DEVON COUNTY COUNCIL

NON TECHNICAL SUMMARY: COMBINED PHASE I AND II SITE INVESTIGATION AT NORTHAM BURROWS FORMER LANDFILL AND WASTE RECYCLING SITE.

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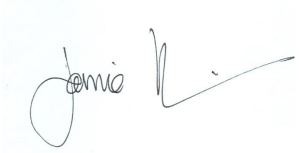
Approved by	**:**	 **Jamie Robinson**

1 PROJECT OUTLINE

Devon County Council (DCC) asked Parsons Brinckerhoff Ltd (PB) to undertake an environmental study of the former Northam Burrows Landfill and Waste Recycling Site, Northam Burrows Country Park, Devon.

The aim of this study is to assess the threat posed to human health, the environment and local amenity if the site was to become flooded by the sea. The study proposes measures that can be applied to reduce or alleviate these potential issues. This study does not assess the likelihood of flooding occurring.

2 OVERALL CONCLUSIONS

After reviewing all the evidence, it has been concluded that Northam Burrows landfill site represents a typical landfill site, and does not pose a health risk for people using the site as it stands now.

It contains a mixture of biodegradable waste, such as paper, card, wood, etc and inert waste such as rubble. The combination of waste is a typical blend of household and commercial waste, common to landfill sites in general. As with other landfill sites, as the waste breaks down, there are contaminants, or chemical elements released into the surroundings, but these are to be expected.

Should the site become flooded, it could start to erode, which may mean that waste could become exposed. This is likely to look and smell unpleasant, but any contaminants are likely to be diluted and dispersed by the surrounding estuary waters or into the atmosphere. It is, however, a consideration, given the site attracts considerable numbers of tourists and visitors.

3 SITE

The landfill site at Northam Burrows is situated on a sand spit to the north of Bideford. This spit was used as a landfill facility and filled with mixed waste from early to mid 1940s to 1994 when it closed. The Northam Burrows Household Waste Recycling Centre also operated on this site between 1974 and 2002.

The landfill is also located within an area that is subject to a number of national designations. The site is located within the Northam Burrows Country Park and is within an Area of Outstanding Natural Beauty (AONB). The sand spit on which the landfill is located forms part of the North Devon Heritage Coast and the landfill is surrounded by Skern, a Site of Special Scientific Interest (SSSI). Furthermore the Burrows form an integral part of the newly designated United Nations Biosphere Reserve.

4 ENVIRONMENTAL SETTING

The investigation of the Environmental Setting was undertaken in two parts; a desk based review of existing information on the site and a detailed site investigation.

The desk based study used commercially available plans, such as an Envirocheck report (2008), which was commissioned to enable a preliminary identification of any environmental conditions affecting the site.

This initial study included the use of historical maps, plans, records and photographs. Interviews were also held with former site workers to establish where and what types of waste might have been deposited in the landfill.

A Groundwater Vulnerability Map details areas where there is natural groundwater and how easily it may be affected by pollutants. The map for the site shows an underlying designated Minor Aquifer. This designation means an underground layer of water-bearing permeable rock or loose materials (gravel, sand, silt, or clay) from which groundwater can be extracted.

There is a pond, approximately 100m^2 in size, located in the south western area of the site. Additionally, as the site is located on a spit it is surrounded on three sides (northeast and west) by coastal waters. The mean high water mark, which marks the highest level to which tides reach on average over a given period, is located approximately 200m east of the site.

A review of existing historical maps of the site identified a number of land drains in the area. Additionally, a large part of the surrounding area is marsh land, including an area of salt marsh to the east.

5 ASSESSMENT

To support the planning of the detailed investigation, preliminary site visits, and meetings with former site workers, were undertaken in May 2008. During this visit it was noted that:

- There is a small lake on the northeast side of the site. At the time of the visit there was no visual evidence of leachate within the standing water. Leachate is liquid that drains through/from a landfill and its chemical composition is dependant on the age of the landfill and the type of waste that it contains.

- A large area of dead grass was observed on the southeast of the site.

PB also undertook extensive consultation with DCC, which provided information on the nature of materials tipped, tipping locations and dates. Information was also drawn from a series of previously published reports. Aerial imagery, dating from the mid 1940s to the 1990s, was reviewed to provide an idea of how the site has visually changed since it first became a landfill site. Information concerning the site and any previous issues were taken from DCC records of correspondence with various bodies such as Natural England (NE) and the Campaign to Protect Rural England (CPRE).

Based on this research, a 'Conceptual Site Model' (CSM) was produced for the site. This CSM is a model of the site created by using all known information to form an idealised model that shows the potential pollutant linkages (means by which a contaminant in the site may affect a person or the environment).

