



INDUSTRIAL WASTE RESOURCE GUIDELINES

SOIL REMEDIATION TECHNOLOGIES IN VICTORIA

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INTRODUCTION

This document provides a matrix of current soil remediation technologies available in Victoria. It is intended as a resource for site owners, developers, portfolio managers and consultants.

In its electronic form it also includes a hyperlink to a document on EPA's website that provides high-level information about thermal technologies.

BACKGROUND

In recent years remediation of soil has become more cost-effective, and the capacity and capability of soil remediation providers have increased considerably.

Contaminated soil can be remediated either **in situ** (soil is left in place), **ex situ** (soil is removed from the ground to a treatment area/plant on site) or **off site** (soil is transported to a treatment facility off site).

Treatment on site means that there will be no costs for transport or disposal to landfill, which includes the gate fee and statutory landfill levy.

MATRIX OF SOIL REMEDIATION TECHNOLOGIES IN VICTORIA

The matrix of currently commercially available soil remediation technologies in Victoria provides an overview of what types of treatment are available for various contaminants.

It also gives an indication of where the remediation can take place (in situ, ex situ, off site or mobile) and how much time is required for treatment.

EPA urges managers of contaminated sites to look into the applicability of suitable technologies and investigate the total cost and time required for remediation.

While some technologies will remediate soils relatively quickly, there may be high setup, excavation and/or analytical costs. Most remediation activities will also

require a number of statutory approvals (for example, EPA works approval, air monitoring requirements or dangerous goods requirements). It is important to note that the time estimations in this matrix do not allow for such requirements.

Feedback on this information is welcome. Please email business.programs@epa.vic.gov.au

A glossary is attached to provide a non-technical description of terms.

This guidance forms part of the Industrial Waste Resource Guidelines, which offer guidance for wastes and resources regulated under the *Environment Protection (Industrial Waste Resource) Regulations 2009*. Publication IWRG622.1 – September 2011. This replaces publication IWRG622, published April 2010.



SOIL REMEDIATION TECHNOLOGIES IN VICTORIA

Treatment	Sub-group	Description	Applicable contaminants	Remediation location (off site = soil is transported off site; ex situ = on site but excavated; in situ = on site in ground; mobile = treatment unit is moved from site to site)	Remediation duration (Short = hours to days; Medium = weeks to months; Long > 6 months)
Bioremediation	Composting – Gippsland Water’s Dutson Downs SORF (Soil and Organics Recycling Facility)	Naturally occurring microbes break down the organic compounds to carbon dioxide, water and soil organics in a controlled environment (in-vessel composting).	TPHs, MAHs PAHs	Off site	Medium
	Composting (including biopiles, enhanced bioremediation)	Addition of organic bulking agent to accelerate the degradation of contaminants.	VOCs, halogenated VOCs, SVOCs, TPHs, explosives	In situ, ex situ, off site	Long
	Phytoremediation (e.g. phytoextraction, phytostimulation, phytostabilisation, rhizodegradation)	Utilisation of natural plant processes to enhance degradation and removal of contaminants. Processes vary depending on which remediation technology is used.	VOCs, halogenated VOCs, SVOCs, inorganics, TPHs, heavy metals	In situ, ex situ	Long
Thermal treatment	Direct-fired thermal desorption	Soil is heated to 500 °C in a rotary kiln to evaporate contaminants. Contaminants are destroyed through heating of vapours to > 1100 °C. Scrubbers and filters deal with the destruction by-products (e.g. acids, particulates).	TPHs, PAHs, OCPs, PCBs, dioxins, furans	Mobile, ex situ	Short
	Enhanced thermal conduction process	Hot air is piped through soil to turn contaminants into gases. The gases are then transferred to a pyrolysis unit, where they are transformed into carbon dioxide and water.	PAHs, PCBs, chlorinated organics	Ex situ	Short to medium



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	Electro Thermal Dynamic Stripping Process	Soil is heated in situ by strategically placed electrodes. This increases the volatility of contaminants, which are destroyed or reused after extraction from the soil using soil vapour extraction or multiphase extraction.	VOCs, SVOCs, PAHs, TPHs,	In situ	Medium
Chemical	Reduction/oxidation or redox	Involves chemical reactions that change contaminants to compounds that are less toxic, more stable, less mobile or inert. Redox reactions are short for reduction-oxidation reactions and occur when electrons, hydrogen or oxygen are exchanged between one substance and another.	VOCs, halogenated VOCs, halogenated SVOCs, explosive residues, nonmetals, PAHs, pesticides, herbicides	In situ, ex situ, off site	Medium
Physical/chemical	Soil washing	Soil washing physically separates contaminants from soil. Chemicals, such as surfactants, complexing agents, alkalis, acids and flocculants, are commonly added during the process to further improve the separation efficiency. This technology does not destroy contaminants. It increases the volume of useable soil by removing the contaminants originally held within it.	TPHs, PAHs, halogenated hydrocarbons, PCBs, heavy metals, pesticides, herbicides	Ex situ, mobile	Short
	Soil immobilisation (also known as stabilisation/solidification/vitrification)	Contaminant solubility, hazard or mobility is decreased through the use of chemical or physical binders (for example, Portland cement, calcium carbonate, manganese oxides).	Heavy metals, PAHs, other organics	Mostly off site	Short
Physical	Soil vapour extraction (multiphase extraction)	Removal and capture of solid contaminant forms that are easily changed into gases by using forced air currents to move the contaminants out of the soil, so they can then be collected.	VOCs, halogenated hydrocarbons, hydrocarbons	Mostly in situ but also ex situ	Medium to long

