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PROPOSED HIGHTHORN SURFACE MINE

HYDROLOGICAL AND HYDROGEOLOGICAL ASSESSMENT

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HYDROLOGICAL AND HYDROGEOLOGICAL ASSESSMENT

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Table of Contents

Page

Page

1. INTRODUCTION

1.1 Background

DAB Geotechnics Ltd. has been commissioned by H. J. Banks Mining Ltd. (**Banks**) to undertake a hydrological and hydrogeological assessment of its proposed Highthorn surface mine. The study has entailed:

(i) the provision of five Landmark, ‘Envirocheck’, reports to determine the location of the licensed surface and groundwater abstractions, discharge consents, landfill sites and pollution incidents in a search area extending across the site and at least 1km from the perimeter of the proposed excavations (**Appendix A**);

(ii) liaison with Northumberland County Council to determine the location of any private (unlicensed) surface and groundwater abstractions (**Appendix B**);

(iii) an inspection of the geological plans and reports published by the British Geological Survey (**BGS**) and reference to a number of borehole logs held in its archive, copies of which are provided in **Appendix C**;

(iv) an examination of the various plans and documents prepared by Banks;

(v) an evaluation of the Coal Authority’s 1/2500 scale abandoned mine plans and 1/10,560 scale Old Workings Plans, relevant copies of which are provided in **Appendix D**;

(vi) a number of targeted walk-over surveys;

(vii) the establishment of groundwater monitoring stations;

(viii) the compilation of a flood risk assessment in accordance with the National Planning Policy Framework (Department for Communities and Local Government, 2012) and the National Planning Policy Guidance document, *‘Flood Risk & Coastal Change’* (**Appendix E**);

(ix) an assessment of the likely impacts of the proposed development on surface and groundwater resources.

Two meetings have been held with the Environment Agency and one with the Lead Local Flood Authority (**LLFA**) to discuss relevant issues.

1.2 Location

The centre point of the Highthorn site is located about 2km south-east of Widdrington, 2km east of Widdrington Station and 2.5km north-north-west of Ellington in the County of Northumberland (**Figure 1**). The approximate Grid Reference for the centre point has been taken as 426865 594525 (1/50,000 Ordnance Survey Sheet No. 81, Alnwick & Morpeth). An aerial photograph is provided in **Figure 2**.

The site is bounded to the west by the A1068, to the north-east by the C110 and on all other sides by agricultural land. Hemscott Hill Farm is located in its eastern part, while the former Highthorn Farm lies immediately to the south.

1.3 Topography

The proposed site is located on the Northumberland coastal plain. Ground levels range from just over 26m above Ordnance Datum (**AOD**) along the western boundary of the site to 2m AOD on the north-eastern perimeter. Surface gradients reach a maximum of about 1v in 13h (4.4º) and are generally directed towards the east.

1.4 Land Use History

Early editions of the 1/2500 scale OS plans indicate that the land has been in agricultural use for some considerable time. However, there is also a long history of surface and underground coal mining in the area. Backfilled excavations are present in the northern and north-eastern parts of the site. Exploratory drilling has confirmed that the fill comprises overburden and there are no records of any materials having been imported. Abandoned mine workings are located in the south and west and although these have given rise to surface subsidence, there are no colliery spoil tips or mine openings within the site perimeter. It is therefore unlikely that there is any contamination. None has been encountered during the extended ground investigations.

1.5 Development Proposal

Details of the proposed surface mine development are shown on the 1/15,000 scale Composite Working Method Plan (Dwg. No. HJB/BA795/PA06) and Phasing Plans (Dwg. Nos. HJB/BA795/PA07 to PA11). The development will entail the removal and reinstatement of the upper reaches of Hemscott Burn which extends across the south-eastern part of the site.

Mining operations will commence with the stripping of soils in the excavation and overburden storage areas; the construction of water treatment lagoons; and the establishment of the site infrastructure. The topsoil will be deposited in discrete visual and acoustic screening mounds of not more than 6m in height (nos. TSM1 to TSM9), the majority of the material being deposited along the western and south-eastern perimeters of the site. Subsoil mounds will be constructed to the north-west, north-east and south of the excavation area (nos. SSM1 to SSM7 and SM11). These will reach a maximum height of 10m. Drift material will also be deposited at a maximum height of 11m to form a screening mound (no. DRM1) along the eastern perimeter. The outer slopes of the mounds will be constructed at not greater than 1v in 2h (26.6°).

