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The contaminant legacy from historic coastal landfills and their potential as sources of diffuse pollution

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ABSTRACT

Prior to modern environmental regulation landfills in low-lying coastal environments were frequently constructed without leachate control, relying on natural attenuation within inter-tidal sediments to dilute and disperse contaminants reducing environmental impact. With sea level rise and coastal erosion these sites may now pose a pollution risk, yet have received little investigation. This work examines the extent of metal contamination in saltmarsh sediments surrounding a historic landfill in the UK.

Patterns of sediment metal data suggest typical anthropogenic pollution chronologies for saltmarsh sediments in industrialised nations. However, many metals were also enriched at depth in close proximity to the landfill boundary and are indicative of a historical leachate plume. Though this total metal load is low, e.g., c. 1200 and 1650 kg Pb and Zn respectively, with > 1000 historic landfills on flood risk or eroding coastlines in the UK this could represent a significant, yet under-investigated, source of diffuse pollution.

1. Introduction

Historically (in the UK and elsewhere) many landfills were built within the coastal zone on low value land, particularly on or near saltmarsh habitats, with limited physical pollution prevention controls. In theory, any contamination from these 'historic landfills' (Mouser et al., 2005) and impacts on nearby coastal and estuarine environments was reduced through natural attenuation, relying on the dilution and dispersion capacity of tidal flushing, and adsorption and/or degradation in surrounding fine-grained sediments to reduce contaminant release to surrounding waters (Shukla and Rai, 2009).

In England alone, there are approximately 20,000 historic landfills (Cooper et al., 2012) constructed prior to the Control of Pollution Act (1974) and without any engineered waste management such as basal or side-wall engineering for leachate control enforced by the later European Union Council Directive (1999/31/EC). Of these 20,000 sites, at c. 1200 are located in tidal flood zone 3 with a 0.5% annual probability of coastal flooding, and many of these sites are within close proximity (< 100 m) to environmentally sensitive areas including sites of special scientific interest (SSSI), special protection areas (SPA), Ramsar sites, EU bathing water catchments and other protected areas (Brand, Spencer, O'Shea, & Lindsay, 2017). Fig. 1 shows the large numbers of historic landfills in the Thames Estuary, UK as an example, but there are likely to be similar sites across the globe. Crucially, these historic landfill sites were also constructed prior to detailed and accurate assessments of the impact of climate change on the coastal environment. Recent predictions regarding sea level rise and the increased magnitude and frequency of storm events will enhance their future sensitivity and hence risk to surrounding habitats and potentially the wider environment. These habitats (saltmarshes and mudflats) are of global social, economic and ecological importance (Barbier et al., 2011) yet are in global decline and there is little understanding of the extent or potential impacts of this significant, yet currently under-investigated source of diffuse pollution in the coastal zone.

Previous research into historic landfills is very limited and has focused on natural attenuation within leachate plumes (Bjerg et al., 2011), leachate composition (Kjeldsen et al., 2002) and groundwater monitoring (Hubé et al., 2011). More recently, a small number of studies have examined contemporary releases of contamination to the environment due to continuing leachate production (Gooddy et al., 2014) and the release of eroded solid waste (Pope and Langston, 2011), demonstrating that historic landfills still have the potential to pollute many decades following site closure. However, very little attention has been given to the impacts of historic leachate production and whether, through natural attenuation, contaminants have been stored in surrounding sediments through e.g. precipitation in the anoxic sub-surface