In the context of land contamination, there are three essential elements to any risk:

- A source – a substance that is in, on or under the land and has the potential to cause harm or cause the pollution of protected waters;

- A receptor – in general terms, something that could be adversely affected by a contaminant, such as people, ecology, property, or a water body; and

- A pathway – a route or means by which a receptor can be exposed to, or affected by, a contaminant. i.e. skin contact, ingestion

Although each of these elements can exist separately, they only cause a risk where they are linked, so that a particular contaminant affects a particular receptor through a particular pathway. This kind of linked combination of source–pathway–receptor is described as a pollutant linkage and there are often many constituting the conceptual model.

Once this information had been reviewed and the conceptual site model developed, a public exhibition was held to explain both the nature of the works to date and future works. This exhibition also provided a further opportunity for local people to provide information.

A full site investigation was undertaken between 7 July and 25 July 2008 in order to confirm that the CSM was accurate and had incorporated testing for all potential pollutant linkages. The aims were to identify:

- The risk to human health (such as dog walkers and other users);
- The risk to controlled waters beneath the site; and
- The risk to controlled surface waters surrounding the site.

The site investigation therefore required:

- Ten deep boreholes (BH) to a maximum depth of 20m below ground level (BGL), to be excavated across the site. Within these boreholes soil gas, soil vapour and groundwater were monitored during sampling visits over the next two months.
- Four window sample boreholes, which are significantly smaller and less deep than standard boreholes, were also excavated under the entrance road to the main part of the landfill site.
- Thirty trial pits, with a maximum depth of 5m BGL, were excavated across the site using a JCB excavator.
- A total of 115 soil samples were collected from the site and analysed.
- The ability of the landfill materials to leach contaminants was also assessed in areas where evidence of contamination was detected.

Throughout and following the site investigation, soil gas and soil vapour monitoring and analysis was conducted.

All works were carried out by experienced personnel under the supervision of a PB Engineer.

6 RESULTS

The ground investigation indicated that the topsoil on the site is underlain by “made ground/landfill material”. This is then underlain by sand/silt and sandstone. The average thickness of the landfill material identified within the boreholes was 4.6m.

Generally the landfill material was noted to have a high organic content, consisting of broken down refuse or broken down garden waste. Concrete, brick, rubble coke, clinker, and sandstone were also noted. Glass, metal, wood (including chipboard) and plastic (including bags and bottles) were found in abundance. This mixture of waste is typical of a mixed household and commercial waste site.

Various assessment criteria have been used to interpret the chemical testing results, and evaluate the potential pollutant linkages identified. The initial assessment is called Generic Quantitative Risk Assessment (GQRA). GQRA involves the comparison of concentrations of contaminants measured in soil, water or soil gas, at a site, with generic assessment criteria or a ‘benchmark’. Generic assessment criteria are typically highly conservative (that is to say with a wide safety margin), to ensure that they are applicable to the majority of sites.

(Note: In the event that they are exceeded, a further level of analysis is usually required. This next level of assessment is called Detailed Quantitative Risk Assessment and could be undertaken if needed. Infact the results did not exceed these levels.)

In order to assess whether a contaminant is present in sufficient quantities to cause a risk to health, it is necessary to consider the use of the site. Currently generic assessment criteria have only been established for three land-use types: residential, allotments and commercial / industrial. There is no recognised standard for assessing a land use typical to Northam Burrows.

As a result, the more conservative standard of 'residential' assessment has been applied. These values would normally be used to assess residential areas, and assume exposure to the contaminants by a small female child aged between 0-6. This means that although the land on the Northam Burrows Landfill site does not directly fall within any of these categories, adopting a conservative approach will ensure the most protection for anyone using the site. More explanation is given below.

Current Situation

Soil

A number of concentrations of contaminants were found to be above the generic soil screening criteria, which are the limits associated with residential use as follows:

Determinand	Unit	No. samples tested	Screening Criteria		Min	Max	No Exceeded
Arsenic	mg/kg	114	22.3	CLEA UK	4.4	80	18
Lead	mg/kg	114	450	SGV 10	<5	3700	6
Zinc	mg/kg	114	8420	CLEA UK	16	9300	1
Benzo(a)anthracene	mg/kg	114	13.7	CLEA UK	<0.1	16	1
Chrysene	mg/kg	114	13.7	CLEA UK	<0.1	15	2
Benzo(b)fluoranthene	mg/kg	114	13.7	CLEA UK	<0.1	15	1
Benzo(k)fluoranthene	mg/kg	114	13.7	CLEA UK	<0.1	8.1	0
Benzo(a)pyrene	mg/kg	114	1.34	CLEA UK	<0.1	17	34
Trichloroethene	mg/kg	27	0.346	CLEA UK	<0.001	0.850	2
Vinyl Chloride	mg/kg	27	0.00248	CLEA UK	<0.001	0.003	1

