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Assessing the risk of pollution from historic coastal landfills

Executive Summary for the Environment Agency

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Executive Summary

1264 historic landfill sites in England are in coastal and estuarine locations that are low-lying and may be at risk of flooding and/or erosion if flood defences are not adequately maintained. With the predicted increase in sea level and extreme weather events due to climate change, it is increasingly likely that coastal and estuarine landfills will be inundated or breached, which could result in the release of leachates or highly contaminated solid waste materials to the intertidal zone. Coastal management budgets are limited and, therefore, it is important to understand which historic coastal landfills pose the greatest pollution risk in order that expenditure on mitigation works can be prioritised. This report presents research into the potential environmental impacts resulting from flooding or erosion of historic coastal landfills, and proposes a new historic coastal landfill risk screening method, which would support coastal landfill managers in prioritising resources on the sites that pose the greatest pollution risk. Previous research

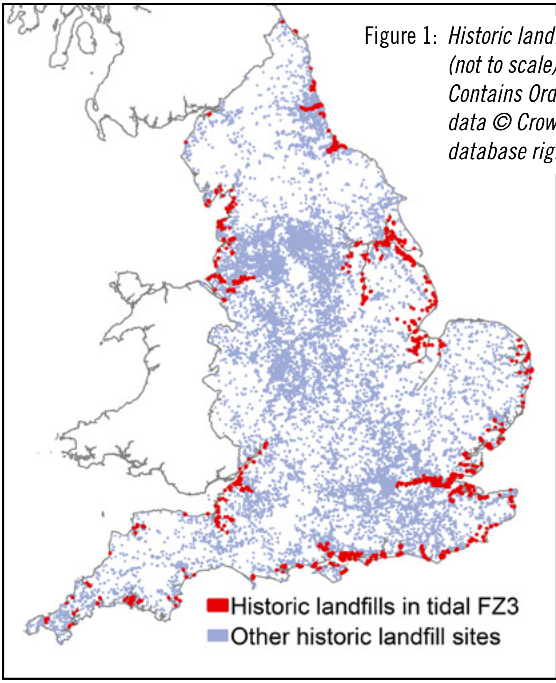

Figure 1: *Historic landfill sites in England (not to scale) (EA, 2015b; Contains Ordnance Survey data © Crown copyright and database right 2016.)*

has focused on the risk of pollution from landfills due to the release of leachates under normal operating conditions, i.e. waste is fully contained and the landfill is not flooded. This is the first research to assess the risk of estuarine or coastal pollution in the event of historic coastal landfills in England being inundated or waste eroding from them.

Two historic coastal landfills in Essex have been used as research sites: Hadleigh Marsh landfill, a waste filled flood embankment, and Leigh Marshes landfill, a recreational area protected by a flood defence. Waste samples were collected by excavating two trial pits in each of the landfill sites. The waste was analysed for a suite of major and trace metals, and for Polycyclic Aromatic Hydrocarbons (PAHs). Contaminant concentrations were found to vary significantly within individual trial pits, between different trial pits in the same site and between the sites. The heterogeneity of the contaminants was found to be so great that obtaining representative contaminant datasets is considered unlikely to be feasible for most landfill sites due to the sampling resolution needed and the associated resource requirements. Therefore, this research concludes a more practicable approach to localised studies would be to undertake limited sampling and analyses to determine the types of materials present and obtain indicative

Photo 1: *Historic landfill waste in situ in Hadleigh Marsh waste filled embankment.*

contaminant datasets that are likely to be within the same order of magnitude as those from more intensive site investigations and, therefore, would provide a reasonable indication of the pollution potential of a site. When assessing multiple landfills even limited sampling and analyses are likely to be prohibitively expensive. Therefore, for risk screening assessment purposes, it is proposed that risk categories are assigned based on landfill types to avoid incurring the costs of obtaining contaminant datasets (after Alaska Department of Environmental Conservation, 2015).