A boxcut will be created in the northern part of the excavation area. The overburden will be placed in an adjacent storage mound (OBM1) which will reach a maximum height of 25m with outer slopes of not greater than 1v in 2h (26.6º). The excavations will progress in a southerly direction by developing a succession of WNW-ESE oriented cuts. The exhausted workings will be backfilled, but overburden will continue to be placed above ground, firstly in the northern storage mound, but then in a second one (OBM2) that will be constructed in the western part of the site. This will reach a maximum height of 27m and will again have outer slopes of not greater than 1v in 2h (26.6°). The final void will be formed in the southern part of the site and will be backfilled using the overburden stored above ground. The soils will be replaced and the watercourse re-instated as part of the restoration works. The excavations will extend up to 71m below ground level (**bgl**).

2. GEOLOGY

2.1 Published Information

The geology of the site has been determined by reference to a number of plans and documents published by the BGS, details of which are as follows:

1/50,000 Scale Geological Sheet No. 9. Rothbury. Drift Edition (1977);
1/63,360 Scale Geological Sheet No. 9. Rothbury. Solid Edition (1966);
1/50,000 Scale Geological Sheet No. 9 Rothbury. Bedrock and Superficial Deposits (2009);
1/10,560 scale Geological Maps, Sheet Nos. NZ29NE and SE;
1/10,000 scale Geological Maps, Sheet Nos. NZ29NE and SE; and
'Geology of the Rothbury District' (Lawrence et al., 2011).

The Rothbury maps were originally surveyed in 1895 and again in the early 1920's, but the BGS has since undertaken a complete revision and the results were published in 2009. This entailed detailed fieldwork and the collation of borehole data, coal seam outcrop and fault locations provided by British Coal, the Coal Authority and other parties. Some of the field slips for the area of interest have been examined with the Survey's permission.

Reference has also been made to a number of archive boreholes held by the BGS, copies of which are provided in **Appendix C**.

2.2 Site Investigations

The extended site was previously investigated by the National Coal Board and British Coal when approximately 1,700 boreholes were drilled to a maximum depth of 288m bgl, though typically not greater than 160m. Many of these boreholes were partly or fully cored from rockhead and logged using geophysical tools. A number of piezometers were also installed. Since that time, Banks have drilled forty-nine boreholes to a maximum depth of 122m bgl, six of which have been instrumented for groundwater monitoring purposes (nos. PZ1 to PZ6). The borehole data have been used to determine the geological structure, the coal reserves, the thickness and nature of the overburden and the lateral and vertical extent of the proposed excavations.

A geotechnical site investigation was carried out by Allied Exploration & Geotechnics Ltd. in January 2015. This comprised a total of 15 boreholes on 13 locations, together with a programme of soil laboratory testing. The borehole logs and test results are presented in a report entitled, *'Proposed Highthorn Surface Mine Ground Investigation – Factual Report'* (Contract 4007). Reference has also been made to the results of an earlier site investigation for a proposed nuclear power station. This was centred largely on the northern part of the site and comprised a mixture of boreholes and trial pits.

2.3 Plans and Documents Provided by H. J. Banks Mining Ltd. and the Coal Authority

The following plans and documents have been prepared or provided by Banks:

1/2500 scale Topographic Plan;
1/15,000 scale Composite Working Method Plan (Dwg. No. HJB/BA795/PA06);
1/15,000 scale Phasing Plans (Dwg. Nos. HJB/BA795/PA07 to PA11);
1/5000 scale Restoration Strategy Plan (Dwg. No. HJB/BA795/PA13);
1/2500 scale Drift Thickness Plan;
1/2500 scale Rockhead Contours Plan;
1/2500 scale Seam Contour Plan for the Ashington (4D00) seam;
1/2500 scale Seam Contour Plan for the High Main or Diamond (E000) seam;
1/2500 scale Seam Contour Plan for Top Main (F200) seam;
1/2500 scale Seam Contour Plan for Bottom Yard (G100) seam;
1/2500 scale Abandoned Mine Plans for Ellington and Linton Collieries;
1/2500 scale Abandoned Mine Plan for Ferneybeds Colliery; and
1/2500 scale Abandonment Plans for Druridge, Radar South and Wallis Opencast Sites.

