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Capping options appraisal

Arnold's Field

Client: London Borough of Havering

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Summary

EPG have been instructed by London Borough of Havering to undertake an options appraisal with regards to the capping of a site known as Arnold's Field. This report presents the findings of the options appraisal.

The site is a former landfill that was restored with a simple soil cover layer. It has since been subject to the illegal deposits of around 50,000 tonnes of illegal waste which is contaminated and contains domestic waste. Fires occur within the waste at the surface.

Due to the regular fires potentially impacting air quality, and the presence of potentially harmful material on the surface of the site in areas of the illegally deposited waste, London Borough of Havering is exploring options on how to make the site safe in the long term.

The current potential contaminant pathways are considered to be via:

- direct contact with/inhalation of contaminated soils due to unauthorised use of the site as public open space;
- off site inhalation due to impacted air quality, either as a result of contaminated dust being lifted off site by winds; and
- by fire emissions.

There are three basic options to break the contaminant linkages:

- Receptor removal;
- Source removal; or
- Breaking the pathway.

Receptor and source removal are not viable options. Three options for breaking the pathway have been considered:

1. Import fill to level the site and then soil cap the whole site:
2. Cut and fill of waste to level the site and then soil cap the whole site:
3. Innovative capping option comprising of some soil placement combined with spray applied cement polymer and hydro seeding.

Both earthworks-based solutions Option 1 and Option 2 have a high financial cost, that is somewhat prohibitive of making these appealing options for the site. Option 2 is less expensive based on our cost appraisal, however, Option 1 may have lesser environmental requirements (although both would require a permit). Option 1 may also have more scope for soil imports to generate revenue to off-set the costs of the work, as there is a greater import volume. The potential for soil imports to generate revenue has not been accounted for in this appraisal and requires input from a specialist contractor on likely rates. Options 1 and 2 have similar scores in terms of the other environmental and social factors that have been considered. The main issues with these two options are: the prohibitive cost, and, as they will require an Environmental Permit, there is uncertainty in additional assessments, environmental controls and significant lead-in timescale involved. The lead-in time for applying for and obtaining the type of Environmental Permit needed is estimated to take from 12 months to 3 years.

Option 3 is an innovative solution that has not been routinely applied in the UK. This option comprises the use of a sprayed cover layer, application of some soil as a growing medium and a spray applied vegetation layer. It is likely to be the most cost-effective solution but requires further specialist contractor engagement to assess the technical suitability for the site. Some discussions with suppliers and contractors have been completed, but further consultation is required. This option is considered likely not to require an Environmental Permit, but this should be confirmed through discussion with the Environment Agency permitting team. Two important aspects of the success of this option long-term are:

1. Allowance for long-term management and maintenance via re-application in certain locations.
2. Stopping public access to the site via robust security measures.

For Option 3 the site landform would remain irregular. This is considered suitable as a short to medium term solution for the site to manage the currently active pollutant linkages associated with fires and dust generation. This option would mitigate the human health hazards posed by the site until such time as a permanent solution can be found, this could be via a permanent soil capping option (as options 1 or 2) or via redevelopment of the site.

Currently Option 3 is the preferred option for further investigation and assessment. However, before any decision can be made on a final strategy for the capping at the site further work is required, and the recommended next step are:

- Consultation with the Environment Agency, to confirm the permitting implications for Option 3.
- Accurate topographic survey of the site recording ground cover conditions, in combination with high resolution drone survey.
- Determine areas that require treatment, and plan access routes across the site.
- Further consultation with suppliers and contractors to inform budget costing and programme.

1 Introduction

EPG have been instructed by London Borough of Havering to undertake an options appraisal with regards to the capping of a site known as Arnold's Field. This report presents the findings of the options appraisal.

1.1 The Site

The site location and layout are presented in Figure 1, below. It is an irregular polygon of approximately 17 hectares, centred around National Grid Reference 554116 182008. It is bounded to the north and west by a watercourse (Common Watercourse), and to the south and east by roads (A1306 and Launders Lane respectively).

Figure 1: Site location and layout

The site comprises a historical closed landfill site with no currently active permit.

The site is a historical sand and gravel pit subsequently landfilled in the late 1960s/early 1970s with a mixture of household, commercial, inert, industrial and liquid sludge wastes. The details of the original cover layer placed across the completed landfill and the final levels are unknown, however planning permission was granted in 1996 to enable some land raise across the site in order to construct a surface more suited for agricultural use. This suggests that the original landfill cover was non-engineered (in keeping with the date of completion) and likely comprised a thin layer of soil and stone, or potentially demolition materials.

The nature of the material imported under this planning permission to form the land raise is unknown at present, however, it is assumed that inert soils only were permitted. In 2004 a stop notice was served when levels on parts of the site exceeded those permitted in the planning permission, however, no record of final levels have been obtained at this time.

Between 30,000 and 50,000 m^3 of illegal mixed waste was subsequently deposited across large areas of the site between 2011 and 2014 (as recorded by the Environment Agency, EA). Recent site walkovers have recorded both domestic and commercial waste on the site surface, including freshly deposited fly tipping.

A significant number of fires have taken place recently across the site. The client commissioned a site investigation in order to identify whether the site should be determined under Part 2A, however, the end decision was that it did not currently meet all the stringent requirements[1], with some recommendations with regards to air quality monitoring.

The current levels across the site based on spot heights are presented in Figure 2, however, there are a significant number of steep sided ditches and bunds.

Figure 2: Approximate topography of site, excluding bunds and ditches

[1] Ground investigation report for the land at Arnold's Field, Launders Lane. Geo-Environmental Services Limited, December 2023, reference GE21483/GIRv2.0/DEC23

The works undertaken by Geo-Environmental Services Limited (GESL) in 2023 on behalf of the Client comprised a desk study and an intrusive investigation. The description of the general site conditions as presented in their report[1] is as follows:

The nature of the ground on the site is uneven, with significant and sometimes sudden variations in elevation across the site. Areas of the site were noted to be significantly raised in relation to the adjacent road (Launders Lane), with the highest elevation being located in the centre portion of the site sloping down to towards the stream bordering the site and adjacent roads. The southern portion of the site was noted to be at generally a lower elevation than the central and northern area of the site.

Traversing the site with access being created through bunds and around bunds on site and down slopes was noted to be slow and restricted areas where movement and access around site could be safely undertaken (both when undertaking a site walkover and with plant).

