

Case Study

The Restoration of Fensbank Aluminium Waste Landfill

The Environment Agency, £600,000 in 2002



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Fennsbank landfill is an aluminium dross disposal site and this unusual waste results in a mass with curious behaviour. Rainfall percolating into the waste reacts with the anhydrous aluminium compounds generating ammonia, acetylene, hydrogen and other unusual nuisance gases. The reactions are strongly exothermic, so waste temperatures are very high. The maximum temperature recorded at the site within the waste is 83°C, with surface temperatures typically around 35°C. Any water that percolates through the waste, without being captured by chemical reactions or vapourisation, infiltrates the underlying aquifer to mix with groundwater. As thermal aluminium processing uses common salt as a flux the infiltrating water has an extremely high salinity, compromising groundwater quality with chloride as well as ammonia and metals. Groundwater around the site characteristically has a deep blue or indigo colour, indicative of the dissolved metals.

The aluminium recovery company that operated the site fell into administration in 2001, leaving the site under the control of the Environment Agency. Using monies set aside by the operator, the EA was able to embark upon a restoration scheme so that the local environment could be protected from the acute effects of the open waste body.

Geotechnology was contracted by the EA to undertake a feasibility study into the restoration of the site. Many options were considered, each of which required technical challenges to be overcome to ensure a desirable outcome. Having undertaken a cost benefit analysis of the various options it was concluded that a capping scheme to limit infiltration offered the greatest benefit for the available funding, though the performance of the cap under such extraordinary conditions was unclear. The first stage of the design project was therefore the development of the cap design, taking account of the extreme local conditions. In principle, the hydrating reactions that give rise to



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the gases, the ammonia and the heat, can be stifled by the exclusion of moisture from the mass. This approach would also prevent groundwater recharge through the waste mass, thereby improving groundwater quality. However, for an interim period the wastes remain hot, cooling slowly after the capping scheme has been successfully installed. Therefore, the cap must be functional whilst the wastes beneath are hot, and this presented several design challenges.

Most modern landfill caps are multi-layer systems using both soil layers and plastic geosynthetics. Typically, the moisture barrier is a plastic membrane, underlain by a gas collection layer and overlain by a moisture collection layer. These layers are often 3 dimensional geocomposites also made of polymeric materials, though they can in

certain circumstances be aggregate layers. Above the barrier system a restoration soil layer is placed, though in some applications a low permeability soil may be compacted to form the moisture barrier, overlain by a less compacted restoration layer. Both mineral and polymer barriers posed difficulties at this site due to the high temperature of the wastes. In the case of clay, dehydration and shrinkage was a significant concern. In the case of plastics, the performance of the polymer at elevated temperature was unknown as it lay so far above the temperature of conventional design. Geotechnology commissioned a series of plastic materials on a testing frame placed within a large oven. The polymer sheets were characterised at 70°C, 80°C, 90°C and 100°C and the data compared with their performance at the standard 20°C. A maximum waste temperature of 44°C at



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the time of the design was obtained from surface probe readings, but it was expected that this would increase with depth. In-principle, temperatures would rise until the reactant (water) is vaporised and boiled-off at 100°C. It was envisaged that a temperature moderating layer would be needed between the hot waste and the barrier plastic so that the temperature at the barrier level could be kept below 80°C.



The test results revealed a dramatic reduction in performance beyond 80°C, but acceptable performance below. Any scheme would therefore have to maintain temperatures below 80°C at the barrier level. Clay materials exposed to these temperatures were shown to undergo significant volume reduction, leading to desiccation cracking and increased permeability. The possibility of a mineral barrier was therefore discounted.



A thermal model was developed and the design reiterated until the predicted temperature at the barrier level remained below 80°C, even if temperatures within the waste rose to 100°C.



Having simulated acceptable thermal behaviour, attention switched to designing a gas collection system from beneath the cap, to prevent gas pressure development in the period after the capping and prior to the reaction stifling. This was carried out using Visual Modflow, a program conventionally used for hydrogeological modelling. The distribution of gas collection pipes, the gas drainage blanket and the vent stack arrangement were optimised using Modflow, allowing the pressure relief layer to be specified.

Having completed a design based on the simulation of the behaviour of the capping system and the reaction of the waste mass to it, the design was adopted for construction in the summer of 2002.