GLOSSARY

Full name	Abbreviation	Description
Aromatic hydrocarbons (polycyclic aromatic hydrocarbons or monocyclic aromatic hydrocarbons)	PAHs, MAHs	Aromatic hydrocarbons are very stable compounds. Many of the earliest known aromatic hydrocarbons, such as benzene and toluene, possess a distinctive odour, which led to the use of the term 'aromatic' for this group of substances. Aromatic compounds that contain one benzene ring are known as monocyclic aromatic hydrocarbons (MAHs). Those with more than one benzene ring are called polycyclic aromatic hydrocarbons (PAHs). Some PAHs are known to cause cancers, mutations and birth defects. Industrial sources of PAHs include refineries, paper mills and asphalt production. PAHs occur naturally as a result of incomplete burning during wildfire. Exhaust fumes from motor vehicles also contain PAHs.
Benzene, toluene, ethylbenzene, xylene	BTEX	BTEX is an abbreviation of four substances that are often discussed together because they are the important gas-forming substances found in petroleum products such as petrol.
Biopile		A biopile can be considered as a mound of contaminated soil. Aerobic microbial activity is stimulated within biopiles through aeration/mixing, or addition of nutrients, minerals and moisture.
Dioxin		Dioxins are a group of pollutants that are formed during combustion in industrial processes, such as paper pulp bleaching and herbicide manufacturing, as well as during waste incineration and forest fires. Dioxins are known to accumulate in humans and wildlife, are teratogenic, mutagenic and carcinogenic.
Furan		Furan is a colourless and flammable liquid. It is toxic and a possible human carcinogen. Furans can also be used to denote a family of related chemicals with similar properties to the specific chemical furan. Furans are used in industry to dissolve substances and can be produced from natural substances, such as pine, oats and corn, with strong acids.
Halogenated		A compound is halogenated if it contains one or more halogen elements: fluorine, chlorine, iodine, bromine or astatine.
Heavy metals	e.g. As, Zn, Pb, Cd, Hg, Ni, Cr	The term 'heavy metal' is used here to encompass metallic elements and metalloids, such as lead (Pb), zinc (Zn), arsenic (As), cadmium (Cd), mercury (Hg), chromium (Cr), copper (Cu), molybdenum (Mo), antimony (Sb) and nickel (Ni). Some heavy metals are naturally present in the environment at trace concentrations or in a particular valency, at which they may be an essential nutrient to humans and other life forms. Other heavy metals (including cadmium, arsenic, lead and mercury) are toxic in any concentration or valency.
Organochlorine compounds	OCCs	Organochlorine compounds (which also include dioxin and furans) are predominantly human-made compounds that are very stable in the environment and are rapidly absorbed by organisms. Organochlorine compounds are known endocrine disruptors and it is considered highly likely that many of these compounds are carcinogenic (for example, 'Agent Orange').
Organochlorine pesticides	OCPs	Organochlorine pesticides are insecticides composed primarily of carbon, hydrogen and chlorine. Most break down slowly and can remain in the environment long after application and in organisms long after exposure. Common OCPs include DDT, Aldrin, Dieldrin, toxaphene and chlordane.
Polychlorinated biphenyls	PCBs	Polychlorinated biphenyls are part of a group of persistent, toxic organic pollutants. PCBs are odourless and tasteless liquids. Up until the late 1970s PCBs were widely used in the production of transformers, capacitors, flame retardants and sealants. In 1975, Australia banned the importation of PCBs. The International Agency for Research on Cancer considers it highly likely that these compounds are carcinogenic. PCBs are confirmed endocrine disruptors and have been linked with the occurrence of diabetes.
Semi-volatile organic compounds	SVOCs	Semi-volatile organic compounds are a group of substances, including polyvinyl chlorides (PVC), perfluorocarbons and halogenated flame retardants, that have higher vapour pressures than VOCs. Impacts on health are more likely due to contact with materials, rather than inhaling of gaseous emissions.



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Total petroleum hydrocarbon	TPHs	Total petroleum hydrocarbon is an umbrella term that refers to a large family of several hundred substances derived originally from crude oil. TPHs include BTEX, jet fuel and naphthalene. Exposure to TPHs can result in a number of negative health effects, such as headaches, damage to nerves or internal organs and dizziness.
Volatile organic compounds	VOCs	Volatile organic compounds form a large and diverse group of substances, including hydrocarbons, oxygenates and halocarbons, that readily evaporate at room temperature. VOCs are ubiquitous in the environment. The most common natural VOC is methane. Industrial sources of VOCs include paints, fossil fuels, and adhesives. Many VOCs (e.g. formaldehyde) are known to cause 'sick building syndrome', which can cause irritated airways, eyes and skin, and general hypersensitivity.