The site is noted to be quite densely overgrown (weeds, brambles and low level bushes) and uneven underfoot in areas with significant obstructions, including but not limited to construction rubble, plastic, wood, metal, domestic waste (including plastic and black bin bags), appliances (including toasters and the like), fabric and material tentatively identified as Asbestos Containing Materials (ACMs) and the potential for voids as a results of poor compaction or historical/recent fires on the site, actively smouldering areas or fires, levelling and revegetation of local areas in order to gain access with the dynamic sampling rig was required as vegetation could be dense and some ruts/hillocks on site were steep and or large in nature.

The southern portion of the site was noted to be more open and less overgrown with vegetation than the central and northern areas of the site. The topography of the site is such that the site slopes steeply down towards the stream along the boundaries. The site boundaries were also noted to be very heavily vegetated.

A small area of hardstanding was located on the south-eastern boundary of the site directly off Launders Lane, through double metal gates. A metal container was located in the north of the hardstanding. At the point of the site walkover on the 8th August 2023 it was understood that concrete blocks had previously been placed in front of the gates, however these had been moved to allow access. A further smaller tarmacked access was present towards the southern area of the site off Launders Lane, which at the point of the walkover and site investigation works had concrete blocks and fly tipped materials at the entrance with only pedestrian access possible.

It is understood that a number of fires have occurred on the site historically and more recently believed at this stage to be associated with the waste mass in the upper layers (historically unauthorised deposited materials) on site. Smouldering trenches were also noted within the central portion of the site during the walkover. It is understood that further fires have also occurred more recently on the southern portion of the site (end of August/beginning of September). Google maps shows historical evidence of areas of burnt ground located in the southern area of the site between the A1306 New Road and Launders Lane. During site investigation works a pile of surface tipped material was smouldering in the southern area of the site.

1.2 Ground conditions

EPG are aware of two site investigations undertaken at the site since 2010. The ground conditions encountered are summarised below.

1.2.1 Site investigation 2012

During the EA investigation into the illegal waste operation, a site investigation was undertaken by Jacobs on behalf of the EA. It has not been possible to obtain a copy of the report or site investigation locations, however, a summary of ground conditions from a technical note produced by Jacobs is presented within the 2023 site investigation report prepared by GESL[1] as follows:

'Brown sandy gravelly clay or sandy clayey gravel over recently deposited landfill waste, or further made ground of black clayey sandy gravel with ash, peat/decayed vegetation, brick and concrete. The recent landfill comprised domestic and commercial waste including documents, wood, paper, glass, plastic, mattresses, furniture/equipment, cables, netting, fabric and occasional empty medical waste packaging'.

'With waste reported typically to be warm/emitting vapour suggesting decomposition was occurring and landfill gasses may be being generated. The full depth of the recent waste material was not proven up to a maximum achieved depth of 4m below ground level.'

1.2.2 Site investigation 2023

The site investigation undertaken by GESL in 2023 comprised the excavation of boreholes (windowless sampler) and trial pits. The locations were targeted to explore general ground conditions, potential contamination in the top 5m, and to enable gas and groundwater/leachate monitoring, however the positioning of exploratory holes was subject to the creation of tracking routes around the site where topography and changes in levels were safe to allow. In some central areas of the site steep gradient changes prevented direct tracking and limited the areas where investigation works could be safely undertaken. The approximate locations of exploratory holes are presented on Figure 3, below, together with a plan indicating areas where steep drops and/or bunds/trenches were encountered during the site investigation.

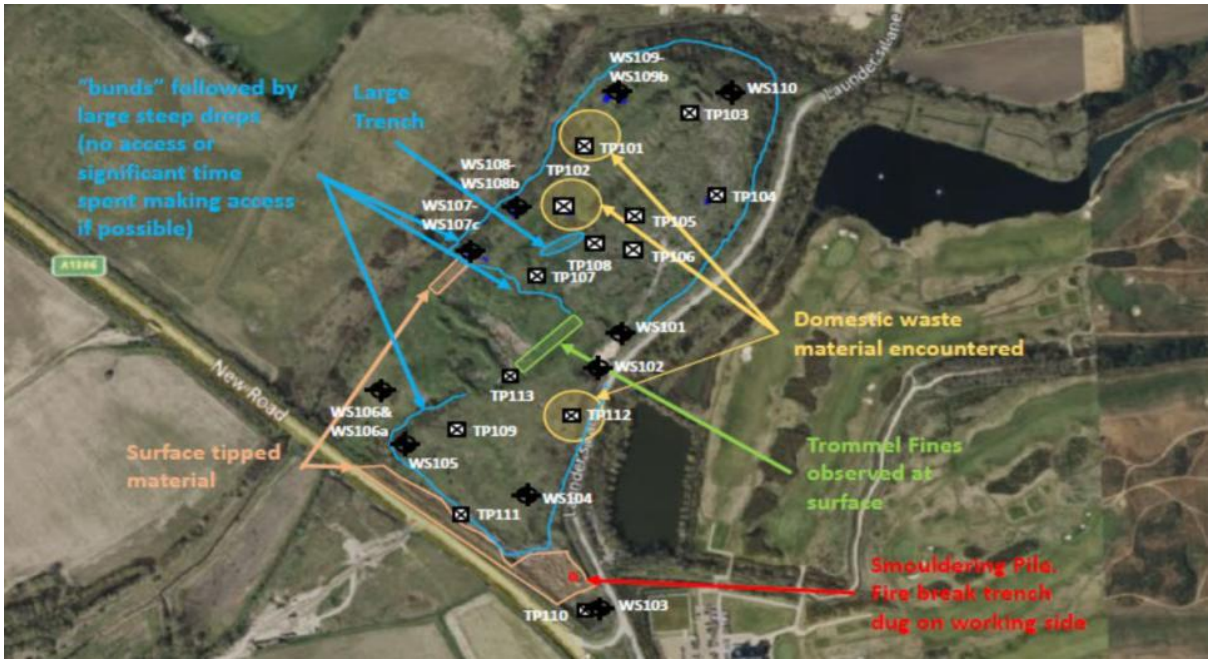

Figure 3: Summary of encountered surface conditions, Figure 5 from GESL report, 2023

Made Ground was recorded to the base of all exploratory holes (5m below ground level (bgl) was the maximum depth of the boreholes). A variety of descriptions were recorded as follows:

- Brown silty/clayey/gravelly sometimes ashy SAND, gravels of brick, concrete, sometimes tarmac. Other items included tyres, plastic fragments, plastic bags, cement bags, CD players, cassette tapes, timber, slate, ceramic tiles, textiles, hessian, plastic gloves, glass bottles, cabling, ceramic pipe, plastic bottles, paper, metal bars, bike parts, packing tape and timber sleeper. Suspected asbestos containing material (ACM). Hydrocarbon odour/sheen (TP105), charred plastic (TP108) and organic odour (TP112).
- Greyish brown ashy gravelly sit, gravel is brick and plastic. Recorded only in two locations (TP103 and TP104) at ground level to 0.4m bgl.
- Surface tipped materials, 70% plastic (mostly bags), 15% textiles, metal, timber and concrete. TP111 only.
- Brown, grey or black gravelly sandy CLAY. Gravel is brick, concrete, flint and occasional chalk. Other items included tiles, metal bucket, metal car parts, polystyrene, timber, glass bottles, fibreglass, plastic, ceramic tiles, clinker, tarmac, hessian, coal, slate, suspected ACM. Organic odour (TP106/107), strong hydrocarbon odour (TP110), tarry odour (WS107c).
- Domestic waste: often comprising 20% to 85% plastic bags, up to 50% gravelly sand, gravel of brick, concrete and flint, 5% timber, 5% textiles. Other items included: metal pipes, plastic pipes, rope metal cans, brick, hessian, cladding, cables, ceramics, plastic bottles, shoes, foam, car parts and registration plates, underlay, cassettes, paper labels, metal, tree trunk, carpet, metal wire, plastic tray, netting, plastic bucket. Hydrocarbon and organic odour (TP101), crisp packet dated 2011 (TP112).
- Lilac iridescent gravels of concrete and clinker (TP107).

There was no clear pattern with regards to deposition, either laterally or vertically.

It is stated within the report that, although no supporting documentation was available, the Local Authority speculated that the top of the original permitted landfill was potentially similar to the level of Launders Lane after restoration. If this is the case, then material identified in WS102, WS103, TP110 and TP111 were likely part of the original landfill. There was also no description indicative of material imported between 1996 and 2004 to raise levels under the approved planning permission.

It should be noted that additional fly tipped material was recorded as being present on site by GESL during subsequent site visits for monitoring.

Analytical results identified heavy metals and poly aromatic hydrocarbons that exceeded screening criteria for public open space, together with asbestos containing materials and loose fibres.

The report concluded that:

In conclusion, based on the limited data available from a review of the desk study information and from the intrusive investigation works, with the exception of TP113, it has not been possible to formally determine whether materials encountered as part of the intrusive investigation positions are part of the original permitted landfill or unauthorised tipping above. Although some inferences can be made based on areas of the site being significantly topographically higher than others, no details as to the finished levels of the original permitted landfill levels have been identified or reviewed as part of these works. A review of historical photographs for the site (From Google Earth) indicated that earthworks were undertaken on the site at the time of the unauthorised deposition of wastes, which may have moved the permitted landfilled materials from their original placement

locations. TP113 can be approximately dated due to the presence of crisp packets with expiry dates still noted to be readable (2011). In addition, areas of waste material were noted at surface level across the majority of the site which are inferred to be unauthorised deposits tipped materials.

While multiple potentially combustible materials were encountered both on the surface and in the soils/waste mass, no significant evidence of ignition sources were identified within the soils or waste mass encountered within the exploratory hole positions undertaken. No evidence of LPG canisters was identified as previously considered to present a potential ignition source on the site. They may be present in other areas of the site remote from the investigation positions undertaken. As such, it has not been possible to identify a definite ignition source on the site as part of the works undertaken to date.

Charred surface items were observed in the southern portion of the site, including but not limited to metal, plastics and textiles. This area of the site was noted to be subject to several fires the week prior to investigation works commencing on site.

In addition, a smouldering trench was identified during the initial site walkover on the site in August 2023 within the central portion of the site, in an area which was noted to have been subject to an historical large fire on site. The trench, that had been dug to attempt to suppress the fire, appeared to contain similar waste type materials to the domestic waste encountered within TP102.

Neither the personal gas monitors nor the radiation monitor on site identified elevated levels/levels of concern during the intrusive investigation works undertaken.

Return spot gas monitoring of the monitoring standpipes installed within the waste mass on site have identified levels of methane, carbon dioxide, carbon monoxide, hydrogen sulphide and VOCs along with depleted oxygen on site, such that the presence of methane where elevated may be acting to exacerbate and sustain fires on the site within the deposited waste materials. Methane is flammable and explosive between certain limits and the presence of pockets of methane could potentially exacerbate or sustain fires, however an ignition source (e.g. arc/flame/heat would still be required). However, without a source of ignition and with no significant flow, the methane would be likely to remain within the waste mass and concentration reduce towards ground surface. In addition, depleted oxygen concentrations were recorded across the site within the monitoring wells, thereby a reduction in oxygen is considered to reduce the risk of sub terranean fires as oxygen would be needed to enable a fire to burn. It is noted that no significant flow has been detected in terms of ground gases and as such the risk to offsite receptors from ground gas migration is considered to be low.

It is suggested that further detailed assessment of gas regime may be beneficial in further assessing the site in order to further to consider the potential for a build-up of gases in pockets across the site and to further assess the presence of ground gases venting from the site. This further assessment is suggested to include continuous gas monitoring, a surface emissions survey and additional TOC analysis of encountered Made Ground materials.

Continuous gas monitoring would provide further data in relation to fluctuations in recorded gas concentrations and gas flow rates in real time. A surface emissions survey would help to identified areas of the site where gases are venting to atmosphere, aiding to identified areas of the site where pockets of gases are located. Additional TOC analysis of the Made Ground underlying the site would help to provide further assessment of the likely gassing potential of the Made Ground

materials located across the site to aid to target areas where gases are most likely to be generated. In addition, it may be prudent to consider the drilling of some deep boreholes in order to locate monitoring wells solely within the former permitted landfill, as this appears to be the main source of gases encountered across the site. It should be noted that the proposed options are with a view to assessing the current status and gassing regime on the site. It should be noted that any works on site such as regrading (excavation, moving and compacting), capping or subsequent development if proposed would be considered to alter the gassing regime of the site and would need to be considered further in the context of any works proposed.