As previously mentioned, the initial generic assessment criteria are highly conservative, ensuring they cover the majority of sites. If they are exceeded, a further level of analysis is usually required, using Detailed Quantitative Risk Assessment (DQRA). DQRA uses site specific data to conduct a more accurate assessment of risks. However, DQRA by nature is highly complex, relying on a good understanding of the modelling amongst other factors, to ensure that the results are valid and are interpreted correctly.

The current site comprises open common ground with a tarmac entrance road. The major exposure pathways associated with the health risks identified for this site are: inhalation (breathing), ingestion (eating) and dermal (skin/ touching) contact. For these pathways to exist, contaminants must be able to come into direct or close contact with humans. As the site is at present, it is considered that contaminants below 0.4m are at a depth where inhalation, ingestion and dermal contact are unlikely and therefore a pathway is not present.

Concentrations of arsenic, lead, BAP and dibenzo[a,h]anthracene were present at concentrations above the Generic Assessment Criteria at depths shallower than 0.4m. So they are at a depth where inhalation, ingestion and dermal contact are possible and therefore a pathway could be present.

Six samples contained raised levels of arsenic within the top 0.4m. Of these, one was below the tarmac entrance road. This hard standing would prevent anybody using the site coming into contact and prevents exposure to the contaminant, thus breaking the pathway between the source and the people using the site. Concentrations of lead and BAP were also found to be higher within this sample.

Arsenic is released into the general environment from a variety of natural and man made sources. In the context of the southwest of England, average natural background soil concentrations of 424 mg/kg have been reported. In this study the maximum arsenic concentration found was 80mg/kg.

The main pathway for arsenic to enter and affect health is via ingestion, which is reliant upon its ability to be absorped during transit through the stomach. Whilst the leachate did show traces of arsenic, it did not exceed the screening criteria levels and is unlikely to be in a readily available form if ingested.

The material used for capping the landfill was sourced locally and is therefore likely to contain a similar concentration of naturally occurring arsenic. Combining this information with the results of the leaching tests overall, it is thought unlikely that the concentration of arsenic found are likely to cause a risk to health.

Polyaromatic hydrocarbons (PAH) like the BAP and benzo(a)anthracene found at the site are among the most widespread organic pollutants. They are present in fossil fuels, eg coal and oil, and also formed by incomplete combustion of carbon-containing fuels. They are common in vehicle exhaust fumes (especially from diesel engines), tobacco, incense and wood smoke, from fireworks and in grilled / barbequed food.

BAP and benzo(a)anthracene are carcinogens or cancer causing agents, which are considered to interact directly with DNA ; as a result, there is no threshold below which there is no risk to health. A toxicological benchmark (Index Dose) is used to identify potential risks to health. This is considered to be an intake associated with minimal risk. However, in practical terms, to assess a compound that people are exposed to in so many ways from everyday living, an ‘unacceptable’ level of risk must be agreed.

Currently there is no single way that has been agreed by the industry as a suitable way of determining what concentration of BAP or benzo(a)anthracene is ‘unacceptable’. Therefore, the risk associated by these chemicals has been assessed in a number of ways, including an approach proposed by the UK Committee on Carcinogenicity of Chemicals in Food, Consumer Products and the Environment and the Health Protection Agency.

This assessment suggested that exposure may be above the minimal risk level (though not substantially) and 'may be of concern'. As a result, it was necessary to carry out a further evaluation considering local site- specific factors.

The asessment criteria model used to compare levels of contaminants uses a concept known as 'residential without plant uptake'. This looks at how the contaminants would affect a small female child aged between 0 – 6 years old in a residential area on the site, but not eating crops or plants that are grown on the site. This model has far stricter limits in reality as no-one actually lives or stays on the Burrows, but it was agreed that using more conservative levels would be better than using a more flexible model.

As a result, there are number of areas where the model is far stricter and tighter on limits than in reality. These include:

The amount of times that the model child would be exposed to any contaminants is calculated over 365 days of the year (with the exception of soil ingestion in 0-1 year olds where exposure is for 180 days). This is considered to be an over-estimate for any site user. The site is open space mainly used by dog walkers and assuming that a dog is walked for 1 hour in the morning and 1 hour in the evening this equates to 2 hours of exposure each day. The dog walker would also have to walk over the specific areas of increased concentrations for the duration of the visit. Within the assessment, soil ingestion rates are estimated in whole days so the exposure frequency represents assumes soil is ingested in a quantity which would be expected by a child playing on the site all day rather than the number of site visits.

