Landfarming: Technical Practice Note

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Note

This best practice note is advisory only. It has been prepared to assist practitioners on contaminated land in NSW. It should be read in conjunction with guidance documents, recognised industry best practice, standards and other technical publications.

The note will be revised from time to time following feedback from stakeholders, ensuring its ongoing relevance and reflecting advances in best practice as the result of regulator and industry experience. Comments are welcome and should be sent to: contlandmgnt@environment.nsw.gov.au

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1. Introduction

This technical note aims to assist those undertaking landfarming in NSW to ensure offences are not committed under the Protection of the Environment Operations Act 1997 (POEO Act); in particular with regard to the uncontrolled release of emissions to air, land and water. This technical note does not provide advice on the application of the landfarming technique, but outlines appropriate control measures that the Office of Environment and Heritage (OEH) recommends should be used to minimise environmental impacts arising from the process. This technical note does not provide guidance for control measures required at permanent or commercial landfarms.

OEH encourages the use of on-site, in-situ, emission controlled and economical treatment technologies. This approach is consistent with the National Environment Protection (Assessment of Site Contamination) Measure (NEPM) hierarchy for site remediation or management (ref. 16)

If appropriately controlled, landfarming is a practical, effective, durable and cost-effective method for the treatment of certain organic contamination within soils. The soils can be treated on-site to a condition whereby they become suitable for re-use, thereby minimising the requirement for off-site disposal.

A review of the current best available guidance for the Landfarming process has been undertaken in compiling this note, the references for which are included at the end of this best practice note, and these should be referred to for further information.

2. Basic Process Description

Landfarming is a biological process which uses naturally occurring micro-organisms (e.g. bacteria and fungi) to eliminate, attenuate or transform polluting or contaminating substances to minimise the risks to human health or the environment (ref. 2). The mere removal of volatile constituents from soils through evaporation (i.e. a physical process only) is not acceptable to OEH, unless the volatile constituents are captured and appropriately treated. If it cannot be demonstrated that biodegradation occurs then it is not landfarming.

Landfarming is often used at petroleum refineries as a means of remediating tank sludges and contaminated soils. It is frequently used for treating superficial hydrocarbon impacted soils typically found at petroleum storage sites.

Landfarming is an above-ground process which involves the spreading of excavated contaminated soils in a thin layer (generally <0.3m - ref. 2) on a suitably prepared surface, followed by the stimulation of aerobic microbial activity within the soils through aeration and/or the addition of minerals, nutrients and moisture. The movement of oxygen through the soil promotes aerobic degradation of organic chemicals. Landfarming is a passive form of remediation and generally requires an extended timeframe. (Ref. 3).

Landfarming may be a suitable remediation option for sites that are remote from residential areas or on sites that have soils with low concentrations of volatiles, so long as all potential emissions to air, land or water are thoroughly managed. If there are high concentrations of volatiles present and the soil is to be excavated, the soil will need to be vented and emissions controlled before excavation. (Ref. 13).

Landfarming is suitable for the treatment of a variety of organic chemicals including:

- Benzene, toluene, ethlybenzene and xylenes (BTEX);
- Total Petroleum Hydrocarbons (TPH) (e.g. diesels, light lubricating oils, crude oil);

- Polycyclic aromatic hydrocarbons (PAHs – e.g. particularly the lower ringed aromatic compounds such as naphthalene and phenanthrene);
- Phenolic compounds;

Biodegradation rates are generally higher for saturated hydrocarbons followed by monoaromatic (e.g. BTEX, phenols) and the lighter polyaromatic hydrocarbons (e.g. 2,3 and 4 ringed PAHs)(ref. 2). Long chain and high molecular weight hydrocarbons (generally 20 carbon atoms or higher) are more resistant to biodegradation, but are still biodegradable. Soils containing >8% TPH concentrations are not generally suitable for landfarming (Ref. 6), as high concentrations of oil, grease and tar can physically block pore spaces in soils limiting mass transfer of nutrients, water and oxygen into the soils and "smothering" the landfarm process (ref. 8). Landfarming is not a suitable treatment method for heavy metals, complex PAHs or chlorinated hydrocarbons, and high concentrations of these contaminants in the soil may inhibit microbial degradation. (Ref. 2).

A considerable percentage of the lighter, more volatile petroleum products will be lost by evaporation during aeration of the landfarmed materials and to a lesser extent, degraded by microbial action; the heavier, non-volatile petroleum products will not evaporate and these products will be primarily broken down by biodegradation processes, but over a longer time period.(Ref. 5). Control of volatile organic compounds (VOCs) may be required if the materials being landfarmed primarily comprise the lighter petroleum products.