The majority of the soil elements encountered are considered to be suitable to be left in-situ beneath the site in terms of risk to human health with regards to public open space (taken as the most conservative end use given the unauthorised access to a private site). While contaminants have been identified including TP110 at 3.40m bgl, TP106 at 2.20m bgl, TP103 at 0.75m bgl and WS107c at 2.30m bgl which had exceedances in arsenic, lead and PAH respectively these were generally noted to be present at depth, such that where the soils remain undisturbed there is not significant risk in terms of risk to human health from the general existing site use. However, the presence of other elevated contamination concentrations associated with the waste materials/soils at shallow depth across the site surface cannot be ruled out given the significantly variable nature of the materials and contamination levels identified within the samples analysed. As such, to reduce the risk of unauthorised entry to the site is it recommended that the site is secured.

Further consideration would need to be given to the presence of ACMs identified on the surface and in shallow soils beneath the site, together with seemingly sporadic low concentrations of free fibres identified within the soils. Whilst it is recommended that air monitoring is undertaken on/around the site to inform further assessment of the potential for airborne fibres to be released to the air given asbestos was identified both on the surface and in the subsurface soils on site. Were asbestos is bound within cement, or mixed within a soil mass, it is considered that there is negligible potential for fibres to be released.

It is considered that the risk to members of the public from the elevated concentrations of specific determinands could primarily be mitigated through securing the site to prevent unauthorised access thereby breaking the source-pathway-receptor for exposure to the contaminants on site.

Water/leachate samples found exceedances (when compared to Environmental Quality Standards (EQS) for Freshwater) in relation to arsenic and PAH in TP110 at 3.50m bgl and Boron, Mercury and Chloride in WS102 at 3.18m bgl. It is thought that these are likely to be isolated pockets of perched water/leachate which has been impacted by waste localised to the area of the monitoring wells. While a continuous water body has not been identified beneath the site within the Made Ground materials/soils to 5m bgl, the nature of the site is such that infiltration of rainfall will occur on the site, which is likely to result in localised leaching of contaminants and pockets of water/leachate forming which have the potential to migrate. The original scope of works for the site did include the proposed monitoring of the nearby surface water Common Watercourse which boarders the site to the west and north. However, due to the overgrown nature of the site and limited access to date, it has not been possible to safely undertake surface water monitoring. As such, works have focused on assessing the potential for leachable contaminants. During the site works no evident of breakout of leachate was noted in relation to the site, however the overgrown nature of the site could have obscured any such occurrences.

The leachability and presence of water within the waste mass/soils on site is considered to be a function of infiltration through the site. As such, in order to reduce the leaching of contaminants and potential migration through the site or to off-site receptors, consideration could be given to providing a capping layer on site formed from a less permeable material with surface water channelled over the site to discharge into the adjacent surface water as opposed to being allowed to infiltrate through the site and waste materials.

Any detailed proposals for capping of the site to reduce infiltration would also need to consider ground gases in further detail to assess any potential to changes to the gassing regime on site as a result of installing a capping system.

Although some of the soils analysed on site were classified as non-hazardous waste (when considered in relation to waste classification for disposal) two samples were found to be hazardous (TP110 3.40m and TP106 2.20m). This classification is based on the chemical properties of the materials. It should be noted that any extraneous materials such as plastic, wood etc present in the soils as observed could impact the waste classifications. The presence of asbestos bonded fragments in soils also impacts the waste classification.

It is recommended that the following works be undertaken to further assess or reduce the potential for significant risk of significant harm in relation to the site.

- *Asbestos air monitoring on the site to assess the potential of airborne asbestos fibres and any associated risk of migration. Recommended to comprise boundary monitoring as well as within the site. It should be noted that due to the topography on site, boundary monitoring may require access to adjacent land to safely access the site boundaries.*
- *Securing of the site to prevent unauthorised access, thereby breaking a number of the source, pathway receptor linkages identified;*
- *Consideration of reprofiling and capping of the waste materials on site to further mitigate potential source pathway receptor linkages identified to reduce the risk from the current status on site.*

It is also suggested that the following works could be undertaken to aid further assessment of the gassing regime on site and key risk drivers with a longer term view of assessing options for works required to reduce the potential for significant risk of significant harm in relation to the site, in the context of the current land use and any subsequent proposed land use.

- *Further assessment of ground gas regime on the site and potential for methane to comprise a flammable source for fires on site in the form of:*
    - *Continuous gas monitoring to monitoring gas concentrations and flow rates in real time.*
    - *Surface emissions survey across the site to aid identification of areas of the site where gases are being produced.*
    - *Additional TOC analysis of Made Ground soils to help identified areas where the risk of future gas generation is considered higher.*
    - *Drilling of deep boreholes to target the historic permitted landfill material.*

It is possible that the risks posed by the site could be reduced by leaving the material on site and capping it to break the pathway between source and receptor, prevent any asbestos fibres from leaving site and to starve any combustible material of oxygen to prevent fires.

It is likely that any remediation required to make the site suitable for a specific development or change in end use would differ from the works proposed in terms of reducing any risk in relation to the current site status and this would be subject to a further assessment which is beyond the scope of the works presented herein. It should, however, be noted that any changes to the site whether that is capping or incorporation of areas of hardstanding will impact on the sites gassing regime and detailed assessment would be required prior to the undertaking of any such works.

1.3 Status under Part 2A

The 2023 GESL report concluded, based on the limited data available:

The site-specific assessment has provided additional information with which to re-assess and further characterise the reasonable possible pollutant linkage groups identified within the Preliminary Risk Assessment (PRA).

With regards to human health (regulated by the Local Planning Authority) and controlled waters (regulated by the Environment Agency), contaminant linkages should be considered as 'significant contaminant linkages' only where it can be demonstrated that they will result in a 'significant possibility of significant harm', often referred to as SPOSH. The strict legal test of SPOSH is where site conditions are such that exposure to the contaminant, and thus the contaminant linkage, would represent an unacceptable intake or other bodily contact assessed on the basis of information on the toxicological properties of that contaminant. The assessment of SPOSH is a regulatory decision and, in relation to human health, should be taken by the Local Authority and/or Environment Agency dependant on receptor.

It is considered that the overall risk of the site (when not on fire) in relation to a number of the source pathway receptor (SPR) linkages identified could be reduced by securing the site, thereby removing unauthorised access on the site.

However, further consideration is required in relation to the SPR linkages associated with the fires on the site, both during fires and of any impacts following fires.

In addition, there are areas where a significant risk of significant harm has not currently been identified but that improvements or limited works on site such as reprofiling and installation of capping across the exposed waste materials, resulting in a reduction of infiltration through the site may also serve to offering a reduction in overall risk.

