Appendix 2: Hydrological report

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Knepp Castle Estate: Hydrological Impact Report of Laybrook Landfill Site

Client

Knepp Castle Estate

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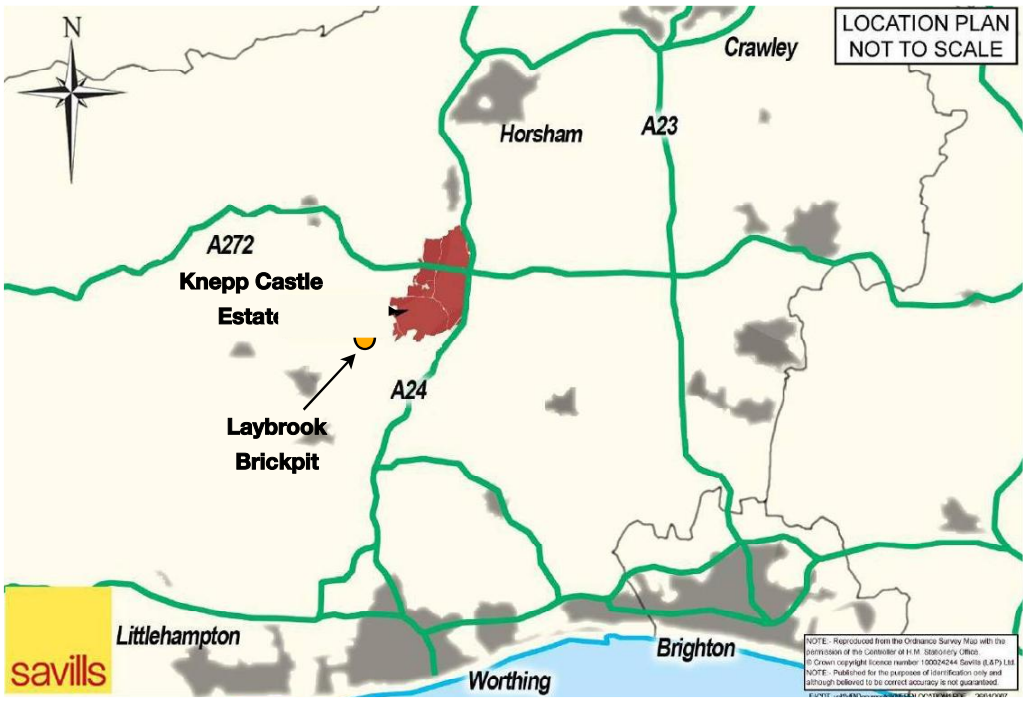
1. Introduction

The Knepp Castle Estate is a 1400 ha estate in lowland England, south of Horsham, West Sussex (see figure 1). The estate is centered at Ordnance Survey Great Britain (OSGB) grid reference 515575,121735. The estate until recently consisted of in-hand and let farmland, including arable, livestock and woodland; typical for an English Estate.

Figure 1. Location of Knepp Castle Estate and the proposed site of the Laybrook landfill. Image edited from Kernon and Countryside Consultants and Land Use Consultants (2007).



In March 2007 a feasibility assessment was completed (Kernon Countryside Consultants and Land Use Consultants, 2007) to evaluate and draft phased plans to return the estate to a natural (climatic climax community) ecosystem. The idea is inspired by the work of Dutch ecologist Frans Vera who pioneered the notion that pre-humanised lowland Europe was in fact a patchwork of open grassland, shrubs and isolated trees browsed and grazed by large herbivores (Vera et al., 2007). A baseline ecological survey was completed in 2005 to support the project.

Running parallel to this renaturalisation of the landscape, is a Natural England funded restoration project of the River Adur running through Knepp Castle Estate. The project is designed to restore the historical meandering form of the now highly modified and canalised stretch of the River Adur. This will reconnect the River Adur and floodplain, restoring it to its natural form and improving biodiversity (Janes *et al.,* 2006).

The proposed site of Laybrook Brick pit, south-west of the estate and hydrologically connected to the estate through the Laybrook is of considerable concern and potential risk to the renaturalisation project that is underway.

This report will review the hydrological and environmental statements issued by Cory Environmental as part of their submitted planning application. The report will also evaluate the statements of concern that have been raised in opposition of the planning application (Knepp Castle Website, 2009). The report will reiterate any potential issues that have not been engaged with to an appropriate level, and raise any other concerns that have not been addressed as part of their hydrological statements.

2. Statement of Competency

Haycock are a specialised Environmental Consultancy with significant experience in advising clients on critical water issues ranging from flood risk analysis and surface water management through to river restoration and management of water quality. Our focus is on rivers, soils, hydrology and landscapes and we are passionate about creating, restoring and protecting the 'natural landscape' through practical and innovative solutions.

For the last 15 years, we have worked with clients to develop water and environmental management solutions in some of the most challenging locations. We have worked for seven years for the Venice Drainage Authority, advised The National Trust for 15 years on all 1192 of their estates. We have undertaken the restoration of Boscastle following the August 2004 flood, designed and built the largest UK river restoration project and undertaken the largest European wetland creation project. We have received a variety of environmental awards in the UK and overseas for our work. In February 2008 Dr N Haycock chaired a group of 12 UK professors in hydrology/hydraulics who made technical recommendations to the Pitt Review and since this has developed with The National Trust a £1M catchment project (Holnicote). Our current clients continue to be The National Trust, Environment Agency, Royal Palaces (Kensington) and numerous private land owners.

All Haycock consultants have profession affiliation of the British Hydrological Society and have a portfolio of hydrological assessments for both private and commercial sites. Dr. N Haycock is a science advisor to DEFRA and the NFU and former chairman of the UKs River Restoration Centre (RRC). In addition Dr Haycock is a visiting research fellow of the University of Manchester and also has close links with University of Birmingham.

