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Application for Permit Variation

Permit Nº 53997 (New Tip)

Document NTPV 01 (C2)

Pre-application discussions with the Environment Agency

Section B

- Technical response provided by Urban Springside Ltd *'R1635-L09/afs'*.

Contaminated Land
Air Quality
Environmental Audit

SMITH GRANT
Environmental Consultancy
LLP

Partnership No: OC 300776

R1635-L09/afs

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John Bamforth
Urban Springside Ltd.

By e-mail: john.bamforth@urbanregen.co.uk

Dear John

Further risk assessment for cement-stabilised New Tip Waste sludge, Springside Mills, Belmont

1. Background

1.1. It is proposed to utilise cement-stabilised New Tip sludge treated to form a stable granular lightweight aggregate as a regulation and gas drainage layer across the Old Tip; this will comprise the basal part of the restoration capping. Upflow percolation testing on the treated New Tip sludge has demonstrated the suitability of the treated material for use as a base layer in the restoration capping of the Old Tip (ref: SGP Letter R1635-L08). However in reviewing the results of this testing the Environment Agency has requested additional assessment of risk to controlled waters with respect to potential sulphate and total organic carbon releases from the treated material due to results in excess of comparable results from limestone aggregate.

1.2. The hydrogeology of the Old Tip is described in SGP report R1635-R01-v3. The conceptual site model in relation to the proposed placement of the treated sludge layer summarised below:

2. Conceptual Site Model

2.1. *Sources:*
Treated sludge subject to leaching via (i) rainfall (across general area of Old Tip sludges ~ 6000m^2, as average 0.5m thick layer) or (ii) intermittent saturation by groundwater (low-lying area adjacent to Mill Lodge ~100m^2) – pollutants of interest are a) dissolved calcium sulphate and b) total organic carbon, principally in the form of fine cellulose fibres;

Upflow percolation tests for the above substances gave the following eluate concentration results:

Table 1. Upflow percolation test results for proposed cover material (treated sludge)

substance	maximum	mean	median	surface water environmental quality standard (EQS)
sulphate	1000	218.7	69.5	400
total organic carbon	14	8	7.5	-

All figures are mg/l

There is no specified surface water environmental quality limit for sulphate under the Water Framework Directive (2000/60/EC) or daughter directives. The Environment Agency non-statutory EQS is derived from recommendations by the Water Research Council (WRC). WRC noted that there was little evidence for sulphate toxicity in aquatic systems, but that impacts were most likely to arise as a result of osmotic effects, as for salinity. Other regulatory authorities have imposed sulphate standards as a consequence of veterinary effects (as a laxative) upon watering livestock, with Australia and Canada setting guideline values of 1,000 mg l^{-1} to protect livestock drinking water.

Due to the absence of observed toxic effects, the World Health Organisation has not recommended a human health based standard for sulphate in drinking water. A standard of 250 mg l^{-1} has been suggested for drinking water (and hence groundwaters supporting potable supplies); this is principally to avoid possible taste or odour, although it is noted that many groundwater resources in former mining areas and regions with natural dolomite or evaporite bedrocks cannot meet this standard, and that bottled mineral waters frequently contain much higher concentrations of sulphates.

Sulphate is a compound of sulphur and oxygen. Sulphur is an essential plant and animal nutrient. There are chemical and biological processes by which sulphate can be removed from solution in water, generally involving reduction to remove the oxygen, or the addition of cations that form an insoluble precipitate with sulphate. Reduction processes involve the generation of sulphide ions, or dissolved hydrogen sulphide gas. Sulphides will form insoluble precipitates in reaction with many metal salts including iron, but sulphide or hydrogen sulphide gas are particularly toxic to aquatic organisms; the EQS for dissolved sulphide is 0.25 µg l^{-1}.

Total organic carbon (TOC) is a measurement of all organic carbon, and in relation to the treated sludge the key organic constituents are natural compounds of plant cellulose and lignin. The potential significance of these lies within the potential for degradation by micro-organisms leading to possible deoxygenation of the water. This potential may also be expressed in terms of Chemical Oxygen Demand (COD) which is the amount of oxygen required to oxidise all matter to carbon dioxide and water in the sample; COD testing is routinely carried out on leachates, groundwater and surface water around the Old Tip. The stoichiometry of cellulose $(C_6H_{10}O_5)_n$ means that each carbon atom in the cellulose will, if fully degraded, potentially react with one oxygen molecule, and typically COD will therefore be a factor of ~3 times the TOC concentration. Accordingly the eluate TOC results indicate equivalent COD values typically as follows: maximum 42 mg/l, mean 24 mg/l.