It is acknowledged that some volatilisation will occur, particularly for more highly volatile contaminants; therefore, using landfarming as a remedial technique requires measures to be taken that optimise/maximise biodegradation and minimise volatilisation. If there is uncertainty as to the effectiveness of landfarming in biodegrading the contaminated soils, treatability studies should be undertaken as a means of determining that the degradation is due to biological processes and not to abiotic processes such as volatilization and photodecomposition. These studies will also provide important design information required for the success of the landfarm as well as providing an estimate of the potential time-scales for achieving the remedial target concentrations.(Ref. 6) Treatability studies can comprise both Laboratory and/or field trials.

3. Process Controls

Biodegradation is enhanced by optimising and controlling a number of key environmental parameters, which include the following:

- ***Oxygen*** - it is crucial that aeration of the landfarmed soils is sufficient to promote optimal microbial degradation of the contaminants, but low enough to prevent excessive volatilisation of volatile compounds (e.g. BTEX) (Ref. 2);
- ***temperature*** - ideally within the range of 10-45°C (ref. 6) – biological activity is regulated by soil temperature;
- ***pH*** - ideally within the 6 to 8 range (ref. 2) to support bacterial growth of the microorganisms, pH also has a large effect on the availability of nutrients, mobility of metals, rate of abiotic transformation of organic waste constituents and soil structure;
- ***nutrient balance*** - the application of additional nutrients may be required to optimise the biodegradation processes, (e.g. addition of manure, fertilizers);
- ***moisture*** - the ideal range for soil moisture is between 12 – 30% by weight (ref. 5), or between 40 and 85% of the field capacity (ref.2 and 5) soils should be moist but not wet as too much moisture restricts the movement of air through the soil;

- *soil texture* (permeability, bulk density) - Soils that clump together (e.g. clay soils) are difficult to aerate and result in low oxygen concentrations (ref.5), the major nutrients limiting biodegradation are nitrogen and phosphorus.

Organic amendment such as wood chips, sawdust, straw, hay and animal manure are used to improve soil structure and oxygen infiltration and to increase the moisture holding capacity in sandy soils.

Mixing (aeration) should be performed at regular intervals to enhance the oxygen infiltration, mixing of hydrocarbons and homogenisation of soils, nutrients, water, air and microorganisms and increases biodegradation rates.

4. Environmental Control Measures

When appraising whether Landfarming is a suitable remedial option for a site, a number of factors need to be assessed and should be detailed within the Remedial Action Plan (RAP), as a single overriding factor can make a site unsuitable for landfarming. In particular, an assessment of the suitability of the proposed treatment location needs to be considered, including area available, site topography, local geology, hydrogeology, proximity to surface water, proximity to groundwater bores, location to nearest residential housing etc.

Any proposal for landfarming should demonstrate adequate safeguards for the protection of human health and the environment. The potential for uncontrolled emissions (e.g. VOCs, leachates) and other adverse effects arising during treatment needs to be considered on a site specific basis taking into account the nature of the contamination and the conditions of the site. Landfarming sites should not be located in sensitive areas (e.g. near residential dwellings).

Detailed below are a number of environmental control measures, the requirement for which needs to be determined when considering whether landfarming is a suitable remedial option for a site. If specific control measures are not considered applicable for a site, these should be documented, with justification provided as to why any control measures are not required. The requirement for particular control measures will have a considerable influence when assessing the cost-benefits of Landfarming as a remedial option.

1. ***Control of volatile emissions*** – volatile emissions need to be controlled both during the excavation of the contaminated soils as well as during the operation of the landfarming process. Air emission controls (e.g. covers, structural enclosures, abatement techniques) may be required if volatile constituents are present in the landfarmed soils. To ensure compliance with air quality regulations the need for air emission controls will need to be determined on a site specific basis and will depend on a number of factors (e.g. nature of contaminated material, location of sensitive receptors). (Ref. 5). The requirement for any control/treatment measures will need to be determined during the remedial options appraisal for the site and if required, appropriate vapour treatment technology should be specified, including operation and monitoring parameters and these should be detailed within the remedial action plan (RAP) and subsequent Environmental Management Plan (EMP).
2. ***Control of leachate and stormwater*** - water management systems for control of run-on and run-off are necessary to avoid saturation of the treatment area and release of leachate from the landfarmed soils. Run-on can be controlled by bunds or ditches which intercept and divert the flow of stormwater away from the landfarmed material. Leachate and surface water run-off can be controlled by diversion of water/leachate to a suitably lined retention pond where it can be either recycled over the landfarmed materials to maintain moisture content, stored, or treated and either released to stormwater, sewer or if required, tankered off-site for off-site treatment and disposal. (Ref. 5). A grade should be created to allow for the drainage of surface water /

leachate. The minimum gradient recommended is 2% so that the final floor level has a gradient sufficient to enable surface water / leachate to drain to a suitably lined retention pond. Leachate retention ponds should be within a bunded area. Heavy rainfall will impact the amount of leachate and covering the landfarmed soils may reduce the amount of leachate generated.