3. Field Notes

Haycock conducted an initial site visit of Knepp Castle Estate on Monday 7th September 2009. The visit was an opportunity to put the proposed landfill at Laybrook Brickpit into the context of the local environment. The second function of the visit was to better scope the estate naturalisation project that is ongoing and the River Adur restoration project that is due to begin.

Based on initial observations from this site visit, it is observed that the environmental risks posed by the proposed landfill will be to the 'southern' and 'middle' management blocks. At present an increase in suspended fine particulates within the Lay Brook can be observed when comparing up- and down-stream sites relative to Laybrook Brickpits (see figure 2).

Figure 2. Photographs of Lay Brook taken immediately upstream (left) and downstream (right) of the Laybrook Brickpit. A significant increase in fine particulate load (clay) is visually apparent.

South of Laybrook Brickpits, Lay Brook flows into Hammer Pond, a carp fishing enterprise within the Knepp Castle Estate. It is noted that if leachates and other contaminants were to be transported from the proposed landfill site, Hammer Pond and the associated carp fishing enterprise would come under significant threat.

Longer term, Hammer Pond may act as sink for any contaminants that are transported by the Lay Brook from the landfill. Lay Brook slows as it enters Hammer Pond and contaminants, particularly those that have a high affinity to fine particulates such as heavy metals, will be gradually enriched in pond sediments.

Observations by members of the River Adur Conservation Society (RACS website, 2009) have noted the presence of Sea Trout redds on Lancing Brook at Brookhouse Paddock and Bentons Place Farm (see figure 3). Adjacent to Lay Brook, these observations suggests that Sea Trout may also be present along the Lay Brook. A detailed fish survey of the Lay Brook to complement the Environment Agency fish survey that is to be undertaken along the River Adur (Charlie Burrell *pers. comm.* 2009) might be worth undertaking.

The planned restoration of the River Adur at Knepp Castle has been funded principally through Natural England (NE), with addition investment from the Environment Agency (EA) and the Knepp Castle Estate. This proposed work is designed to return the current canalised form of the river (see figure 3), into a natural meandering river that has improved connectivity with its floodplain. This project will improve the biodiversity and ecology of the River Adur and its floodplain at Knepp Castle as well as providing potential attenuation of flood water to reduce flood risk downriver.

A robust monitoring strategy is required along the River Adur and Lay Brook if accurate assessment of the impact on the landfill on the downstream environment is to be made. At present there is just one EA flow gauge on the stretch of the River Adur at Knepp Castle (see figure 5). Observations suggest that water quality monitoring is required along the River Adur and Lay Brook as there is the potential for Knepp Castle Estate to act as a contamination sink. An appropriate monitoring program coupled with a detailed baseline survey is therefore required to help mitigate this risk.

Figure 3. The current canalised form of the River Adur at Knepp Castle immediately west of where it leaves the estate beneath the A24 (right). EA flow monitoring equipment can also be seen (left).

4. Bedrock and Superficial Geology

4.1 Knepp Castle Estate

Sub-surface geology underlying the Knepp Castle Estate is made up entirely of the Weald Clay Formation (WC). Weald Clays and thinly-bedded mudstones, some with subordinate siltstones, fine- to medium-grained sandstones, including calcareous sandstone, shelly limestones and clay ironstones (BGS Website, 2009). Weald clays were deposited during the Lower Cretaceous. Unweathered, Weald Clay is generally blue-grey in colour, weathering to an orange/yellow-brown.

Superficial deposits which include Pleistocene River Adur deposits and Holocene alluvium deposits are found associated with the River Adur and its tributaries. Undifferentiated head deposits are found in very localised areas to the south of the River Adur as it flows past Knepp Castle (Mid Sussex District Council, 2005).

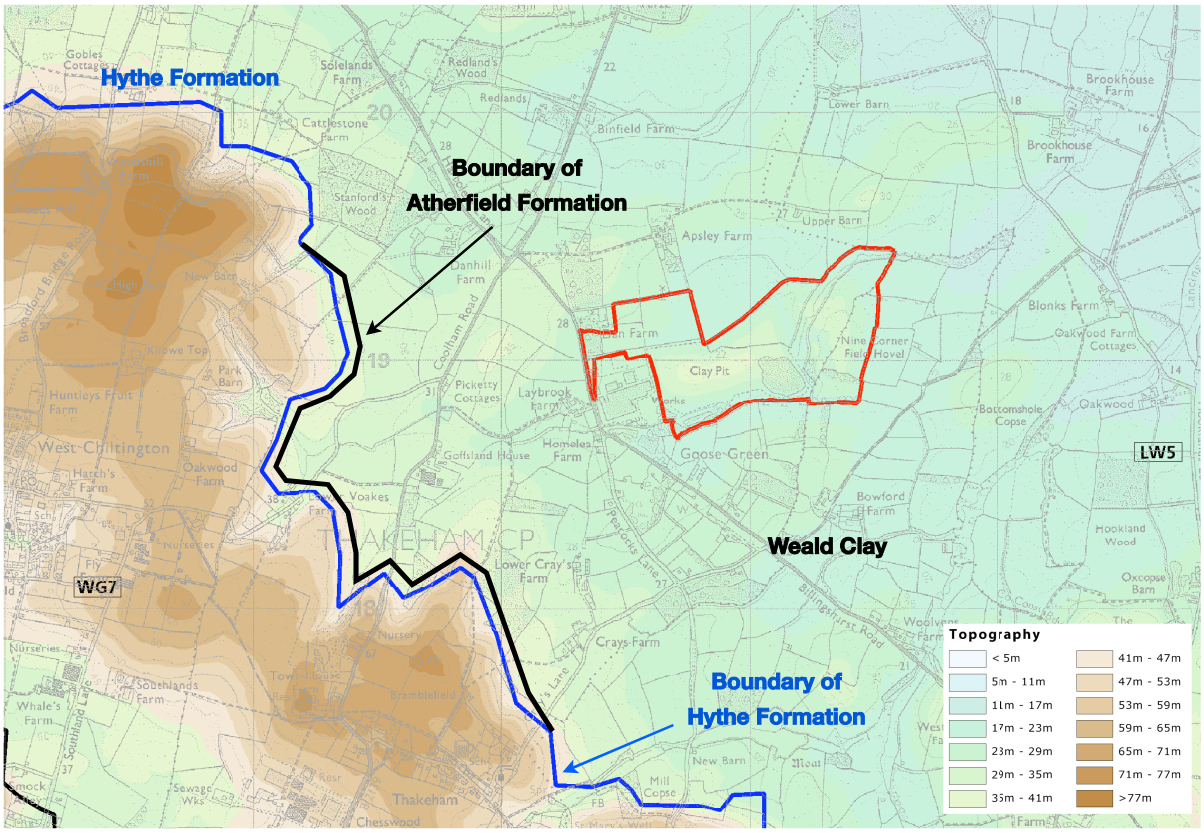
The overall result of the bedrock and superficial geology, is a landscape of clay-rich soils that generate a high proportion of surface run-off rapidly, in response to rainfall (EA, 2007).

