐ 8 metres	☐ Unknown

Human health exposure pathways			
	Pathway	Complete	Incomplete
Current site use ☐ Petroleum use ☐ Industrial/commercial ☐ Residential ☐ Agricultural	Soil ingestion Dermal absorption Maintenance/excavation worker Inhalation of vapour from soil Inhalation of vapour from water Groundwater usage Produce ingestion	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
Future site use ☐ Petroleum use ☐ Industrial/commercial ☐ Residential ☐ Agricultural	Soil ingestion Dermal absorption Maintenance/excavation worker Inhalation of vapour from soil Inhalation of vapour from water Groundwater usage Produce ingestion	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
Adjoining site use ☐ Petroleum use ☐ Industrial/commercial ☐ Residential ☐ Agricultural	Soil ingestion Dermal absorption Maintenance/excavation worker Inhalation of vapour from soil Inhalation of vapour from water Groundwater usage Produce ingestion	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Ecological risk assessment			
	Significantly impacted	Limited impact	Not impacted
Ecological receptors:	☐	☐	☐
Describe all likely receptors:			

Aesthetic issues				
	Significantly impacted	Limited impact	Not impacted	Description of impact (*if applicable*)
Odour	☐	☐	☐	
Soil structure	☐	☐	☐	
Visual	☐	☐	☐	
Vegetation	☐	☐	☐	

Comments

Report prepared by:			
Authorised by:		Date:	

5 Additional Information

The following reference documents contain information that may assist in reporting on contaminated sites.

5.1 New Zealand

Auckland Regional Council (1999). *Trace Element Concentrations in Soils and Soil Amendments of the Auckland Region*.

Centre for Advanced Engineering, University of Canterbury (2000). *Landfill Guidelines: Towards sustainable waste management in New Zealand*.

Ministry for the Environment (1997). *Guidelines for Assessing and Managing Contaminated Gasworks Sites in New Zealand*.

Ministry for the Environment (1998). *Ambient Concentrations of Selected Organochlorines in Soils*.

Ministry for the Environment (1999). *Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand (Revised 2011).*

Ministry for the Environment (2003). *Contaminated Land Management Guidelines No. 2: Hierarchy and Application in New Zealand of Environmental Guideline Values (Revised 2011)*

Ministry for the Environment (2004). *Contaminated Land Management Guidelines No. 5: Site Investigation and Analysis of Soils (Revised 2011).*

Ministry for the Environment (2004). *Contaminated Land Management Guidelines No. 3: Risk Screening System.*

Ministry for the Environment (2006). *Identifying, Investigating and Managing Risks Associated with Former Sheep-dip Sites: A guide for local authorities.*

Ministry for the Environment (2011a). *Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health.*

Ministry for the Environment (2011b). *Hazardous Activities and Industries Lisdt (HAIL).*

Ministry of Health (1995). *Drinking-water Standards for New Zealand*.

Ministry of Health / Ministry for the Environment (1997). *Health and Environmental Guidelines for Selected Timber Treatment Chemicals*.

Occupational Safety and Health, Department of Labour (1992). *Code of Practice for the Design, Installation and Operation of Underground Petroleum Storage Systems*.

Occupational Safety and Health, Department of Labour (1994). *Health and Safety Guidelines on the Cleanup of Contaminated Sites*.

Occupational Safety and Health, Department of Labour (1995). *Code of Practice for the Transportation and Disposal of Petroleum Storage Tanks and Related Wastes*.

Occupational Safety and Health, Department of Labour (1995). *Code of Practice for the Design, Installation and Operation of Underground Petroleum Storage Systems – Supplement 1: Management of existing underground petroleum storage systems*.

Percival HJ, Webb TH, Speir TW (1996). *Assessment of Background Concentrations of Selected Determinands in Canterbury Soils*. Landcare Research Contract Report LC9596/133, prepared for Canterbury Regional Council.

5.2 Australia (New South Wales)

NSW Agriculture and CMPS&F Consultants (1996). *Guidelines for the Assessment and Cleanup of Cattle Tick Dip Sites for Residential Purposes*.

NSW Department of Urban Affairs and Planning / Environment Protection Authority (1995). *Contaminated land. Planning Guidelines for Contaminated Land.*

NSW Department of Water Resources (1992). *A Practical Guide for Groundwater Sampling*.

NSW Environment Protection Authority (1994). *Contaminated Sites: Guidelines for assessing service station sites*.

NSW Environment Protection Authority (1995). *Assessment of Orchard and Market Garden Contamination: Contaminated sites discussion paper*.

NSW Environment Protection Authority (1995). *Contaminated Sites: Guidelines for the vertical mixing of soil on broad-acre agricultural land*.

NSW Environment Protection Authority (1995). *Contaminated Sites: Sampling design guidelines*.

NSW Environment Protection Authority (1995). *Technical Report: Provisional water quality investigations manual – Preferred methods for sampling and analysis*.

NSW Environment Protection Authority (1997). *Bananalands Contaminant Distribution Studies*.

NSW Environment Protection Authority (1997). *Guidelines for Assessing Banana Plantation Sites*.