To ensure leachate from the landfarmed soils does not impact the underlying groundwater, the landfarm should be located on a suitable low permeability liner, which can comprise compacted clay or another impermeable material with a permeability equal to or less than 10^{-9}m/s (ref 4). A suitable depth of sacrificial material must be placed on top of the liner to protect the liner during tilling and placement / removal of soils (ref. 7).

3. ***Control of dust*** – Dust may be generated during the excavation and mixing of the soils. Dust and soil erosion may be controlled by use of covers, bunds/berms, or nets. Bunds/berms or nets should be constructed around the entire perimeter of the landfarm, the height of which should be sufficient to contain the dust / soils.
4. ***Control of odours*** – Odours may be generated during the excavation and mixing of the soils. Odours are difficult to control but control measures may include the use of odour suppressants/foggers, the use of biodegradable foams and/or locating the landfarmed soils in remote areas away from sensitive receptors.
5. ***Other controls*** - The site should be clearly demarcated with appropriate signage to prevent unauthorised public access.

Regular environmental monitoring will be required to ensure the emission control measures are effective during the operation of the landfarming process.

5. Landfarming Strategy

Prior to undertaking landfarming on a site an appropriate landfarming strategy needs to have been developed and implemented. This strategy should be detailed within the Environmental Management Plan for the site, which should include the following details:

- Location and layout plans of the proposed landfarm showing its proximity to sensitive receptors, such as surface water, residences, infrastructure, groundwater bores etc., and the space available on the site for the landfarming process. Generally landfarming needs to be carried out on large isolated sites, (>0.5ha).
- List of the main contaminants of concern and their maximum concentrations.
- The volume of soil requiring treatment.
- Details of baseline sampling of soils above which the landfarmed soils are to be placed.
- Local climatic conditions, including average rainfall, temperature, prevailing winds – prevailing winds can dictate the location of the landfarm with reference to nearby populations (ref. 6)
- Information on the materials to be used to construct a low permeability liner for the base and retention ponds.
- Details of air emission control measures and air quality monitoring.
- Details of stormwater, leachate and run-off management, including details of groundwater and / or surface water monitoring.
- Details of odour control and monitoring requirements.
- Details of measures to be taken to control dust and erosion of soils from the landfarmed area.

- Details of the proposed soil sampling and analyses program, including the remediation target levels and predicted timescales for completion of the landfarming process.
- Details of the monitoring undertaken to ensure the optimisation of biodegradation rates during the landfarming process. The monitoring should include the assessment for the reduction in contaminant mass, rates of CO2 production and biodegradation (generation of intermediate products), oxygen, moisture, nutrient levels, temperature, pH etc.
- Details of how often the landfarmed soils will be mixed (aerated), and the requirement for the addition of nutrients.
- Details of the proposed uses of the treated soils and contingency measures if the soils do not meet the set target concentrations within the timescales. Any materials removed from the site will be characterised as waste and will need to be dealt with in accordance with the NSW Government's framework for managing wastes.
- Details of proposed community consultations, including details of how complaints will be handled.

Landfarming must comply with all legislative requirements.

6. Validation

The time frame for landfarming is site specific and treatment is complete when the remedial target levels have been achieved for the specified use of the soils, and it is confirmed that the chemicals of concern no longer present a risk of harm to human health or the environment. The number of samples collected and analysed for the validation of landfarmed soil should be adequate to provide a statistically reliable result, taking into account the intended use of the soils. (Ref. 3). After removal of the landfarmed soils the underlying area should be validated to confirm that contamination has not migrated vertically through the underlying liner (Ref. 4).

All information of the landfarming process, including all environmental monitoring data collected during the landfarming process and validation results of landfarmed soils and the underlying soils should be detailed within a validation report for each site. The validation report should also include records of all measures that were taken to ensure biodegradation of the contaminated soils was optimised and volatilisation kept to a minimum, including details of any lab/field trials.

This Technical Note outlines OEH's expectations for those who undertake landfarming remediation practices in NSW. Failure to comply with these guidelines, resulting in a breach of the Protection of the Environment Operations Act 1997, may result in enforcement action being taken by OEH.

References

Landfarming Guidance used in the preparation of this best practice note:

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Other useful references

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Links were current at the time of publication.