4.2 Laybrook Brickpit

The sub-surface geology at the site of Laybrook Brickpit is also Weald Clay. From the site of Laybrook Brickpit, the land gently rises to the west (see figure 2). Approximately 1km west, the Weald Clay gives way to Lower Greensands, subdivided into a brief Atherfield Formation outcrop, followed by a much larger outcropping of Hythe Formation sandstones. The boundary between the Weald and Atherfield Clay is marked by a sandy and pebbly clay (BGS Website, 2009). The Hythe Formation generally consists of fine to medium-grained sands, sandstones and silts with some interbedded clay (BGS Website, 2009).

Superficial geology is associated with narrow corridors of alluvium and deposited along the course of the Lay Brook. Undifferentiated head deposits are also found between Laybrook Brickpit and the River Adur.

Figure 4. Topography of land surrounding Laybrook Brickpit. Image based on Volume 3, Figure 6 of Cory Environmental Planning Application



5. Soils

The Soil Survey of England and Wales (Soil Survey of England and Wales, 1983) classifies the soils encompassing the region including both Knepp Castle Estate and Laybrook Brickpit as Wickham 5 (Soil ID 711e). Described as a seasonally wet load to clayey over-shale (wetness index IV), it is associated with Cretaceous clay and mudstone bedrock geology (Jarvis *et al.,* 1984). Vertical drainage capacity through the soils is low. With an associated Hydrology of Soil Types (HOST) Base Flow Index (BFI) of 0.178 (Boorman *et al.,*

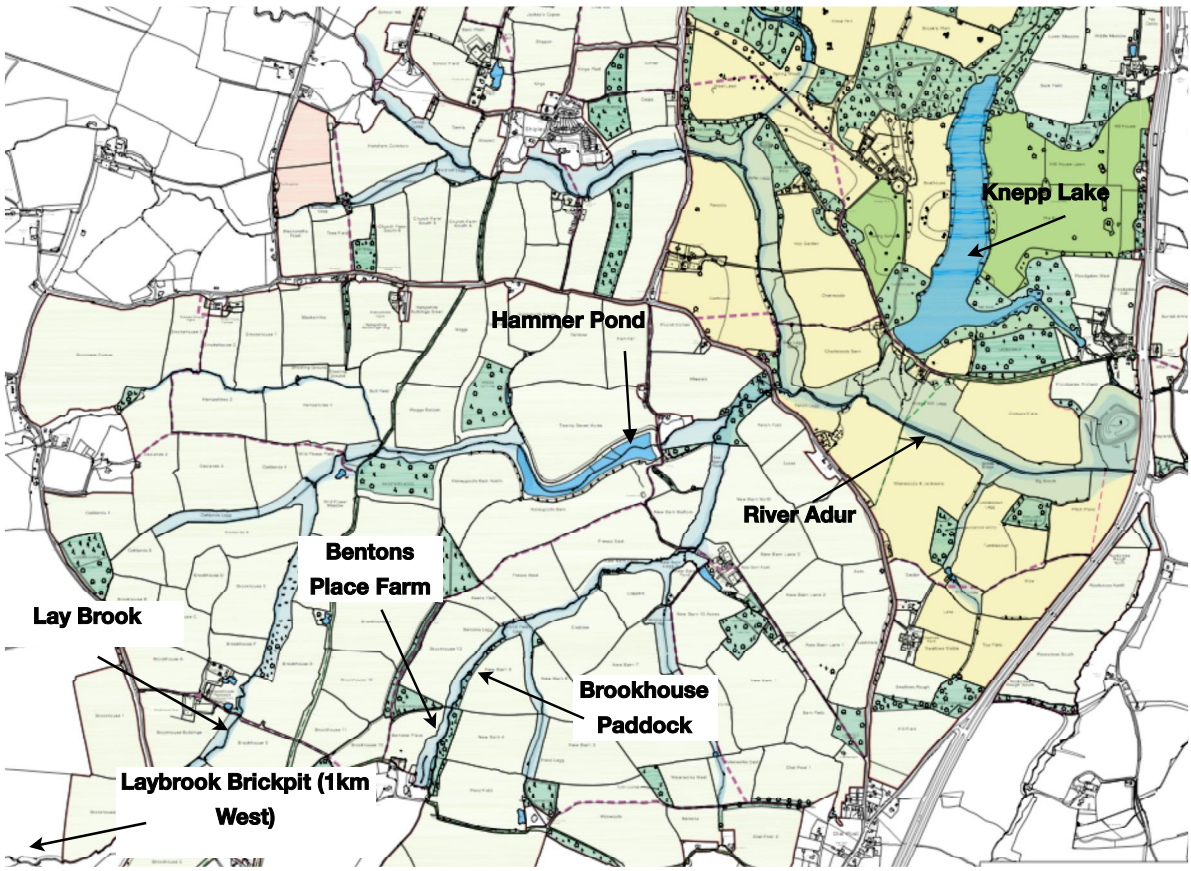
1984), only 17.8% of rainfall hitting the soil infiltrates it, the other 82.8% generates surface run-off and as such, rivers and streams respond quickly to rainfall events.