2.2. *Controlled waters receptors:*

a) Mill Lodge surface water impoundment and overflow to downstream Three Nooked Shaws Brook (TNSB), flowing to Eagley Brook
b) Eagley Brook via original valley pathway (see below)

Existing water quality data including sulphate and COD values are available for a number of monitoring points over several years. Data for the last 2 years of quarterly monitoring are summarised in the table below.

Table 2. Last 2 years of quarterly water monitoring data at key locations

		Apr-15	Jul-15	Oct-15	Feb-16	May-16	Jul-16	Oct-16	Feb-17	mean	median	max	95%ile
Old Tip discharge	SO4	*0.5*	*0.5*	4.9	4.4	0.6	2.3	1.6	2.4	2.2	2.0	4.9	4.7
	COD	45	42	38	16	33	45	45	25	36.1	40.0	45.0	45.0
Old Tip Leachate (BH3/11)	SO4	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	2.5	*0.5*	1.6	0.9	0.5	2.5	2.2
	COD	920	590	330	190	480	420	400	270	450.0	410.0	920.0	804.5
Mill Lodge (SWR1)	SO4	11	6.7	7	8.8	7.5	8.2	9.5	5.3	8.0	7.9	11.0	10.5
	COD	26	20	50	13	5	16	16	35	22.6	18.0	50.0	44.8
"Ochre" Culvert (SWR5)	SO4	69	99	130	120	63	54	56	63	81.8	66.0	130.0	126.5
	COD	8	5	13	*0.5*	*5*	5	15	27	9.8	6.5	27.0	22.8
Eagley Brook (SWR6)	SO4	7.6	9.8	8.3	8.4	71	7.2	6.5	4.9	15.5	8.0	71.0	49.6
	COD	20	16	37	21	11	35	32	30	25.3	25.5	37.0	36.3

results are mg/l, results in italics are below the limit of detection

Environmental data for TOC are not routinely collected, but samples obtained on 22/02/17 from the Mill Lodge and Eagley Brook sampling sites (SWR1 and SWR6 respectively) provided TOC values of 12 and 14 mg/l (results certificate attached).

The catchment contains extensive peat moorland and the local surface waters are typically peaty, containing suspended solids of natural humic acids, lignin and cellulose.

Flow monitoring data for the local watercourses are not available, with the nearest monitoring station downstream being the River Croal at Farnworth Weir (NRFA Station 69024). The catchment area for this station is 145km^2 and the long-term mean flow is 2.988m^3/s. This equates to an average effective rainfall rate of 650mm/y; this may be low when related to the actual site catchment alongside Winter Hill where rainfall is typically in the range 1300-1700 mm/y. The catchment for Eagley Brook below the site is estimated to be 15.8 km^2, and taking the above rainfall rate of 650mm/y this gives a mean river flow at the downstream side of the site of 0.33m^3/s. The catchment for TNSB at the Mill Lodge outlet is estimated to be 1.3 km^2 and the derived mean flow is 0.03m^3/s. The mean flow in the Ochre Culvert downgradient of the Old Tip is estimated at 1-3 l/s.

From the above catchment analysis, typical mean dilution rates for water draining between the Old Tip potential source area (0.6 ha) and Mill Lodge/TNSB and Eagley Brook are estimated to be at least 1:100 and 1:1000 respectively. In dry weather conditions it is likely that flows through the cover of the Old Tip will reduce to negligible rates, and therefore risks of pollution transport into receiving waters are likely to be mimimal under low-flow conditions.

2.3. *Pathways*

a) Sub-horizontal drainage through base of placed cover over existing waste surface westwards to Mill Lodge; Mill Lodge then drains via TNSB culvert to Eagley Brook;
b) Vertical infiltration of seepage entry to Old Tip landfill body with subsequent lateral drainage westwards to Mill Lodge
c) Vertical infiltration of seepage entry to Old Tip landfill body with subsequent lateral drainage eastwards via infilled valley to "Ochre Culvert" and Eagley Brook

The geology surrounding the site is low permeability glacial till and all site drainage either flows west (estimated ~80%) to Mill Lodge, or east (estimated ~20%), as perched groundwater within made ground and relict drains via the ash-filled valley to Ochre Culvert and Eagley Brook. Ochre Culvert also collects drainage from other parts of the valley including old ash tips and the former paper mill complex.