NSW Environment Protection Authority (1999). *Guidelines on Significant Risk of Harm from Contaminated Land and the Duty to Report*.

5.3 Australian and New Zealand Environment and Conservation Council (ANZECC)

ANZECC (1992). *Australian Water Quality Guidelines for Fresh and Marine Waters*.

ANZECC/NHMRC (National Health and Medical Research Council) (1992). *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites*.

ARMCANZ (Agricultural and Resources Management Council of Australia and New Zealand) / ANZECC (1995). *Guidelines for Groundwater Protection in Australia*.

ARMCANZ/ANZECC (2001). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

NHMRC/ARMCANZ (1996). *Guidelines for Drinking Water Quality in Australia*.

5.4 National Environment Protection Council (NEPC)

NEPC (1999). *National Environment Protection Council (Assessment of Site Contamination) Measure* including schedules:

Schedule B(1)	*Guideline on Investigation Levels for Soil and Groundwater*
Schedule B(2)	*Guideline on Data Collection, Sample Design and Reporting*
Schedule B(3)	*Guideline on Laboratory Analysis of Potentially Contaminated Soils*
Schedule B(4)	*Guideline on Health Risk Assessment Methodology*
Schedule B(5)	*Guideline on Ecological Risk Assessment*
Schedule B(6)	*Guideline on Risk Based Assessment of Groundwater Contamination*
Schedule B(7A)	*Guideline on Health-Based Investigation Levels*
Schedule B(7B)	*Guidelines on Exposure Scenarios and Exposure Settings*
Schedule B(8)	*Guideline on Community Consultation and Risk Communication*
Schedule B(9)	*Guideline on Protection of Health and the Environment During the Assessment of Site Contamination*
Schedule B(10)	*Guideline on Competencies and Acceptance of Environmental Auditors and Related Professionals*.

5.5 South Australian Health Commission, Adelaide (National Environmental Health Forum)

Imray P, Langley A (1996). *Health Based Soil Investigation Levels*, Soil series No. 1.

Lock WH (1996). *Composite Sampling*, Soil series No. 3.

Taylor R, Langley A (1996). *Exposure Scenarios and Exposure Settings*, Soil series No. 2.

5.6 South Australian Health Commission, Adelaide (contaminated sites monographs)

Edwards J, Van Alphen M, Langley A (1994). *Identification and Assessment of Contaminated Land: Improving site history appraisal*, Contaminated sites series No. 3.

El-Saadi O, Langley A (eds) (1991). *The Health Risk Assessment and Management of Contaminated Sites: Workshop proceedings of the National Workshop on the Health Risk, Assessment and Management of Contaminated Sites*.

Langley A, Markey B, Hill H (eds) (1996). *The Health Risk Assessment and Management of Contaminated Sites: Proceedings of the Third National Workshop on the Health Risk, Assessment and Management of Contaminated Sites*, Contaminated sites series No. 5.

Langley A, Van Alphen M (eds) (1993). *The Health Risk Assessment and Management of Contaminated Sites: Proceedings of the Second National Workshop on the Health Risk, Assessment and Management of Contaminated Sites*, Contaminated sites series No. 2.

Olszowy H, Torr P, Imray P (1995). *Trace Element Concentrations in Soils from Rural and Urban Areas of Australia*, Contaminated sites series No. 4.

5.7 US Environmental Protection Agency

US Environmental Protection Agency (1987). *Data Quality Objectives for Remedial Responses,* US EPA 540/G-87/003.

US Environmental Protection Agency (1988). *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA,* OSWER Directive 9355.3-0.

US Environmental Protection Agency (1989). *Methods for Evaluating the Attainment of Clean-up Standards, Volume 1: Soils and solid media,* US EPA 230/02-89-042.

US Environmental Protection Agency (1989). *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A)*.

US Environmental Protection Agency (1991). *Summary Report on Issues in Ecological Risk Assessment*.

US Environmental Protection Agency (1992). *Guidance for Data Useability in Risk Assessment (Parts A and B)* PB92-963356.

US Environmental Protection Agency (1992). *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods, 3rd Edition, SW-846*.

US Environmental Protection Agency (1994). *Guidance for the Data Quality Objectives Process,* US EPA QA/G-4, EPA/600/R-96/055.

US Environmental Protection Agency (1997). *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites:* OWSER Directive 9200.4-17, Office of Solid Waste and Emergency Response.

5.8 Other references

American Public Health Association, American Water Works Association and Water Environment Federation (1998). *Standard Methods for the Examination of Water and Wastewater* (20th edition).

American Society for Testing and Materials (1998). *Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites*.

Australian Bureau of Statistics (1993). *Australia New Zealand Standard Industrial Codes*.

Brisbane Bureau of Emergency Services (1992). *Guidelines for the Assessment of Contaminated Land in Queensland*.

Standards Australia (1997). *Guide to the Sampling and Analysis of Potentially Contaminated Soil – Non-volatile and semi-volatile compounds,* AS4482.1.

Standards Australia (1999). Guide to the Sampling and Analysis of Potentially Contaminated Soil – Volatile substances, AS4482.2.