Outside of the Wickham 5 soils type, one other localised soil type is found; Fladbury 3 (Soil ID 813d). Described as a seasonally wet deep clay, this soil is associated with the alluvium deposits within the River Adur floodplain (Jarvis *et al.,* 1984). Fladbury 3 soils have a HOST BFI of 0.437 (Boorman *et al.,* 1984) allowing for greater infiltration of rainwater compared with the surrounding Wickham 5 soils.

6. Hydrology

Laybrook Brickpit is hydrologically connected to the Knepp Castle Estate through the Lay Brook. Rising to the west of Laybrook Brickpit, it flows in a east-northeasterly direction past Laybrook Brickpit and into the southern block of Knepp Castle Estate. Here the Lay Brook is confluent with the River Adur just south of Knepp Lake. The River Adur from this location continues in an easterly direction through the estate, eventually leaving Knepp Castle beneath the A24 (see figure 5).

Figure 5. Locations of Lay Brook and River Adur adapted from Kernon Countryside Consultants and Land use Consultants (2007).



Haycock

6.1 River Adur

Catchment parameters for the River Adur have been obtained using the Flood Estimation Handbook v2 (FEH) (CEH, 2006). The catchment of the River Adur as calculated to the eastern edge of the Knepp Castle Estate where the river leaves the estate beneath the A24 is 78.85 km^2 (see figure 6).

Figure 6. Topographical catchment area of the River Adur based on the location where the River Adur exits Knepp Castle Estate owned land beneath the A24 (OSGB grid reference 516380 120725) (CEH, 2006).

Rainfall-runoff modelling using the Revatised Flood Hydrograph (ReFH) (WHS, 2006) combined with the catchment parameters from FEH (CEH, 2006) has been undertaken to calculate the total and peak flows that occur at the point where the River Adur flows beneath the A24 for a series of designed rainfall events (see table 1).

Table 1. Rainfall-Runoff modelling outputs for the River Adur using FEH (CEH, 2006) and ReFH (WHS, 2006).

	1 in 2.33 Year Flood	1 in 5 Year Flood	1 in 10 Year Flood	1 in 30 Year Flood	1 in 50 Year Flood	1 in 75 Year Flood	1 in 100 Year Flood
Peak Discharge (m^3/s)	26.63	33.6	40.35	51.54	58.07	64.04	68.76
Total Discharge (m^3)	596.37	733.92	867.46	1088.54	1216.18	1332.54	1424.54

6.2 Lay Brook

Catchment parameters for the Lay Brook have been obtained using the Flood Estimation Handbook v2 (FEH) (CEH, 2006). The catchment of Lay Brook as calculated to the eastern edge of the of the proposed landfill site is 2.8 km^2 (see figure 7). Rainfall-runoff modelling outputs can be found in table 2.

Figure 7. Topographical catchment area of Lay Brook based on the location where Lay Brook exits Laybrook Brickpit (OSGB grid reference 512150 119050) (CEH, 2006).