3. Risk Assessment – Total Organic Carbon

3.1. The maximum and mean eluate concentrations for treated sludge were 14 and 8 mg/l respectively. The TOC concentrations of the surface water receptors at Mill Lodge and Eagley Brook on 22/02/17 were 12 and 14 mg/l respectively. On this comparison, the placing of treated sludge as part of the Old Tip restoration (as worst case, using upflow leaching data to represent total inundation of cover) produces short-term concentrations similar to or lower than the receiving surface waters. This is highly unlikely to result in any significant increase in TOC levels within either the Mill Lodge or Eagley Brook, even without considering attenuation or dilution effects.

3.2. Converting the eluate TOC to equivalent COD values by using a factor of 3, the eluate CODs would be 42 mg/l (maximum) and 24 mg/l (mean) respectively. These are compared to the long term COD values of leachate within the Old Tip waste body (920 max, 450 mean mg/l) and discharge point adjacent to the Mill Lodge (45 max, 36 mean mg/l). Again it can be seen that the treated waste carries lower concentrations than the directly adjacent waters associated with the Old Tip, and therefore the proposed treated sludge use in restoration would not increase concentrations in these bodies.

3.3. The overall concentrations of TOC (and likely equivalent COD) in the eluate are considered to be low and are unlikely to result in any significant deoxygenation of surface waters. The risks from TOC are therefore concluded to be insignificant with respect to all controlled waters receptors and dependent ecosystems.

4. Risk Assessment – Sulphate

4.1. The maximum and mean eluate sulphate concentrations for treated sludge were 1,000 and 219 mg/l respectively. Given that the sulphate is likely to arise from cementitious material combined with limestone fillers, the dominant chemical form is likely to be calcium sulphate. Typically, sulphate and high pH leachate from cement-stabilised soils will rapidly decrease over time due to the completion of cement curing and carbonation of calcium salts, and therefore the elevated sulphate levels are considered to be a temporary phenomenon.

4.2. The maximum eluate concentration of sulphate exceeds the EQS however the EQS value is non-statutory and sulphate is a non-priority pollutant under the WFD. The under-pinning research by WRC showed that sulphate had low toxicity and should be regarded as having similar effects to elevated salinity, i.e. effects would only be apparent under brackish concentrations; the 400 mg/l standard recommended by WRC was considered by them to be arbitrary. The principle concern relating to sulphate at low concentrations relative to brackish water is potential effect on drinking water for farm livestock, where some authorities have set a limit of 1000 mg/l to protect against laxative effects.

4.3. Sulphate concentrations are routinely monitored for a variety of locations including within tip leachate, groundwaters and surface waters around the site. Natural concentrations in the local environment are typically around 25mg/l in Eagley Brook and the Mill Lodge. Higher concentrations are evident in the Ochre Culvert at around 50 mg/l due to the industrial catchment. Concentrations in the Old Tip leachate are very low due to the anaerobic environment where any sulphate present will be reduced to sulphide; sulphide is not required to be monitored outside the Old Tip and there is no visual or odour evidence of significant sulphides leaving the Old Tip in leachate. It is likely that sulphides within the Old Tip will combine with metal ions to form insoluble precipitates.

4.4. Taking the key identified pathway for drainage across the stabilised sludge used in the Old Tip cover laterally towards the Mill Lodge, little attenuation in sulphate concentration is expected between the source and principal surface water receptor. Therefore at the point of discharge via the dam wall of the Mill Lodge there will be dilution in the water body but probably slow attenuation as a result of biological uptake. Sulphate reduction to sulphide is not likely given the well oxygenated conditions and flow through the Lodge. For a typical minimum dilution rate of 100 between drainage from the Old Tip cover and the TNSB / Mill Lodge water, the predicted concentrations within the mixed water would rise from a baseline of 25 mg/l to ~35 mg/l for the short-term eluate maximum (1000 mg/l in discharge), falling to ~27 mg/l for the eluate average (219 mg/l in discharge). These concentrations are insignificant in terms of potential impact upon TNSB and Mill Lodge, and subsequently Eagley Brook, where further very substantial dilution would occur.