2 Remediation objectives and feasible options

Due to the regular fires potentially impacting air quality, and the presence of potentially harmful material on the surface of the site in areas of the illegally deposited waste, the Client is exploring options on how to make the site safe in the long term.

The current potential contaminant pathways are considered to be via direct contact with/inhalation of contaminated soils due to unauthorised use of the site as public open space, or via off site inhalation due to impacted air quality, either as a result of contaminated dust being lifted off site by winds, or by fire emissions.

There are three basic options to break the contaminant linkages:

- Receptor removal;
- Source removal; or
- Breaking the pathway.

2.1 Receptor removal

Receptor removal would require the prevention of public access to the site, and potentially the relocation of nearby residential properties. This option is not considered further within this report.

2.2 Source removal

Source removal would require excavation and disposal of approximately 50,000 tonnes of illegally deposited waste (as estimated by the EA). This would be a very robust and permanent solution for the site. If it is assumed that:

- The EA estimation is accurate;
- 50,000 tonnes of waste represents approximately 60,000m^3 volume (this is dependent on composition and density which is assumed to be 800kg/m^3);
- The waste can be determined as non-hazardous (also dependent on composition).

Using the SPONs rate of £65.25/m^3 for the disposal of non-hazardous waste, the cost would be in the region of £4 million. This is a tipping cost only and does not include landfill tax, excavation or transport to the landfill. Standard rate landfill tax is currently £126.15 tonne so the tax could easily double this cost.

In order to improve the original landfill surface cover an undetermined volume of soil would need to be imported onto site adding at least £2 to £3 million to the above cost. Some of the material could be processed for recycling and reuse during this operation, but this has not been allowed for in this simple estimate, and reuse of materials could also have permitting implications. The underlying material imported onto site under the planning permission granted in 1996 is an unknown element, so cannot be assumed to form suitable cover at this point.

The environmental impact of this operation would also be significantly detrimental due to the risks and emissions during material transport. Based on the environmental impact and the overall cost falling somewhere over £ 10 million, this option is not considered further within this report.

2.3 Breaking the pathway

This report explores the option of breaking the pathway by installing a cover system across the site. Given the extremely irregular profile of the site, three approaches have been appraised as follows:

1. Import fill to level the site and then soil cap the whole site:
2. Cut and fill of waste to level the site and then soil cap the whole site:
3. Innovative capping option comprising of some soil placement combined with spray applied cement polymer and hydro seeding.

Further details of the proposed options are provided below and the full evaluation of comparative cost, environmental and practical aspects of the options is provided in section 4.

2.3.1 Earthworks options, soil capping

Options 1 and 2 are both capping options which require the import of suitable materials to form an engineered soil cap over the waste. These options will break the contaminant pathways by providing a barrier to contaminated dust generation and will limit oxygen ingress into the waste mass at depth, therefore preventing fires.

Option 2 is the most straightforward option in terms of the works required. And would comprise the following physical stages of works:

1. Surface clearance of vegetation and preparatory works.
2. Cut and fill within the waste (including illegal waste) to level the site (some processing of waste materials could occur during the cut and fill, with as a minimum fly tipped bulky materials removed for disposal or recycling, and potential for other recycling and reuse of waste inclusions during this stage of work).
3. Import of suitable cover soils and engineered placement of soil capping layer.

The requirement for bulk cut and fill earthworks with waste materials means this option would require an Environmental Permit.

Option 1 was derived as a means to limit the potential environmental impacts, by undertaking minimal disturbance of the waste materials and importing a larger volume of soil to fill void spaces prior to installing a cap above the current maximum topography on site. The physical stages of work required would be:

1. Surface clearance of vegetation and preparatory works.
2. Minor cut in waste to batter back steep slopes on site.
3. Import of suitable general fill to fill current topographic low points, ditches and hollows.
4. Import of suitable cover soils and engineered placement of soil capping layer.

Due to the steep slopes at the site perimeter both options would require some cut and fill in waste materials and for that reason an Environmental Permit would be required for both options (see section 3.5). Option 1 has a greater scope for generating revenue from soil imported to site as a greater volume of fill can be accommodated.

2.3.2 Innovative spray cover option

Option 3 has been included as a potential alternative to the more traditional capping options. It utilises cover system products that can be spray applied to steep slopes, thereby minimising the earthworks requirements. Careful evaluation of the feasibility and technical suitability of this option is required prior to design and implementation. This will require input from suppliers and contractors. The physical stages of work with this option are anticipated to comprise:

1. Surface clearance of vegetation in some areas and preparatory works.
2. Light compaction of the waste surface by driving over with a vehicle, where accessible.
3. Surface dressing of up to 300mm subsoil as a growing medium over required areas.
4. Spray applied hydro seeding with appropriately specification vegetation mix.
5. Application of polymer-based, spray applied cover system to parts of the site, particularly areas suffering from oxygen ingress and smouldering.

Given the current site profile, it may be necessary to create some access routes across the site to enable Option 3 to proceed. However, the spray applied products can be applied up to 100m away from a vehicle by a hand-drawn hose.

The product that has been identified for use as the polymer-based, spray applied cover system, is called Pozi-shell and is produced by a company called LSC https://www.lscenv.com/landfill-cover-systems-pg.html, and distributed in the UK by Halcyon Environmental. EPG has completed some preliminary consultation with both companies, which has been used to inform this report. It is possible that there may be other equivalent products commercially available. The suitable mix for the spray cover application would be 1kg Pozi-shell to 4kg portland cement to make an "intermediate" cover layer that is more long lasting.

The finished surface can be walked on, but it will crack and break up if it is driven on.

It considered that Option 3 is unlikely to require an Environmental Permit.

3 Remediation options evaluation criteria

3.1 Context

The three identified capping options have been subject to more detailed evaluation in order to determine the preferred option.

Although the site has not been determined under Part 2A, the evaluation criteria as presented within the statutory guidance are considered appropriate and have been adopted.

3.2 Cost

A cost comparison has been completed for each solution. The overall costs are indicated in this options appraisal report as a qualitative value. This is because the costs calculated were for comparison purposes only and should not be used for budgeting. The costs do not include many key items that will be needed for the work to progress. These ancillary costs are likely to be similar for all options, so it is acceptable to exclude them for comparison purposes.

The volumes of materials are a basic assessment of cut and fill to inform the options appraisal. There is no up to date detailed topographical survey for the site and so the levels have been obtained using LiDAR data. Levels would also be amended in any detailed design taking account of all the constraints on the final landform such as blending in to ground levels at the edge of the site, etc.