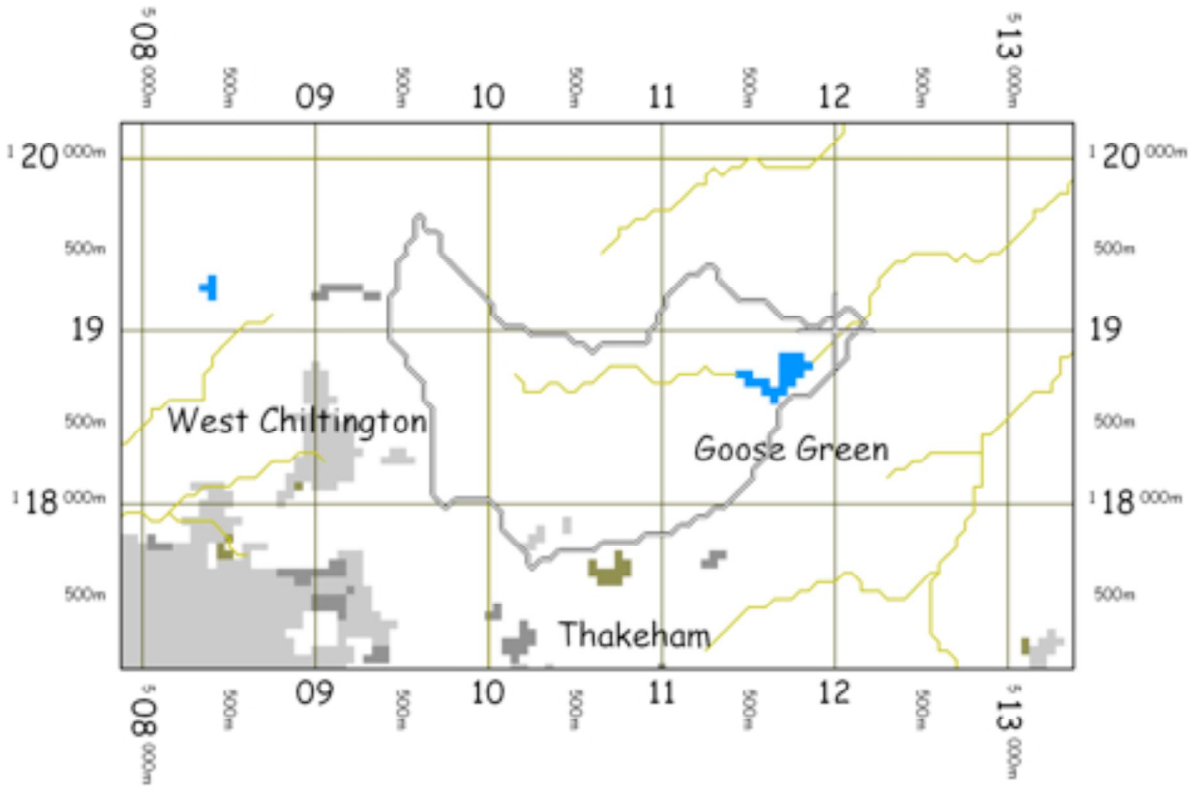


Table 2. Rainfall-Runoff modelling outputs for Lay Brook using FEH (CEH, 2006) and ReFH (WHS, 2006)

	1 in 2.33 Year Flood	1 in 5 Year Flood	1 in 10 Year Flood	1 in 30 Year Flood	1 in 50 Year Flood	1 in 75 Year Flood	1 in 100 Year Flood
Peak Discharge (m^3/s)	1.27	1.62	1.97	2.55	2.89	3.2	3.45
Total Discharge (m^3)	30.32	36.76	43.13	53.74	59.99	65.64	70.13

7. Cory Environmental Statement

A detailed review of the hydrological statements and flood risk assessment submitted by Cory Environmental as part of their planning application (COR/LA/SPH/1450/01/NTS/FIN) has been undertaken by Haycock. This planning application relates to the development of Laybrook Brickpits for for the purpose of a non-inert landfill site. This review has highlighted a number of issues that require attention and resolution before the planning application is accepted.

Our review has highlighted a number areas of the Cory Environmental planning application were insufficient information has been provided to demonstrate adequate mitigation of the hydrological and hydrogeological risks posed to, and by the planned landfill activities. Our review has also highlighted a number of discrepancies with the methodology employed within the calculations associated with the surface water management ponds to the north-east and north-west of the proposed development. Clarification of these concerns is necessary before planning permission is granted.

8. Haycock Appraisal

8.1 Hydrogeology

Cory Environmental have stated in paragraph 21.14 of their environmental statement (Document reference - PL11587 Final) that "*due to the low permeability of clay it is unlikely that there is significant flow in clay strata or significant continuity with the Lay Brook*." However, Cory Environmental also note in their environmental statement that "*minor seepage from a bed of sandstone in the northern face of the quarry was observed during the site walkover survey*" (paragraph 21.15). Cory Environmental have asserted that due to anticipated lateral discontinuity in the sandstone, siltstone and limestone interbeds within the Weald Clay, lateral movement of groundwater and associated dewatering of the wider region including the Lay Brook is unlikely to occur.

The Weald Clay has been subject to a number of detailed geotechnical investigations during the construction of the Channel Tunnel Rail Link (CTRL) and associated infrastructure (Roscoe *et al.,* 2002; Richards *et al.,* 2007). Horizontal permeability measurements for Weald Clay have provided values ranging from 3×10^{-7} to 1×10^{-9} m/s (Richards *et al.,* 2007). It is however noted by Richards *et al.,* (2007), that water strikes during drilling, associated with horizontal sand and silt laminations, suggests that horizontal permeability may be at least an order of magnitude higher. This is concurred with the finding of Roscoe *et al.,* (2002) who found that trial boreholes in the Weald Clay deteriorated and collapsed rapidly as a result of water seepage and inflows.

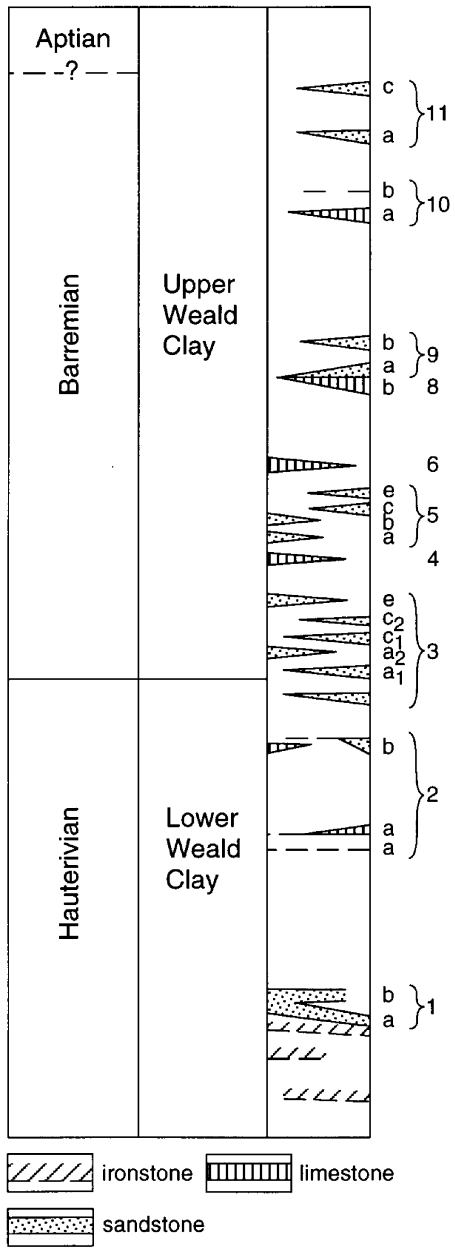
Cory Environmental have stated that an engineered, low permeability liner will be constructed to prevent the migration of leachate into groundwater. Cory Environmental note "i*t will be necessary to control the level of the groundwater seeping from the [sandstone, siltstone and limestone] lenses in the quarry face to below the base of the site during the construction of the low permeability liner*" (paragraph 9.51).