There are no specific standards or guidelines for assessing the pollution risk from eroded landfill waste. So, on the assumption that any eroded solid waste materials will ultimately breakdown and become incorporated into sediments, contaminant concentrations in the waste samples were compared to Canadian Sediment Quality Guidelines, which are commonly used in the absence of UK sediment quality guidelines. This research has found that contaminant concentrations in matrix materials (fine and medium grained soil like particulate materials in the waste), wood, paper and textiles from the landfill sites exceed Canadian Sediment Quality Guidelines. For example, median lead concentrations in matrix materials from Leigh Marshes exceed probable effects levels by a factor of 12, signifying there are likely to be significant adverse ecological effects if the waste from the sites erodes into adjacent intertidal habitats and/ or tidal waters. The pollution risk from eroded waste materials is of particular concern as there are multiple designated ecological sites in the Thames Estuary adjacent to the research sites, and across England at least one-third of historic landfills are in or within 100 metres of at least one designated ecological site. In addition, the landfills are located near bivalve mollusc production areas and tourist resorts, which rely on bathing water beaches to attract visitors and are likely to be adversely affected if waste materials erode from the landfills and wash-up on

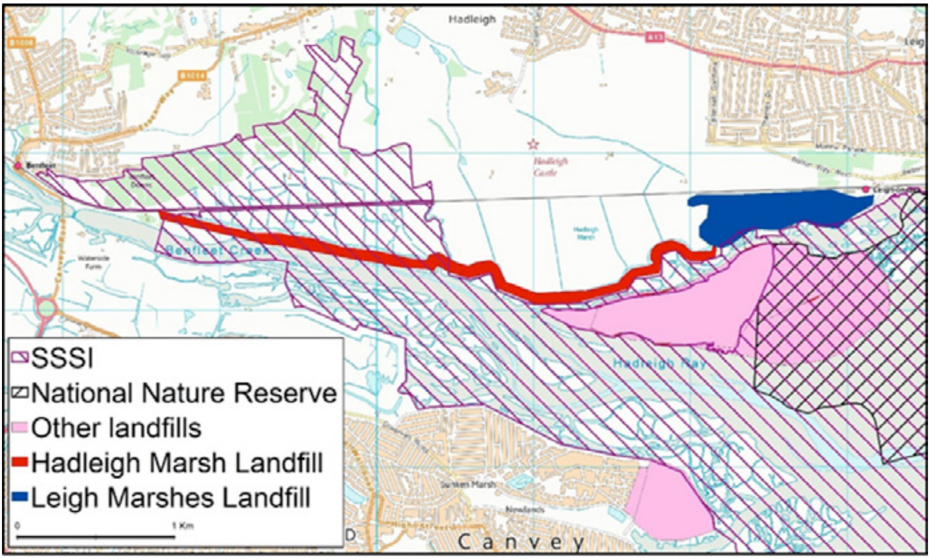

Figure 2: *Hadleigh Marsh and Leigh Marshes landfills and the adjacent estuary have multiple environmental designations, including SSSI and NNR (© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2014. © Crown copyright. All rights reserved. Natural England [2015]). (North up the page)*

the beaches. It is clear that in the short-term these landfill sites and their defences must be maintained to prevent any contaminated materials being released while sustainable management strategies are developed. In the long-term it may be necessary to relocate the waste if climate change pressures prohibit continued maintenance of the landfills.

In addition, leaching experiments were carried out using matrix material samples from the waste in order to assess the potential for the pollution of surface waters by soluble metals in the event of landfills being flooded or eroded. These experiments showed that seawater flooding of landfills could increase the proportions of metal contaminants released up to 5,450% (median values) compared to freshwater flooding; however, for most metals analysed the proportion released to solution would still be significantly less than 1% of the total mass of those metals in the waste. It is likely that metals leached by inundation of the waste in situ will be attenuated by surrounding sediments, but if waste is eroded then metals will be leached directly into surface waters. For the research sites, there are unlikely to be any adverse effects on surface water quality due to leaching metals, because the very high volume of water in the Thames Estuary would dilute soluble metal concentrations to significantly below annual average and maximum allowable concentration limits defined in Environmental Quality Standards for the Protection of Surface Water Quality. However, there is a low risk that leached metals may have an adverse impact upon local water quality where larger landfills are located adjacent to smaller waterbodies. In addition, only a limited suite of metals has been considered and other soluble contaminants, e.g. Ammonium-N, may adversely affect surface water quality. The significant increase in metals leached in seawater compared to freshwater has implications for waste acceptance criteria (WAC) testing for present-day waste destined for currently operational landfills.