Generalised rates for the works have been taken from SPONS 2024 price book for Civil Engineering and Highway Works or from other sources where listed. Professional judgement has also been used and figures rounded up. All costs are provided excluding VAT.

- The costs accounted for the main remediation works, excavation and filling and application of cover layers.
- It is assumed at this stage that leachate and landfill gas collection or venting is not required, this would make the costs for both cover layer options higher.
- The costs do not allow for site establishment, preparatory works, supervision, or any other ancillary works. These costs have been excluded for comparison purposes.
- Professional fees for additional site investigations and assessments, management and monitoring of the work, and detailed design and verification, are not included.
- No allowance has been made with respect to land values being impacted positively or negatively by the remediation. This is considered to be an incalculable factor. It is unclear if there will be any effect.
- Costs for long term maintenance and management have not been included. Option 3 will have long term management costs, these are uncertain at this time. This should be considered when comparing this to the other options.
- The quantities used for costing have been measured and informed by outline feasibility designs completed by EPG, based on LiDAR data, and not accurate topography.

Rates for hydro mulching have been obtained from a contractor to inform the cost comparison for Option 3. These are for application to a site with readily available access for a tractor. On this site the plant would need to be placed onto a vehicle that can access the required areas or an access route

made through the stockpiled waste materials. It is also possible to apply the spray cover and hydro seed from a hose and access on foot. The cost of application of the cement polymer cover layer is not known so the rate for hydro mulching has been used to provide an indication of possible costs.

3.3 Practicability, effectiveness, and durability

The below considerations from the statutory guidance have been considered during the assessment of practicability, effectiveness and durability. Different aspects have been assessed qualitatively on a scale of "Very Poor - Poor – Moderate – Good – Very Good" and where the evaluation of the element is unknown this is highlighted as "Uncertain". The qualitative assessments of each aspect are then combined and an overall qualitative score from 0 to 5 is given.

The enforcing authority should ensure that any requirement it makes in regard to remediation is practicable and effective – i.e. it should be possible, within reasonable limits, for the person to undertake the required actions, and the actions should be effective in addressing the problem at hand. This applies both to the remediation scheme as a whole and the individual remediation actions of which it is comprised.

In assessing the practicability of any remediation, the authority should consider, in particular: (i) technical constraints, such as whether the technical capacity and resources needed to undertake the work exist, and could reasonably be made available; (ii) site constraints, such as access to the relevant land or waters, the presence of buildings or other structures in, on or under the land; (iii) time constraints, such as whether it would be possible to carry out the remediation within the required time period; and (iv) regulatory constraints, such as whether the remediation can be carried out within relevant statutory or similar controls.

The enforcing authority should consider the durability of remediation. In some cases it will be reasonable to require (or otherwise ensure) a permanent solution to the problem. In other cases this may not be possible or reasonable, in which case the authority should consider how to ensure a reasonable standard of durability. The aim should be to ensure (as far as practical and reasonable) that the scheme as a whole would continue to be effective during the time over which the significant contaminant linkage would continue to exist or recur.

In considering durability, the enforcing authority should consider whether it is likely that some other future action (such as redevelopment) will resolve or control the problem. If the authority feels that such action is likely to occur within a reasonable timescale, the authority may consider whether it would be appropriate to require remediation of limited durability, pending a more durable solution later.

Where a remediation scheme cannot reasonably and practicably continue to be effective during the whole of the expected duration of the problem, the enforcing authority should require the remediation to be effective for as long as can reasonably and practicably be achieved. In such circumstances, additional monitoring actions may be required.

Where a remediation method requires on-going management and maintenance in order to continue to be effective (for example, the maintenance of gas venting or alarm systems), these on-going requirements should be specified in any remediation notice (or similar remediation agreement if remediation is being taken forward without such a notice) as well as any monitoring actions necessary to keep the effectiveness of the remediation under review.

3.4 Health, safety and environmental impact

The below considerations from the statutory guidance have been considered during the assessment of health, safety and environmental impact. Different aspects have been assessed qualitatively on a scale of "Very Poor - Poor – Moderate – Good – Very Good" and where the impact is "Uncertain" this is also highlighted. As all elements under consideration are potential adverse impacts (no positive impacts assessed) therefore where there is no adverse impact, this has been assessed as "Good" or "Very Good". The qualitative assessments of each aspect are then combined and an overall qualitative score from 0 to 5 is given.

In considering the costs of remediation and the seriousness of harm or pollution, the enforcing authority should also consider other costs and impacts that may, directly or indirectly, result from remediation. This should include consideration of: (a) potential health impacts of remediation; and (b) environmental impacts of remediation. In considering such impacts it is for the authority to decide whether or not to describe such costs in terms of monetary value or whether to make a qualitative consideration.

The enforcing authority's consideration of potential health impacts of remediation should include: (a) direct health effects (e.g. resulting from contaminants being mobilised during remediation, and worker safety); and (b) indirect health effects such as stress-related effects that may be experienced by affected people, particularly local residents. In making this consideration the authority should also be mindful of the health benefits of remediation and the potential health impacts of not remediating the land.

With regard to environmental impacts of remediation, the enforcing authority should consider whether remediation can be carried out without disproportionate damage to the environment, and in particular: (a) without significant risk to water, air, soil and plants and animals; (b) without causing a nuisance through noise or odours; (c) without adversely affecting the countryside or places of special interest; and (d) without adversely affecting a building of special architectural or historic interest.

The enforcing authority should strive to minimise impacts of remediation on health and the environment (and comply with any relevant regimes that might require this, for example the health and safety, planning and environmental permitting regimes). If the authority considers that health or environmental impacts of a particular remediation approach are likely to outweigh the likely benefits of dealing with the risk posed by the contamination, it should consider whether an alternative approach to remediation is preferable, even if it may deliver a lower standard of remediation than other techniques.

3.5 Environmental permit requirements

Discussion with the EA indicates that some form of Environmental Permit will be required for both soil capping options being considered (Options 1 and 2). Initial discussions with the EA indicate that either a landfill permit for non-hazardous/inert waste or a deposit for recovery (DfR) permit will be required. There are significant costs and timescales associated with both. Industry experience is that at the present time it can take from 12 months to 3 years to obtain a permit.