This lateral movement of groundwater which is a highlighted concern during the construction of the engineered liner may continue to pose a risk to the integrity of the liner after its installation. There is the potential for impeded groundwater to build up in these sandstone, siltstone and limestone laminations behind the low permeability engineered liner. Under lower groundwater pressure conditions, this would result in an increase in the hydraulic gradient across the liner and increased groundwater seepage. In a higher groundwater pressure environment, there is the potential for the structural integrity of the engineered liner being undermined. The occurrence of these higher permeability laminations is well documented in other studies (see figure 8). In the

eventuality that groundwater seepage increased or the liner breached, two significant environmental risks would be posed:

- Increased seepage as a result of the higher hydraulic gradient and/or localised failure of the engineered liner would allow greater groundwater ingress to the landfill. This could result in an increase in leachate formation and the potential for heavy metal mobilisation.
- Localised failure of the low permeability liner in the base of the landfill would undermine the leachate collection system and may provide a contamination vector for leachate and other pollutants to the surrounding environment.

Figure 8. Generalised stratigraphy of the Weald Clay (Radley, 1999).



8.2 Surface Water Management

Management of surface water onsite is critical to ensuring there is no detrimental influence on water quality downstream of the development. The method used for calculating attenuation storage (Appendix H - COR/LA/SPH/1450/11) is from the technical manual developed by the National Coal Board in 1982 (NCB, 1982). There are three particular issues that need addressing as a result of application of this method:

- The National Coal Board equations were originally developed for the management of surface water run-off from slag heaps in the North of England. The calculation allows for infiltration as this was part of the design process for the coal based slag heaps. The landfill at Laybrook Quarry is to be clay capped and will not have an infiltration capacity on the same scale (see Appendix G - Higgins, 2008). Therefore there is some doubt cast over the actual quantities of run off calculated and the size and attenuation times that are required to ensure the site meets the requirements of the discharge consent.

- Referring to Appendix H (COR/LA/SPH/1450/11) it is unclear from the calculation what the source of the rainfall duration and intensity figures is . As previously described the Coal Board Method was designed to be used in ares of Northern Britain. The rainfall intensities and durations experienced in the South East of England will be significantly different. The use of incorrect data may cause an underestimate of the required attenuation for a large rainfall events. Therefore there is some clarification required as to the source of this information to ensure it is representative of the landfill location.

- In the same calculations, run-off coefficients of 0.80 and 0.75 are utilised for the north-east and north-west settling lagoons respectively. This implies that there is an expectation of 20% and 25% of the total rainfall-runoff to infiltrate the clay. There is however no explanation as to why this coefficient has been used, or why the coefficient is different for the two areas in question. The infiltration capacity of the regional soil type (Wickham 5), is expected to be 17.8% of the total rainfall-runoff. It therefore seems unlikely that the exposed clay within the proposed landfill site would allow a greater amount of infiltration.

- The development of this methodology (NCB, 1982) was done before the development of the Water Framework Directive (2000/60/EC) and as such, does not account for the environmental requirements of this legislation. A more recent methodology that engages in the Water Framework Directive would be a more appropriate tool for calculating the requirements of the attenuation ponds.

Settlement of clay particles in the attenuation pond is key to ensuring that water discharged to the nearby brook meets the standards of the consent. There are a number of issues that need clarification with regard to the settlement process.

- The attenuation required in the north east area pond is calculated using a clay particle size of 2×10^{-6}m. This is widely accepted value for these calculations. The attenuation ponds in the north west area use a value of 5×10^{-6}m for the calculations and there is no information provided in Appendix H (COR/LA/SPH/1450/11) as to why this has changed from the value used for the north east area pond. A larger sized particle will result in a shorter settlement time. These values need to be validated as the true settlement time may have been underestimated. This could have an influence on the quality of water discharged from the site

- Appendix H (COR/LA/SPH/1450/11) provides some figures as to the volume of water to be attenuated as a result of a 1:100 year rainfall event and the area required to settle out the clay particulates. For the north east area pond the volume required is 19,215.27 m^3 with an area of 2540 m^2. This will create a pond which is 7.5 m deep. For the north west area pond the volume required is 22,592.09 m^3 with an area of 620 m^2. This will

provide a pond which is 36.4 m deep. Clay particles require a shallow environment in order to settle efficiently. With settlement ponds this deep the time to settle is extremely long (north west area pond = 40 days and north east area pond = 50 days based on settling velocities quoted in Appendix H (COR/LA/SPH/1450/11) of the Cory Environmental report). It is advised that if the existing scheme is developed that discharge from the ponds is not started until adequate settlement has occurred. Discharge consent clause 1(a) states that discharged water shall not contain any poisonous, noxious or polluting matter or solid waste. Removal of particulate matter from the site is key to ensuring this clause is met.

- If the ponds are built to attenuate a 1:100 year event then there will be no capacity to deal with any further rainfall on the site in the following days. If a large rainfall event occurs then it is likely, in this country, to be followed by further rain in the following days. To ensure the quality and quantity of discharge meets the consent standards it is advised that further attention capacity is provided to allow for this scenario.
- As an EA requirement of development planning, climate change has been factored into the rainfall-runoff calculations provided in appendix H (COR/LA/SPH/1450/11). However, it has only been accounted for as a 10% increase in rainfall as opposed to the EA's 20% requirement (Communities and Local Government, 2006).