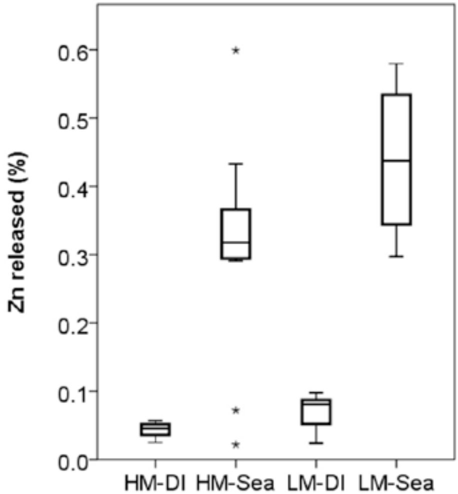

Figure 3: *Percentage of the initial concentration of zinc leached from the Hadleigh Marsh (HM) and Leigh Marshes (LM) matrix material in deionised water (DI) and artificial seawater (Sea)*

British Standards currently only require freshwater leaching tests, but the results of this research suggest that the standards and corresponding WAC limits should be updated to also include seawater leaching tests for waste destined for landfills in coastal environments.

Until now, there has been no method to determine which of England's 1264 historic coastal landfills pose the greatest environmental risk and, therefore, need prioritizing for maintenance, improvement or future relocation. This is significant as it is likely mitigation programmes will need to be phased over many years due to the substantial costs involved, e.g. the landfill tax alone for relocating a site the size of Hadleigh Marshes could be £23-30 million. A new risk screening assessment method is proposed that utilises existing datasets to rank historic coastal landfills based on their exposure to drivers of coastal erosion, their vulnerability to erosion, the waste materials they contain, and the proximity of sensitive environmental and ecological sites. The proposed method has been tested by applying it to eight historic coastal landfill sites in Essex. Of the eight sites tested, the only two waste filled flood embankments screened (Hadleigh Marsh and Sea Wall in South Fambridge) were found to

Photo 2: *South Fambridge waste filled flood embankment.*

pose the greatest risk of pollution despite their relatively small sizes. This is due to their relatively high exposure to drivers of coastal erosion and vulnerability to erosion, which means they are more likely to breach than the other sites screened and, if breached, are likely to release waste at a greater rate than most other sites screened. However, these results are preliminary and may change as the proposed method does not currently include any weightings to reflect the relative importance of different parameters. Subject to funding, prior to a national scale assessment being undertaken it is intended that the proposed method is developed further through consultations with relevant experts in coastal processes, landfill engineering and landfill contamination, and stakeholders from ecological and environmental organisations. The purpose of these consultations would be to agree the parameters used and apply any necessary parameter weightings. The results of the national scale risk assessment would support the Environment Agency and other coastal management organisations in the allocation of resources for the maintenance and improvement of historic coastal landfill sites and their defences.

Sensitivity testing of the proposed risk screening assessment found that parameters representing the probability of waste being released, the rate at which it would be released, and the vulnerability of receptors, are of much greater importance in determining the overall risk score than parameters representing the total landfill volume and contaminant concentrations in the waste. The importance of the landfill volume and contaminant concentrations in the waste in determining the overall risk score may increase once the risk screening assessment method has been reviewed with experts and regulators and parameter weightings have been applied. However, it is not anticipated that the importance of knowing the contaminant concentrations will increase significantly once weightings have been applied, because most waste has the potential to be ecologically harmful in some manner regardless of the contaminants it contains, e.g. by smothering the intertidal zone with its presence in large quantities or harming fauna by being mistaken for food (plastic waste). This supports the recommendation that contaminant datasets for individual sites are not collected for risk screening assessments, particularly given the difficulties of obtaining representative contaminant data and the high costs involved. Instead resources would be better utilised on understanding the probability of historic coastal landfills eroding, the vulnerability of likely receptors and appropriate mitigation.

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For further information see: Brand, J.H. 2017. *Assessing the risk of pollution from historic coastal landfills*. PhD thesis, Queen Mary University of London.

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Front cover photo: *Excavating waste samples from Hadleigh Marsh waste filled embankment in Essex.*

References: Alaska Department of Environmental Conservation, 2015. *Waste Erosion Assessment and Review (WEAR) Final Report.*
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