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Technical Note

INVESTIGATION OF CONTAMINATED SITES

INTRODUCTION

This Technical Note provides an overview of how to investigate sites for the presence of contamination. The Note provides a minimum list of soil and groundwater testing for contaminated sites.

It is recommended that where the presence of contaminated sites is investigated, the works be assessed by suitably qualified staff (environmental specialists and groundwater specialists). Proposals by consultants and contractors should also be assessed by suitably qualified staff.

BACKGROUND

Contaminated ground refers to a soil or rock that includes a foreign contaminant typically from fuel spills, industrial chemicals, mining chemicals, agricultural chemicals, or landfill materials. Contaminated ground tends to result from industrial sites, mining sites, municipal landfills, illegal dumping, etc. Contaminated ground can occur at any depth and at any lateral location. The contaminant may be located within a small area, or may be widespread due to being carried by water or from land use impacts. Depending on the level and concentration of contamination, the current and future use of the site may be impacted.

INVESTIGATION

Contaminated sites must be investigated in accordance with various documents including:

- Australian Guidelines for Water Quality Monitoring and Reporting (Reference 2),
- Australian Standard 4482, Guide to the Investigation and Sampling of Sites with Potentially Contaminated Soils (Reference 3),
- Australian Standard 5667, Water quality – Sampling (References 4 & 5),
- EPA Sampling Guidelines (Reference 7),
- National Environment Protection Measure (Reference 9).

To address the potential harm of contaminated sites, a comprehensive occupational health and safety assessment should be prepared and appropriate personal protective equipment made available.

Contaminated sites may be investigated in two phases:

1) Desktop review and preliminary site investigation,
2) Detailed site investigation.

PHASE 1: Desktop Review and Preliminary Site Investigation

A desktop study of available information is used to assess the potential extent of contamination of the site. The desktop review includes:

- Review of historical records to determine previous use of sites,
- Examination of aerial photographs to assess if the area has been disturbed (e.g. contains imported fill, types of previous land use),
- Assessment of existing geological, hydrogeological, geomorphological and meteorological information to identify potential contamination migration pathways.

The desktop review assesses the potential for contaminated ground and roughly defines the extent of the affected area. The site is normally inspected to confirm the existing features with available information.

When investigating contaminated sites, some limited fieldwork is normally completed at this stage. The fieldwork may include: geophysical survey (e.g. ground penetrating radar), topographic survey, and limited examination of conditions using a backhoe or drill rig.

To indicate the likely hazards that may be encountered in further investigations, a risk assessment should be prepared based on the information from Phase 1.

PHASE 2: Detailed Site Investigation

The outcome from Phase 1 determines the work required for Phase 2 for contaminated sites. Under AS4482 (Reference 3), the information and risks from Phase 1 should be continuously reviewed as the works proceed. It is critical that the Phase 2 investigation is sufficient to fully identify the level, type and location of the contamination.

The key elements for this phase are:

- Identify types and concentrations of contaminants,
- Identify sources of contamination,

- Determine lateral and vertical movement pathways for contamination,
- Identify potential hazards,
- Assess potential risks.

Sampling Grid

The location of sampling points may follow a grid pattern or be concentrated in particular areas based on the specialist's judgement. The grid method can be applied where the investigation is being used to delineate the extent of contamination across the site or to more accurately define the boundaries of known "hot spot" sources of contamination. The grid may take a rectilinear or herringbone form, although the latter is considered the better of the two patterns to produce representative data.

SAMPLING

The sampling methods are chosen based on the requirements of each site to ensure sufficient samples, and to protect the surrounding environment and groundwater. The best techniques also minimise sample exposure, cross contamination and the volume of excavated material produced at the surface. Some common techniques are:

- Shallow test pits by backhoe,
- Hollow or solid stem auger drilling,
- Cable percussion drilling,
- Rotary drilling (including coring),
- Push in soil or groundwater probes.

The techniques above allow the collection of soil or rock samples either from the (hollow) centre of the bore drill or from the outside of the auger. Sonic core drilling is a new technique which has achieved good results in contamination investigations and is being introduced in Australia. Sonic drilling uses high frequency sound waves to penetrate the ground.