8.3 Water Quality

Water Framework Directive (2000/60/EC)

Low flow in the Lay Brook has been calculated at 0.04 to 0.05 m^3/s using ReFH (WHS, 2006). The landfill development can discharge a maximum of 0.0116 m^3/s (see discharge consent) into the Laybrook and during low flow periods this discharge may account for between 23% and 29% of the total flow.

There is a significant possibility that a failure of the settlement ponds to work efficiently may result in a deterioration of water quality downstream of the site. This is contrary to the objectives of the Water Framework Directive, of which the Environment Agency will be the sole competent authority charged with its implementation in England and Wales.

The major aims of the Directive are:

- To prevent further deterioration and protect and enhance the status of aquatic ecosystems and associated wetlands;
- To promote the sustainable consumption of water; to reduce pollution of waters from priority substances;
- To prevent the deterioration in the status and to progressively reduce groundwater pollution.

There is also a general "no deterioration" provision to prevent deterioration in status of the water body. The overall requirement of the Directive is to achieve "good ecological and good chemical status" by 2015 unless there are grounds for derogation. There is a significant possibility that the contribution of this discharge to the Laybrook could cause a failure to meet the requirements of the Water Framework Directive.

Leachate

The formation and subsequent management of leachate on the site is of concern for local downstream habitats. A number of opposition statements have already voiced concern about the management of leachate on site and the need to demonstrate in a greater form, the safety aspects that have been put in place.

As discussed previously, there is concern over underlying geology. Present within the Weald clay are small seams of sand and siltstone containing groundwater. This may exert a pressure on the outside of the liner and over time higher hydraulic gradient across the liner will result in increased groundwater seepage through the liner to create greater volumes of leachate. The worst case scenario would be for the pressure to increase to a level where the engineered liner may completely fail in localised areas. Therefore there is a greater need for detail about the containment and processing volumes of leachate that can be safely stored and treated onsite.

8.4 Monitoring

The planning document has undertaken an assessment of the immediate area around the proposed landfill development but has not looked in detail at the potential impact on the downstream environment. There needs to be a rigorous assessment of the potential downstream impacts and a robust monitoring regime put in place due to the connectivity between the landfill site and the the downstream environment.

In order to track any changes over time there is a requirement for a baseline data set so any sampling taken during or after the landfill development is complete can be compared to a pre development data set. It is advised that soil and water samples are taken prior to any landfill development to enable this monitoring to take place. Key parameters to focus on are nitrogenous compounds, phosphates, heavy metals, biological oxygen demand and chemical oxygen demand. In particular there needs to be a greater understanding of the impacts of the proposal on Knepp Castle Estate and Knepp Wildland Project, as an organic farm and wildland project downstream of Laybrook.

The aim of the monitoring is to ensure that Lay Brook and River Adur meet the standards set for salmonid freshwater fish. Freshwater fish surveying included as part of the River Adur restoration feasibility study has identified the presents of brown and sea trout in the River Adur (Janes *et al.,* 2006). WRc Technical Report TR207 stipulates a number of parameters that need to be met to comply. These include Zinc (30-500 ug/l), Lead (4-20 ug/l), Arsenic (50 ug/l), BOD (3 mg/l) and phosphate (65 mg/l). Monitoring should aim to ensure these parameters are not exceeded in the Laybrook as a result of the landfill operation.

This is of particular concern to the Knepp Castle Estate, who with their funding partners have begun a renaturalisation of the estate farmland and an section of the River Adur. The proximity of the estate and the natural and River Adur management mean that this site would become a potential ‘sink’ for pollutants that are mobilised from the landfill site. The investment that Natural England have made through the Environment Agency to implement this naturalisation strategy may be put at risk if a suitable baseline ecological survey and a robust monitoring programme of the aquatic environment are not implemented.

9. Haycock Statements of Concern

- A full investigation of the groundwater dynamics associated with sandstone, siltstone and limestone laminations within the Weald Clay has not been presented. Given the experiences of other civil engineering

work within the Weald Clays and the associated geotechnical and groundwater information, the risk of increased seepage and potential breaching of the engineered liner needs to addressed and planned for within the landfill design.

- Clarification is required on the use of the National Coal Board methodology (NCB, 1982) to estimate volumes of water required to be attenuated after a large rainfall event. In particular the infiltration rates included in the calculation are of concern as the landfill site is situated on, and will be capped with Weald Clay. The source of the rainfall duration and intensity data also needs clarification to ensure they are representative for this particular region.

- The settlement duration and pond area calculations use different particle sizes for the different ponds. Some clarification is required as to the reason behind this as some estimates may be underestimated if the correct values are not used.

- The surface-water pond calculations (Appendix H - COR/LA/SPH/1450/11) also assume that discharge of surface water into the Lay Brook can occur from the very onset of a rainfall event. This will not allow for the sedimentation of clay particles and may result in a breach of the current discharge consent for suspended sediment loadings.

- There is concern that during high rainfall events the ponds used for settlement will become less efficient. According to the planning report at the end of 48 hr storm the north-east area pond will be 7.5 m deep and the north-west area pond will be 36.4 m deep. Clay is most efficiently removed in a shallow water environment. Deep water can initiation thermal stratification and circulatory regimes and as such clay takes longer to settle. Poor settlement will result in a poorer quality of water discharged to the Lay Brook and this will be detrimental to downstream habitats and in breach of the Water Framework Directive (2000/60/EC).

- If the ponds are built to attenuate a 1:100 year event then there will be no capacity to deal with any further rainfall on the site in the following days. To ensure the quality and quantity of discharge meets the consent standards it is advised that further attention capacity is provided to allow for this scenario.