It also important to understand the liabilities and issues related to these permits. Key issues are:

- Who will be the legal operator for the permit (because it will be responsible for complying with the permit). The organisation must be considered to be a competent operator by the EA;
- The Permit will require specific assessments and potentially monitoring for stability, hydrogeology and landfill gas.
- Compliance with the permit requires items such as ensuring waste acceptance and testing is complied with, the volumes of material are not exceeded and all the required monitoring and management is in place and records kept. This is a significant responsibility and will need to have appropriately qualified managers for the waste activity who are members of a government-approved technical competency scheme.
- The permit applies to the site and at some point will need to be surrendered.

There is currently limited site investigation data (including the composition of the waste and gas generation) and there will likely be a substantial amount of investigation and design work required for the options that require an Environmental Permit.

For Option 3 we anticipate that an Environmental Permit may not be required. However, confirmation of this is required through consultation with the EA permitting team. Some small volume of imported soil is required for Option 3, we would hope that a non-waste material could be imported to the site, considering that it is currently closed and has no active permit, without triggering the requirement for a new permit to be put in place.

Import of clean, suitable (non-waste) soils will need to be appropriately documented and this could be done under the CL:AIRE Definition of Waste, Code of Practice via a direct transfer.

3.6 Planning permissions

The Local Planning Authority will determine the planning application requirements for the remediation capping options under consideration.

Options 1 and 2 are very likely to require planning permission. It is not clear if planning permission would be required for Option 3.

4 Evaluation of capping options

4.1 Option 1 Import fill to level the site and then soil cap the whole site

The first option under consideration is the infilling of the existing landform with imported inert soils to create a usable working platform prior to the placement of a 1m thick cap across the whole site.

At present the site comprises a very uneven surface of non-compacted mixed waste. In order to enable the placement of capping materials, the surface must be levelled in order to provide a safe working environment.

Option 1 requires the placement general fill soil within the deeper areas in order to create a platform with no slope gradients exceeding 1 in 4. A 1m thick capping layer would then be placed across the entire site, with the final surface meeting the site boundaries to the north and west abutting the watercourse. This would leave a 10m buffer to the south and east in order to retain the mature trees along the boundary with the roads. There would need to be some cut and fill or cut and offsite disposal required to slacken slopes around the northern edge of the site so that none of the final slope gradients exceed 1 in 4.

It should be noted that there are additional mature trees on the southern boundary that extend further within the site, and on the boundary within the far northeast that suggest no illegal waste has been placed in these areas. There is also an area in the far southwest corner that will possibly be excluded should a detailed design be required. These are not considered within this options appraisal.

Factors that will require careful consideration for detailed design are:

- Settlement and slope stability;
- Health and safety during the works;
- Surface water drainage;
- Environmental Permit.

It is possible that a Landfill Directive compliant cap would need to be provided (TBC based on EA discussions) this has not been allowed for at this stage. A simple clay soil cap has been allowed for in both Options 1 and 2.

All of the above are similar for both earthworks options (Options 1 and 2) and are not included in the cost comparison. With this option it may be possible to operate the site so that payment is received for imported fill and the scheme could be fully or partially self-funding. This needs to be explored with a contractor. An Environmental Permit will be required. It is likely that planning permission would be required.

Table 1 Option 1 assessment

Option 1 Import fill to level the site and then soil cap the whole site:		
Criteria	**Evaluation**	**Score**
Volumes	Imported material to infill undulations – 270,000m^3 Imported material for capping layer – 250,000m^3	N/A
Cost comparison value (subject to limitations in section 3.2)	~~£££££~~ (could possibly be partially funded if site is operated to accept suitable fill)	2.5 / 10
Practicability, effectiveness, and durability	Practicability **Good** – This is a standard earthworks operation and should not present any unusual difficulties. Durability **Good** – There is no long-term maintenance required.	4 / 5
Health, safety and environmental impact of works	 Stress for residents **Moderate** – The remediation will take time to complete. Risk of pollution to water, air and soil **Good** – improvements to the site will reduce emissions to atmosphere. Habitats and biodiversity **Good** – The remediation can be designed to improve the site in this respect at little or no extra cost.	3 / 5
	Total	9.5 / 20

4.2 Option 2 Cut and fill of waste to level the site and then soil cap the whole site

The second option under consideration comprises cut and fill of existing waste materials to create a usable working platform prior to the placement of a 1m thick cap across the whole site.

At present the site comprises a very uneven surface of non-compacted mixed waste. In order to enable the placement of capping materials, the surface must be levelled in order to provide a safe working environment.

Option 2 requires the cut and fill of the existing waste materials in order to create a platform with no slope gradients exceeding 1 in 4. If the waste is excavated and then moved on site it will just need to be placed and compacted. It will not require sorting. Some large objects or fly tipped materials present at or close to surface may be removed from site for recycling or disposal during the cut and fill. A 1m thick capping layer would then be placed across the entire site, with the final surface meeting the site boundaries to the north and west abutting the watercourse. This would leave a 10m buffer to the south and east in order to retain the mature trees along the boundary with the roads.

It should be noted that there are additional mature trees on the southern boundary that extend further within the site, and on the boundary within the far northeast that suggest no illegal waste has been placed in these areas. There is also an area in the far southwest corner that will possibly be excluded should a detailed design be required. These are not considered within this options appraisal.

Factors that will require careful consideration for detailed design are:

- Settlement and slope stability;
- Health and safety during the works;
- Surface water drainage;
- Environmental Permit.

It is possible that a Landfill Directive compliant cap would need to be provided (TBC based on EA discussions) this has not been allowed for at this stage. A simple clay soil cap has been allowed for in both Options 1 and 2.

All of the above are similar for both earthworks options (Options 1 and 2) and are not included in the cost comparison. With this option it may be possible to operate the site so that payment is received for imported fill and the scheme could be fully or partially self-funding. This needs to be explored with a contractor. An Environmental Permit will be required. It is likely that planning permission would be required. The key factor here is that it requires less import of soil so the site works would be completed faster. This option is also more sustainable as there will be fewer lorry movements for imported materials.

An indication of potential final levels for Option 2 are shown in Appendix A.