The limits used for exposure to contaminants by inhalation and dermal or skin contact is based on limits that would be found if a typical house was built and inhabited on the site. Since there are no buildings on site, it means that some of the ways in which a person could be exposed to contaminants do not exist. For example, if vapours were to build up, as they might inside a house, then there could be a way in which they could cause contamination, but since there are no houses and vapours discharge into the atmosphere, the pathway does not exist.

Overall it is considered that as the sites stands, concentrations of BAP or benzo(a)anthracene in the soil are not considered to pose a risk to site users.

Vinyl chloride and trichloroethane are volatile organic compounds (VOC's) that vaporize and enter the atmosphere. The majority of VOCs detected were from samples below 0.4m, so they do not pose a risk because they are not entering the atmosphere and the pathway – as defined above, does not exist. Trichloromethane was also detected at a concentration of 45µg/kg in WS3 at a depth of 0.4 mBGL, with the sample coming from below the road surface.

Leachate and Groundwater

Leachate is water or fluid that has percolated through the landfill from rain or tidal waters. Groundwater is the natural water that underlies the site,.

Preliminary conclusions suggested that local groundwater flow is likely to be influenced by the tide and is likely to flow towards the closest shoreline at any given location. This means that there may not be one specific flow direction as the site is surrounded on three sides by coastal waters and most of the site was once part of a tidal lake.

Within the Northam Burrows Landfill concentrations of arsenic, selenium and ammoniacal nitrogen were higher in the leachate sampled from the landfill than in samples from the groundwater beneath the waste. This suggests that the concentrations of these contaminants in groundwater may come from the movement of leachate from the landfill to the groundwater as it would not occur naturally.

Thirty-four groundwater samples were tested for mercury. Eleven of these samples were found to exceed the recommended Environmental Quality Standard of 0.0003 mg l^{-1}. Of these eleven samples,

5 were taken from boreholes drilled outside the waste mass, 5 were from boreholes installed in the waste and 1 was from a borehole previously installed by DCC. None of these samples were from the borehole installed in the aquifer or water bearing rock directly below the waste. The highest concentrations of mercury were found in groundwater in BH2 (0.0025 mg l^{-1}). It is possible that the mercury in the groundwater is a result of migration from the landfill.

Concentrations of hydrocarbons and volatile organic compounds were noted in the landfill leachate in BH109 but not in the groundwater beneath or surrounding the site. It therefore does not appear that these compounds are migrating from the landfill to the groundwater.

As before, the concentration limits used as a measure are conservative in nature and set at a level that is both protective of health (the reason of the target), and of groundwater quality (environmental).

The elevated concentrations of some compounds in both groundwater and leachate results suggest that these compounds may be moving from the landfill to the groundwater. However, it is important to note that this would be expected on a site such as Northam Burrows. The site, following common practice at the time, was filled by allowing leachate to soak into the ground, where it would become diluted and disperse so that concentrations of contaminants were reduced to acceptable levels. In this case this assessment does not take into account the likely extra dilution by the waters of the sea / Taw / Torridge Estuary.

Groundwater within the underlying aquifer deposits is saline and not a usable resource eg for drinking water. As groundwater makes its way into the sea the contaminants will be diluted to such an extent by the sea and estuary waters, that it is unlikely to exceed any environmental water quality standard, reducing any effects to an acceptable level. The impacts of any potential discharges to these waters are therefore not likely to be measurable.

However, to confirm this view it is suggested that the Environment Agency is consulted on the results.

Ground Gas

Land fill gas occurs as the biodegradable waste in the site rots down. This is a normal process in all landfills that contain this type of waste.

Gas monitoring was conducted in boreholes BH102 – BH110 and oxygen, carbon dioxide, methane and volatile organic compound concentrations were recorded. The maximum recorded peak of methane concentration was 82.7% v/v in BH110 and the maximum recorded peak of carbon dioxide concentration was 35.1% v/v in BH109. The presence of VOCs was also detected at a peak concentration of 19.7ppm.These boreholes are within the waste mass. Concentrations of landfill gas in this range are not unusual for a landfill containing the waste identified in the investigation but are higher than various guideline concentrations used to assess the potential risk these may pose.

However, it is important to remember that these readings are taken from a sealed well and are not representative of readings at the ground surface where ground gas mixes with the air. Landfill gas will undergo dilution in air prior to interacting with people using the site. The concentration of gas in ambient or surrounding air is directly proportional to its release rate from the soil.