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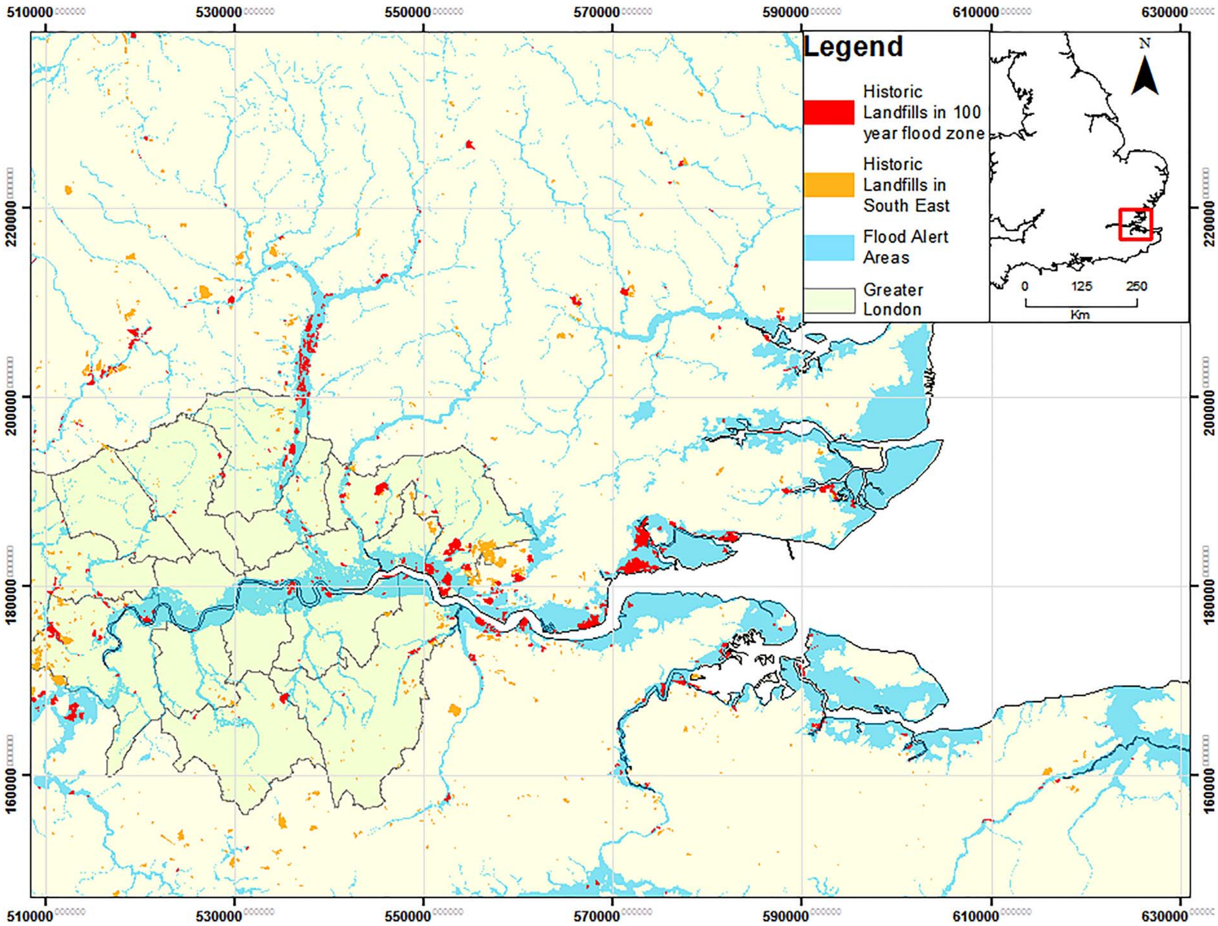

Fig. 1. Historic landfills within the Environment Agency flood alert area on the Thames Estuary, South East England (Environment Agency, 2010).

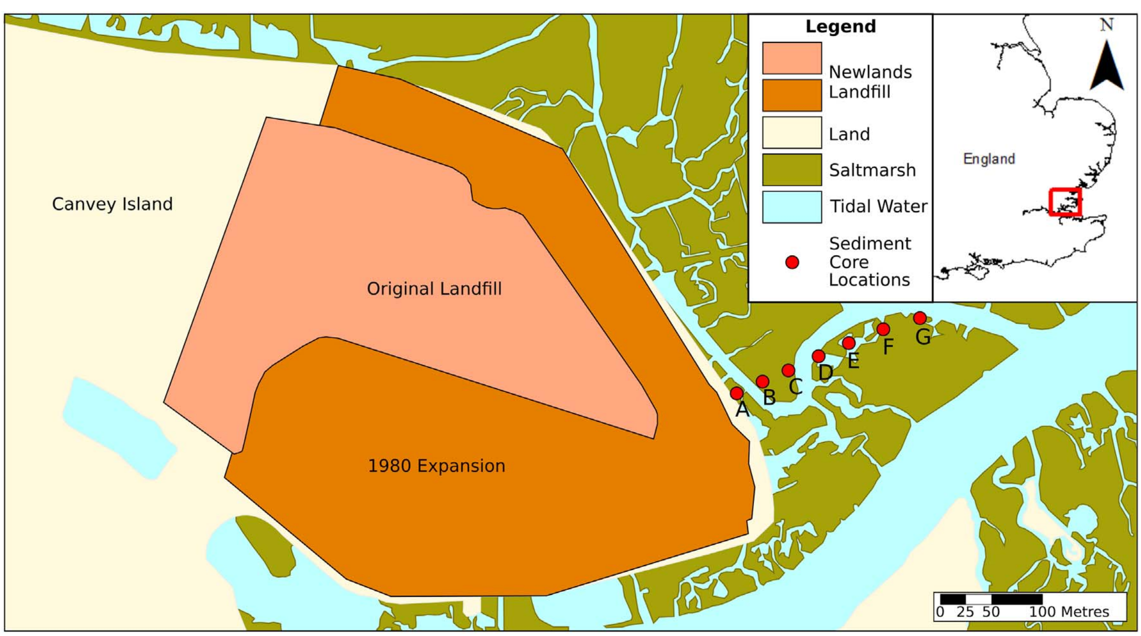

Fig. 2. Newlands landfill site.

environment and/or sorption to fine-grained, organic rich saltmarsh sediments (Michalak and Kitanidis, 2002; Njue et al., 2012). Legacy sediment contamination has been identified as a significant cause of ecological deterioration in surface waters, yet the extent and magnitude of this potential diffuse pollution source surrounding historic landfills is poorly understood. Stores of legacy contaminants in surface and subsurface sediments can be released to the water column due to a range of physical, chemical and biological processes, particularly associated with physical erosion and re-working of sediments (Spencer et al., 2003) and may present issues for stake holders and parties responsible