Soils Limited Guide to Site Remediation:

Site remediation in the 20th century was often as simple as excavation of the contaminated soils and their removal to a suitable landfill ('dig and dump'). However, with landfill space rapidly dwindling, a growing awareness that treatment (i.e. destruction of contamination) is better than relocation, and an increasing appreciation that on-site treatment is better than taking material off-site, the 21st century is seeing a proliferation of on-site treatment techniques.

These can be broken down broadly into ex-situ or in-situ methods.

- *Ex-situ* methods require the contaminated soil to be excavated, and the treatment is managed above-ground. This allows better control of soil conditions and hence gives a faster and more reliable result, but is limited to material which is economically excavable.
- *In-situ* methods tend to be more expensive, less reliable and more open-ended in term of timescale, but may be the only way to control risks to deep groundwater, for example to protect a drinking water abstraction point.

Techniques available include:

- *Activated Carbon Treatment.* Used for treating off-gases or groundwater. Expensive, but may work where nothing else will.
- *Air Stripping (Soil Vapour Extraction).* Used for removal of volatile organic contaminants.
- *Bioremediation.* Used for destruction of an ever-widening range of organic pollutants, particularly the most common contamination due to petroleum hydrocarbons. Ex-situ and in-situ versions available. Often the cheapest option, and highly sustainable, but not suitable for all organics and may also take too long or be too unpredictable.
- *Capping.* Often a simple and safe way to break exposure pathways and reduce risks, but does not 'treat' the contaminants
- *Chemical Dehalogenation.* An in-situ method for treating chlorinated man-made compounds.
- *Chemical Oxidation.* A method for destruction of organics that may not be susceptible to other techniques. Expensive but may be applied in- or ex-situ.
- *Excavation.* This still has a role, for example when contaminants are not amenable to other forms of treatment.
- *Fracturing.* Used to increase the flowpaths in, for example, deep chalk, to complement in-situ treatment.
- *In Situ Flushing*. This uses surfactants or solvents to wash contaminants out of the soil.
- *In Situ Thermal Treatment Methods.* Heating the soil can be used to vapourise organic contaminants, allowing them to be safely drawn off.
- *Incineration.* An ex-situ method which tends to be expensive but reliable, and may be economical where the contaminant has a high calorific value (e.g. tar) or may be useful where incineration is the only method of destruction.
- *Monitored Natural Attenuation.* This increasingly popular in-situ approach relies on the fact that many contaminants naturally degrade safely, and if this can be proven to be occurring and demonstrably is dealing with potential risks, may allow more expensive interventions to be avoided.

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- *Permeable Reactive Barriers.* An in-situ method which relies on interception and filtering or destruction of a moving plume of contamination in groundwater. Now with several variants suitable for many different pollutants.
- *Phytoremediation.* Many plants can immobilise or destroy contaminants, so for some sites it may be appropriate to alternately plant and harvest as a means to reduce contamination.
- *Pump and Treat.* This combined in/ex-situ technique relies on intercepting the plume and pumping the contaminated groundwater to the surface, where the contamination can be removed or destroyed by a variety of methods.
- *Soil Vapor Extraction and Air Sparging.* An in-situ method using vacuum extraction and/or pumped air (above and/or below groundwater level) to drive off and capture or destroy volatile contaminants.
- *Soil Washing.* The ex-situ equivalent of soil flushing, where excavated soils are washed with solvents or surfactants to remove contamination.
- *Solidification/Stabilization.* A complement to capping, this method may be applied in- or ex-situ to trap and immobilise contaminants in the soil, e.g. by excavation, addition of cement and replacement.
- *Solvent Extraction.* See soil flushing and soil washing. In certain circumstances it may be possible to use two solvents and recycle the first, a cost-effective treatment for certain organics.
- *Thermal Desorption.* Not as expensive as incineration, this ex-situ method relies typically on rotating cement kiln technology to heat soil and drive off organic contaminants as vapours.
- *Vitrification*. Literally glassification of soils, using extreme heat or strong electric currents. Very expensive, but in critical situation may be the least worst option, e.g. for the safe immobilisation of heavy metals or radionuclides.

Often a combination of two or more techniques is optimum. The choice of technique – and correct management of it – are best left to specialist brownfield consultants and contractors. Many factors need to be taken into account, including site suitability, the detailed risk assessment results, the nature of the proposed development, sustainability issues, health and safety issues, regulator attitudes, whether the cleanup is simply legislation-driven or aspires to meet higher standards, what the stakeholders can agree on, technical suitability and feasibility, and – not least – the cost-effectiveness and treatment timescale required.