Careful consideration is required with schemes using either rotary core or wash bore drilling methods. Both inject large quantities of water-based flushing medium into the ground as part of the drilling process. This can lead to enhanced migration of contamination, as well as possible reaction with contaminants in the vicinity of the borehole, producing consequent reduction in sample usefulness and an increased off-site contamination problem.

Sampling of soil/rock tends to be completed only once. Groundwater and gas should be sampled on several occasions to ensure the samples are representative of the actual condition and composition of the groundwater or gas. Samples of groundwater and gas can be collected using a variety of methods from boreholes. The number of solid samples collected at each location will usually depend on the judgement of the specialist on-site. Sampling should be undertaken by trained staff to ensure the samples are representative.

Sample containers should be clean or sterile before use and must be resealed immediately after use. Containers must be composed of materials which will not react with the sample or otherwise degrade it, and may also contain chemical preservatives to inhibit degradation. Filled sample containers should be stored out of direct sunlight under chilled conditions for transportation from site to the laboratory. The suitable containers which should be used to take samples for particular purposes are given in the relevant EPA document and in AS5667. The sampler will normally take a number of duplicate samples from the same point. About 1kg of solid sample is sufficient for most sets of analyses, while groundwater samples may be as much as 10 litres in total contained in a multitude of containers. Samples of gas may be collected in pressurised sealed stainless steel or glass tubes.

As part of groundwater sampling, certain parameters should always be measured on-site during the sampling process, as they can change markedly when the sample is removed from the ground. These parameters include: alkalinity, pH, temperature, electrical conductivity, dissolved oxygen and redox potential (the tendency of a chemical species to acquire electrons and thereby become chemically reduced).

A number of suitable testing laboratories for sample analysis are available in Victoria and are recorded on the NATA register. It is recommended that when possible the test results be NATA endorsed, although not all tests can carry the NATA stamp. It is important to note that it may be necessary to carry out the more unusual tests at interstate institutions. Analytical methods selected for the work should follow the recommendations in the National Environment Protection Measure (NEPM) Schedule B(3) (Reference 9) or other techniques given in relevant Australian Standards which supersede those listed in NEPM.

Lists of typical tests are given in the Tables 1 and 2. The list represents a mixture of legislative requirements and best practice to avoid human harm, however the list is not exhaustive and a specialist should always be consulted to prepare a testing regime for works of this nature. Further notes on analytes (chemical groups) which should be targeted are provided in NEPM Schedule B(2) for soil or rock samples and Schedule B(1) for groundwater.

The testing regime should be determined only by specialists. Generally an initial screening for each class of analytes would be performed to check threshold concentrations. When the results indicate significant concentrations of analytes, a second series of more specific testing is undertaken to determine specific contaminants. The chemicals targeted may not necessarily have specific trigger values for contamination indication, but may be important in assessing the contamination risk over the site as a whole.

Information gained in the desk top review phase of the work will generally be used to indicate whether specific suites of chemicals should be targeted during analysis.

RESULTS

Laboratories normally only report results of the tests that were requested, and do not provide interpretation of results. The results of the field and laboratory testing should be interpreted only by specialists to determine the extent, type and distribution of contaminated sites.

The results from the testing for contaminated sites should be discussed with geotechnical and environmental experts and the EPA.

Table 1: Basic set of tests for contaminated soil/ rock samples.