Table 2 Option 2 assessment

Option 2 Cut and fill of waste to level the site and then soil cap the whole site		
Criteria	**Evaluation**	**Score**
Volumes	Cut and fill existing waste – 135,000m^3 Imported material for capping layer – 250,000m^3	N/A
Cost comparison value (subject to limitations in section 3.2)	~~£££££~~ (could possibly be partially funded if site is operated to accept suitable fill)	2 / 10
Practicability, effectiveness, and durability	Practicability **Good** – This is a standard earthworks operation and should not present any unusual difficulties.	4.5 / 5
	Durability **Good** – There is no long-term maintenance required.	
Health, safety and environmental impact of works		4 / 5
	Stress for residents **Moderate** – The remediation will take time to complete, but there would be fewer traffic movements.	
	Carbon emissions **Moderate** – The work will involve use of large construction plant, extensive earthworks and transport of materials.	
	Habitats and biodiversity **Good** – The remediation can be designed to improve the site in this respect at little or no extra cost.	
	Total	10.5 / 20

4.3 Option 3 Innovative capping option comprising of some soil placement combined with spray applied cement polymer and hydro seeding

Option 3 provides an innovative alternative solution to the traditional capping options provided as options 1 and 2. The option includes the use of spray applied cover layers, some soil dressing and hydro seeding.

This option is more temporary, would require long-term management and maintenance, including re-application of treatments in the future. **This option is also only viable if public access to the site can be robustly prevented.**

Site preparation would be needed to clear vegetation from areas requiring treatment. For this option it would be possible to be selective and limit treatment to areas subject to fires and wind-blown pollutant migration, so some parts of the site which area densely vegetated and not posing a risk could potentially be left untreated. The cover layer will be applied to certain parts of the site where there is current smouldering. The sealing cover layer combats fires by limiting oxygen ingress to the surface of the waste. It is a proven technology for treating landfill fires and dust generation. This will require detailed survey and assessment ahead of design of this remedial option.

The first stage of work would be minor levelling, compaction (by driving over) and soil dressing of areas to be treated. This is required to minimise over-application of the cement/polymer cover layer. At this stage any large waste items present at the surface (i.e. tyres, drums, household appliances) could be picked up from the surface and moved to a skip for off-site recycling or disposal.

After the areas for treatment have been prepared (levelled and dressed with imported soil) to provide a smooth application surface the cover system is applied. This is recommended to comprise treatment with a seed mix followed by polymer-based spray applied capping material. The material is a blend of clay binders, reinforcing fibres, and polymers that, when mixed with water, produces a spray-applied mortar that dries in the form of a thin durable stucco. The product can be mixed with cement (recommended in a 1:4 ratio) to form an "intermediate cover" layer, this is recommended for this use case.

The hydro seeding in combination with the spray cover layer will encourage formation of vegetation, which will grow through the polymer/cement cover. Vegetation cover binds the underlying soils through root growth, stabilising the ground. Vegetation at the surface also reduces infiltration by increasing evapotranspiration.

The spray applied polymer layer and hydro seed can be successfully used on steep slopes, so the site would not need to be reprofiled. Detailed topographic surveys are required and high-resolution drone imagery recommended to inform the detailed design and planning of the work.

The treatments are likely to require reapplication. The initial application works may only take few weeks to complete. The site would need to be inspected annually and reapplication considered and potentially completed every few years.

The approximate cost of hydroseeding/hydro mulching on a flat site with easy access is £1 per m^2. On this site the equipment would have to be adapted to work on the rough terrain and progress would be slower which would increase the cost. The cost for the polymer cement spray cover is not known. An allowance has also been made for importing subsoil and creation of site access routes.

It is considered that the work would not require an Environmental Permit. Further consultation with the EA is required to confirm this. It is not clear whether planning permission would be required.

Contractor engagement is required to confirm technical suitability of this option for the site and to provide more detailed costing information.

Table 3 Option 3 assessment

Option 3 Innovative capping option comprising of some soil placement combined with spray applied polymer layers and spray applied hydro mulch		
Criteria	**Evaluation**	**Score**
Cost comparison value (subject to limitations in section 3.2)		8 / 10
Practicability, effectiveness, and durability	Practicability **Good** – This is a standard landscape operation but will require adaption of the plant to allow access.	4 / 5
	Durability **Poor** – May require further applications.	
Health, safety and environmental impact of works	Health and safety **Good** – Standard landscaping operation. Should not require contact with waste.	5 / 5
	Stress for residents **Low** – The remediation will take a few weeks to complete and would be few traffic movements.	
	Carbon emissions **Low** – The work does not require extensive use of large construction plant.	
	Risk of pollution to water, air and soil **Good** – improvements to the site will reduce emissions to atmosphere.	
	Habitats and biodiversity **Good** – The remediation can be designed to improve the site in this respect at little or no extra cost.	
	Natural resources and waste **Good** – The works use recycled materials that may otherwise end up being landfilled.	
	Total	17 / 20

5 Conclusions and recommendations

The options appraisal has identified three potential options to remediate the site. None of the solutions are straightforward and require further discussions with contractors and the Environment Agency.

The innovative spray-applied cover system scores best in the options appraisal. However, the main problem will be that of long-term durability. There will be a requirement for re-treatment of some areas estimated at every few years. The landform would also remain irregular. This option is also only viable if public access to the site can be robustly prevented.

For the earthworks-based solutions, Option 1 is lower cost than Option 2, although options to reduce these costs could be explored with a contractor. They have similar scores in terms of the other factors that have been considered.

Option 3 is potentially the most cost-effective solution and would be quicker to employ. This option includes a polymer modified spray-applied cover to some parts of the site to prevent fires. This is a fairly novel application in the UK, however the product has been used on at least two landfill sites in England in response to environmental issues with full agreement of the Environment Agency. Therefore, we feel it is a viable solution for the site which merits further feasibility study and contractor engagement. We consider that Option 3 may not require an Environmental Permit.

The next steps for progressing Option 3 towards delivery are recommended to comprise:

1. Consultation with EA outlining the proposed approach for the site, to confirm acceptance in principle and that there are no permitting implications.
2. Accurate topographic survey of the site recording ground cover conditions, in combination with high resolution drone survey.
3. Design of the capping solution, in terms of areas that require treatment, and plan access routes across the site.
4. Further consultation with LSC (supplier of polymer/cement product and hydroseed mixes) and UK distributor (halcyonenvironmental.com) and UK based hydroseeding contractors to get budget cost and programme.
5. Prepare a detailed remediation strategy/specification document, and submit this to EA and Havering contaminated land team for comment/approval.
6. Tender the package of work for construction.
7. Construction and verification of the cover layer installation.
8. Annual site walkover/inspection and maintenance in the form of reapplication.

Appendix A

Drawings showing existing levels and possible levels over remediated site

epg

Appendix B

Cost estimate for comparative purposes (not to be used for budgeting)

Redacted

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