4.5. Sulphate in seepage entering the body of the Old Landfill would be subject to microbial reduction to sulphide in the strongly anaerobic environment of the waste mass. Sulphides would then either continue to migrate within the Old Tip leachate with attenuation through the formation of insoluble metal sulphides or possible emission of hydrogen sulphide gas alongside existing methane and carbon dioxide emissions to atmosphere. Sulphide in leachate from the Old Tip has not be a problem to date, and the potential for any change in this situation following capping of the site is considered to be minimal given the relative sizes of cover material (~3000m^3) to the existing volume of Old Tip paper sludge wastes (estimated at 19,500m^3). The construction of the Old Tip restoration cover is designed to mitigate such emissions by forming an aerobic soil zone where methane (and hydrogen sulphide) will be largely oxidised by autotrophic bacteria. Gas monitoring of the Old Tip has shown very low existing hydrogen sulphide concentrations in the landfill gas emissions (see SGP landfill gas risk assessment report, R1635-R02-v2).

4.6. The introduction of sulphate via leaching from the cover material into the Old Tip waste body is expected to be minimal, with most drainage likely to be sub-horizontal across the surface of the waste. However in the course of this drainage, it is possible that some sulphate reduction could occur at the existing waste surface of the tip, and there is a potential short-term risk of sulphide entering the Mill Lodge. The extent of any risk is uncertain, and it is therefore proposed that monitoring for sulphide be included within the overall suite of water testing to be carried out during the restoration and aftercare phases for the Old Tip. In the event of sulphide concentrations approaching or in excess of the EQS being detected, with possible risk to fish or other aquatic organisms, mitigation could be implemented by means of water aeration of the Mill Lodge using bubble diffusers.

5. Conclusions and Recommendations

5.1. The Environment Agency has requested additional risk assessment for controlled waters to support the proposed use of cement stabilised New Tip sludges in the restoration of the Old Tip with specific respect to potential sulphate and total organic carbon (TOC) emissions from the treated material.

5.2. Groundwater in the natural cohesive soils and underlying bedrock down-gradient of the Old Tip is not in significant hydraulic continuity with the tip and will therefore be unaffected. Groundwater/leachate flowing from the Old Tip both passes westwards directly to the Mill Lodge or eastwards via industrial fills in the down-valley drainage and Ochre Culvert to Eagley Brook. No significant pollution attributable to Old Tip landfill leachate has been detected within the Mill Lodge, Ochre Culvert or Eagley Brook over years of regular monitoring.

5.3. TOCs released during upflow percolation testing of the treated material are of low concentration and are consistent with existing levels of TOC in the receiving surface waters of the Mill Lodge / Three Nooked Shaws Brook and Eagley Brook. The character of the organic materials detected in the TOC testing are generally similar natural plant-derived substances of cellulose and lignin. No negative impact from TOCs are therefore likely and it is noted that the test results indicate worst case conditions that are likely to be very temporary.

5.4. Sulphate concentrations were temporarily elevated in the eluate testing and this is consistent with cement-based stabilisation methods, with concentrations reducing over time as the cements complete their curing process over weeks or months. The maximum sulphates exceed the surface water Environmental Quality Standard, however the standard is non-statutory, arbitrary and unsupported by evidence of impacts; the evidence indicates that sulphates are of low toxicity and only become significant at much higher concentrations similar to those found in brackish waters. High rates of dilution between drainage carrying sulphates from the Old Tip restoration cover into the Mill Lodge indicate that the potential rise in concentration within the Mill Lodge and downstream would be marginal, and would remain considerably below the EQS.

5.5. Sulphates in water entering the Old Tip waste body would be subject to conversion to sulphides, and there is a potential risk of some additional sulphides entering the Mill Lodge. The risk is uncertain but likely to be low, and mitigation by means of monitoring and remedial treatment if necessary to remove sulphides are proposed. Any effects of sulphates or sulphides are likely to be very short-lived before the landfill cover is fully stabilised.

5.6. Overall, the restoration of the Old Tip is expected to result in an improvement in water quality surrounding the site as a result in the reduction of direct runoff from the landfill into the Mill Lodge, and reduction in infiltration of rainfall to the Old Tip as a result of the establishment of cover system incorporating drainage and managed vegetation cover..

5.7. It is recommended that full scale cement stabilisation treatment is commenced to demonstrate the functionality and practicality of treatment and placement of treated product as part of the Old Tip restoration. Testing and monitoring arrangements will be included within the deployment documentation to be prepared by the waste treatment specialist contractor.

Yours sincerely
For: Smith Grant LLP

A F Smith BSc PhD MCIWM SiLC, Partner

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