Heavy Metals	Cations	Other Tests
Cadmium* Chromium* Cobalt Copper* Iron* Lead* Manganese* Mercury* Molybdenum Nickel* Silver*	Aluminium* Barium Beryllium Bromide Chloride* Fluoride* Nitrate* Nitrite*	Antimony Arsenic* Boron Methyl mercury Selenium Sulphur Total organic carbon
Screening Tests		
Acid/phenoxyl herbicides screen[a]	OP insecticides screen[a]	PCBs (total)[b]
(BTEX) screen[a]: Benzene Cumene Ethyl benzene Styrene Toluene Xylene	Organochlorines screen[a]: Aldrin + Dieldrin Chlordane DDD, DDE, DDT Heptachlor	Phenols screen[a]: Phenol
Chlorinated benzenes screen[a]	PAH screen[a]: Fluorene Naphthalene Pyrene	Plasticisers screen[a]
Chlorinated phenols screen[a]		TPH screen[c]
Cyanides (complexed & free)*		Triazine herbicdes screen[a]

Notes for Table 1:

* Typical inorganic analytes used in initial contamination screen; other inorganics selected during secondary screen

a Screening testes performed if judged appropriate, refer NEPM Schedule B(2)

b Polychlorinated biphenyls (PCBs) targeted if judged appropriate

c Total petroleum hydrocarbons (TPH) screen performed if judged appropriate

REFERENCES

1. *Apello and Postma. Geochemistry, Groundwater and Pollution. A.A. Balkema, Rotterdam, 1994.*
2. *Australian and New Zealand Environment and Conservation Council/ Agriculture and Resource Management Council of Australia and New Zealand. National Water Quality Management Strategy No. 7: Australian Guidelines for Water Quality Monitoring and Reporting, 2000.*
3. *Australian Standard AS4482: 2005. Guide to the investigation and sampling of sites with potentially contaminated soil.*
4. *Australian Standard AS5667: 1998. Water quality – Sampling; Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples.*
5. *Australian Standard AS5667: 1998. Water quality – Sampling; Part 11: Guidance on Sampling of Groundwaters.*
6. *Department of the Environment, London. Sampling Strategies for Contaminated Land. CLR Report No. 4, 1994.*
7. *Environment Protection Authority of Victoria. A Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes, 2000.*
8. *Environment Protection Authority of Victoria. Publication 448: Classification of Wastes. EPA Publication 448.3, 2007.*
9. *National Environment Protection (Assessment of Site Contamination) Measure, National Environment Protection Council Service Corporation, Adelaide, 1999.*

Table 2: Basic set of tests for contaminated groundwater samples.

Screening Tests			
Chlorinated benzenes screen[c]: Trichlorobenzenes	DNAPL screen[c]: Carbon tetrachloride 1,2 dichloroethane Dichloromethane Hexachlorobutadiene Tetrachloroethene	Organochlorines screen[c]: Aldrin + dieldrin Chlordane DDT Heptachlor PCBs	Plasticisers screen[c]: Di-n-butylphthalate Di(2-ethylhexyl) phthalate Other phthalate esters
Chlorinated phenols screen[c]	MAH (BTEX) screen[c]: Benzene Ethyl benzene Toluene Xylene Styrene	PAH screen[c]: Benzo(a)pyrene	TPH screen[c]
		Phenols screen[c]: Phenol	
Other Tests			
Aluminium	Chloride[b]	Magnesium[b]	Selenium
Ammonia[b]	Chromium (VI)	Manganese[b]	Silver
Antimony	Cobalt	Molybdenum	Sodium[b]
Bacteriological testing[d]	Copper[b]	Nickel	Sulphate[b]
Barium	Cyanide[b]	Nitrate[b]	Thallium
Beryllium	Dissolved oxygen[a]	Nitrite[b]	Total arsenic[b]
Bicarbonate alkalinity[a]	EDTA	pH[a] & temperature[a]	Total iron
Biochemical oxygen demand	Electrical conductivity[a]	Potassium[b]	Total mercury[b]
Boron	Fluoride	Redox potential[a]	Tributyl tin
Cadmium	Iron (II)[b]	Total Chromium[b]	Vanadium
Calcium[b]	Lead[b]	Total dissolved solids[b]	Vinyl chloride
Chemical oxygen demand	Lithium	Total organic carbon	Zinc

Notes for Table 2:

a Parameters generally measured in the field immediately after sampling and also in laboratory

b Analytes normally targeted in initial laboratory screening if site history unknown

c Screen for particular analyte suite if predicted to be present on site when site history examined; some specific targets may be listed

d Bacteriological tests that may be required are site specific

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