The amount of dilution of the gases has not been measured as this is a specialist task. Whilst it is unlikely that gas migrating through the landfill cap could pose a risk to health, to be entirely confident in this assessment, the risk potentially posed by the flow of landfill gas (assumed to be primarily methane) through the surface of the landfill will need to be monitored in a specialist flux box survey.

Landfill gas may also damage plants including grass. The limit of vegetation stress is based on research, which suggests that vegetation stress can be caused by concentrations of 5–10 % carbon dioxide (compared to normal air levels of 0.28%) and approximately 45 % methane in the root zone. During the site investigation it was clear to see a small area of stressed vegetation on a banked area in the southeast of the site. Soil sampling in this area did not find any elevated concentrations of

contaminants. Limited investigation of this area suggests this is an embankment of porous inert waste that may be allowing gas to leak through.

7 RISK POSED FROM INUNDATION

It is thought that should the landfill be inundated and start to erode, both buried landfill material and natural material could become exposed and may wash onto surrounding areas. This is likely to both look and smell unpleasant as rubbish is exposed and carried by the tide along the coast. It is also possible that a risk may be posed from these materials should sharp objects etc be exposed. Given the importance of the site for both tourism and wildlife this needs to be given further consideration.

As noted previously, as the site is now, concentrations of contaminants in the soil are not considered to pose a risk to site users. However, should the landfill be inundated and start to erode, buried material, which does not currently pose a risk, could start to become exposed. This will include some of the material that has concentrations of contaminants which could be above the limits used in the assessment model. However, it has to be remembered that the limits are set very low indeed, and in reality, considering any exposure is likely to be to small amounts for short periods in small, relatively inaccessible areas, it is thought unlikely this would present a risk.

Leachate could escape should the site start to wash out. Whilst this leachate does contain elevated concentrations of some potential contaminants, dilution by the estuary and sea waters of the sea are likely to disperse them. However, to confirm this view it is suggested that the Environment Agency is consulted on the results.

8 RECOMMENDATIONS

The groundwater and leachate results suggest that the contaminated compounds may be moving from the landfill to the groundwater. However, it is important to note that this would be expected on a site such as Northam Burrows as like many other sites, it was filled by allowing leachate to soak into the ground, where it would become diluted and disperse. In this case this assessment does not take into account the likely dilution by the waters of the sea / Taw / Torridge Estuary. As a result of such dilution, contaminant concentrations are likely to be reduced to acceptable levels. However, to confirm this view it is suggested that the Environment Agency is consulted on the results.

Depending on the views of the Environment Agency, further hydraulic modelling may need to be carried out in order to be entirely confident that the contamination in the leachate is not affecting the underlying aquifer.

Whilst present in boreholes, landfill gas will undergo dilution in the surrounding air prior to interacting with people using the site. This dilution effect has not been measured as this is a specialist task using a flux box survey. With respect to the continuing use of the site as a recreational open space, consideration should be given to keeping the current fence in place and therefore preventing access to the areas understood to be producing greater concentration of ground gas until such a time the flux box survey can be carried out.

9 REMEDIAL WORKS

It is thought that should the landfill become inundated and start to erode, landfill and natural material at depth could become exposed and may wash out onto surrounding areas. This is likely to both look and smell unpleasant as rubbish is exposed and carried by the tide along the coast. It is also possible that a risk may be posed from these materials should sharp objects be exposed. Given the importance of the site for both tourism and wildlife this needs to be given further consideration.

However, allowing for the volume of waste buried within the landfill, it would be extremely costly to remove, with DCC estimating the cost at £150 million in 2007. Due to the nature of the sand spit experiencing a continual process of erosion and deposition through the tidal waters, any protection engineering works to prevent erosion would be expensive and may not last.

In line with current policy, consideration of work which could remedy any of the issues outlined above needs to take into account political, social and economic factors which could be affected, such as tourism in the area or leisure users. This is done via an options appraisal. The aim of the appraisal stage is to establish which option, or combination of options, provides the best approach to addressing what may happen if the site is inundated or erodes. This can be undertaken in conjunction with the Environment Agency consultation and additional assessments suggested above.

Overall the evaluation should also take into account the Best Practicable Environmental Option, cost benefit, environmental outcomes and appropriate timescales for remediation.

The shore line management team are in the process of undertaking a comprehensive assessment and management plan for the coast line; however, this has been put back to late 2009. The options appraisal should be progressed with an understanding of this document as it evolves. It is possible that a ‘hard engineering’ solution such as a barrier system or combined barrier / permeable reactive barrier element may be appropriate to deal with the potential areas of concern noted.