- Calculations for the storage capacity of attenuation ponds at the proposed landfill do not take into account the effect of climate change to the levels required by PPS 25 (Communities and Local Governments, 2006). An increase of at least 20% on top of the 1in100 year rainfall event is required rather than the 10% used in the submitted calculations.

- During low flows the discharge from the landfill development will account for between 23% and 29% of the total in the Lay Brook. Failure of the settlement ponds to work efficiently may result in a deterioration of water quality downstream of the site. This is contrary to the objectives of the Water Framework Directive.

- There has been a lack of assessment on the potential impact of the landfill operation on downstream environments. There is a need to undertake a rigorous assessment of the potential downstream impacts and put in place a robust monitoring regime. A baseline data set of water and soil samples is required to enable land owners and the Environment Agency to track change.

- Fish surveys conducted by The River Restoration Centre (Janes *et al.,* 2006) have noted the presence of Sea and Brown Trout. It is therefor imperative that the quality of water discharging from the proposed Laybrook landfill site meets the stringent requirements of salmonid freshwater. In addition to this, lamprey have been found in the River Adur immediately south of Knepp Castle Estate. As a subject of the Habitats Directive (92/43/EEC), the impact of water discharge from the landfill in relation to Lamprey has not been address.

10. Review of Relevant Public Issues

Below is a review of the main water related statements already submitted in objecting to the planning document (COR/LA/SPH/1450/01/NTS/FIN), relating to landfill operation at Laybrook Brickworks Quarry. The statements have been categorised into main topics.

Leachate Containment

- Theresa Greenaway, Ecological Advisor, states there is a lack of detail in the technical information regarding leachate seepage. For instance, clarification is needed on materials to be used for lining and capping to ensure they will adequately perform the task required over the life of the landfill. Some clay materials are understood to be insufficient to prevent leaching over time.

- The site is situated on The Weald Clay which has a very low permeability (3×10^{-7} to 1×10^{-9} m/s from Richards et al., 2007). The proposal states there is a process of selecting the most suitable clay to construct the clay liner from that extracted from the quarry (Technical Statement para 3.9).

- It is our understanding that over time water will permeate through the lining layer, especially with the presence of groundwater pressure from the outside, and this will potentially have an impact on the quantity of leachate formed. Concerns have bee raised (see Greenway, 2009 for review) stating that Landfill liners are not a solution as they are susceptible to breakage/cracking via stones, roots, sharp rubbish through compacting and age.

- The River Adur Conservation Society states that a failure of the planned measures to contain leachates at the Laybrook landfill site could contaminate a 31 km stretch of the River Adur with disastrous consequences for fish and other wildlife. The River Adur Conservation Society is concerned that measures to prevent the escape of contaminants from the site may not be adequate, especially in view of the length of time that the site will be in use. "This proposal means that we shall have the possibility of a major pollution incident near the source of one of the River Adur's tributaries for decades to come."

- In addition, the stretch of the River Adur passing across The Knepp Castle Estate is under assessment for re-naturalising so that the floodplain can function naturally and reduce flooding further downstream; any pollution or nutrient enrichment would have a detrimental impact on this; poisoning aquatic life, wetland invertebrates and livestock drinking the water.

- Historic Houses states both the Knepp Castle, its lake and the River Adur - which is currently also being restored by the Environment Agency and Natural England as part of the Knepp Wildland Project (Kernon Countryside Consultants and Land Use Consutlants, 2007) - are highly likely to be affected by leachates from the proposed Lay Brook landfill.

- The National Trust states that the proposed landfill site lies directly upstream of Knepp, on the headwater of the River Adur. It would be grossly irresponsible to risk compromising the restoration of wetland systems along the River Adur at Knepp Castle by citing a 4.1m tonne landfill site, of 20-30 years usage, directly upstream. It is almost certain that water quality at Knepp Castle would be adversely affected.

Down Stream Risk Assessment

- Theresa Greenaway, Ecological Advisor, states there is a lack of assessment for the impact of the development on downstream water quality and associated habitats. In particular there needs to be a greater understanding of the impacts of the proposal on Knepp Castle Estate and Knepp Wildland Project, as an organic farm and wildland project downstream of Laybrook. There are a number of environmental concerns regarding short-term (at least 40 years) and long-term adverse impacts.

- Assessments have been taken for the immediate area but no detail has been provided on the effect of the development on water quality downstream of the site. Theresa Greenaway, Ecological Advisor, states water quality, any deterioration of which has the potential to affect fishing interests, wildlife interests and public amenity interests of both Knepp Wildland Project and the wider public. There does need to be a full assessment taken for water quality on coarse fish & sea trout, wetland and aquatic flora and fauna, livestock and wildlife drinking and well-water supplies downstream of Laybrook. Such assessments should address the effects of phosphates, nitrogenous compounds, heavy metals, thallates, sex-disruptive hormones etc., on aquatic flora and fauna and on species higher up the food chain.

- Separate to the assessment on water quality should be an assessment on the likelihood of an increase in the biological oxygen demand for the Laybrook. Organic matter entering ground water and water courses from seepage, rain water run-off and spillage should be included. An increase in (BOD) will affect flora and fauna downstream.

Climate Change

- Theresa Greenaway (Greenway, 2009) states that climate change is resulting in an increase in occurrence and severity of droughts and flooding. The impacts of such events on lining integrity and run-off have not been addressed.

- A land fill site will not only contaminate the ground water but will cause huge emissions of methane CH4 which is molecule for molecule, 20 times as powerful at warming the air as CO2. If the UK government is hoping to achieve 50% reduction in emission reductions by 2020 this is no way to start.

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