Reference has also been made to the 1/10,560 scale Old Workings Plans, extracts of which are provided in **Appendix D**.

2.4 Geological Succession

2.4.1 Superficial Deposits

2.4.1.1 Holocene Wind Blown Sand and Peat

Deposits of wind blown sand are present along the perimeter of Druridge Bay, but are confined to the east of the C110 road that runs from Cresswell to Druridge (**Figure 1**). The dunes form a wide zone of 100 to 250m in width with shore parallel foredunes that reach 10 to 15m in height and landward dune ridges that are discrete or interlocking. The dune line is interrupted at a number of locations around the bay, in particular by the discharge channels of Hemscott and Blakemoor Burns. The sand is fine to coarse and has a median grain size of about 0.30 to 0.35mm.

The toes of the foredunes generally lie at an elevation of about 4m AOD and rest on a 1-2m thick layer of peat that was formed about 4,700 years ago. This in turn overlies deposits of glacial till.

2.4.1.2 Alluvium

A very thin deposit of alluvium (i.e. interbedded clay, silt, sand and gravel) is present along the course of Hemscott Burn which flows through the south-eastern part of site.

2.4.1.3 Made Ground

Backfilled opencast coal workings are present in the northern and north-eastern parts of the site (Section 2.6.1). The deposits comprises a heterogeneous mixture of partly remoulded, soft to firm, silty sandy, gravelly clay and silt to boulder sized, angular to subangular fragments of mudstone, siltstone, sandstone and seatearth. The materials were loose tipped, but will have undergone significant self-weight compaction since their placement. They range in thickness from 6 to 58m.

2.4.1.4 Glacial Deposits

The BGS 1/50,000 scale Geological Maps record that apart from the areas affected by historic surface mining, Highthorn site is covered by Devensian glacial till or, *'boulder clay'*.

The 1/2500 scale Drift Thickness Plan provides a more definitive picture of the conditions on the site because it is based on exploratory drilling. The plan shows that the deposits measure between 7.50 to 28.25m and that they generally thicken towards the north and south-east due to the presence of infilled glacial or en-glacial channels. The borehole logs provided in AEG's Factual Report confirm that the deposits predominantly comprise a succession of firm to very stiff clay (glacial till).

2.4.1.5 Rockhead Surface

The glacially weathered rockhead surface is generally inclined towards the south and east in the western part of the site, whilst a more complex pattern is present in the east. The gradients range from about 1v in 57h (1.0º) to 1v in 8h (7.1º). The surface has been modified by historic surface mining in the northern and north-eastern parts of the site. Details are shown on the Rockhead Contours Plan.

2.4.2 Bedrock Strata

The proposed excavations will extend from above the Ashington (4D00) coal seam to the base of the Bottom Yard (G100). Details are presented on the Generalized Vertical Section (**Figure 3**). The strata form part of the Pennine Middle Coal Measures of Upper Carboniferous age. They comprise interbedded silty mudstones, siltstones, sandstones, seatearths and coal seams. None of the strata is exposed on the site. There are a number of rocky exposures along the coast to the south-east, but these are of sediments higher in the succession.

2.5 Geological Structure

The BGS 1/63,360 and 1/50,000 scale Geological Maps show that the Northumberland Coalfield is traversed by a number of NW-SE, WSW-ENE and NE-SW trending faults. Greater detail is recorded on the 1/10,560 and 1/10,000 scale Geological Maps.

The geological structure at Highthorn site is dominated by the Grange Moor Fault (**Figure 4**) which is now referred to as the Stobswood Fault by the BGS. This is one of the major WSW-ENE faults that traverse the coalfield. It extends across the northern part of the proposed excavation area and downthrows to the south by up to 45m. The downthrown strata dip towards the east, south-east and north-east at between 1v in 56h (1.0°) and 1v in 12h (4.8°).

Surveys carried out at a number of historic surface mines in the Highthorn area and core samples from the site have shown that there are at least two major, subvertical joint sets. The joints and bedding planes provide the principal flow paths for groundwater where the strata have not been disturbed by mining subsidence.

2.6 Mining History

2.6.1 Surface Mining

Copies of the abandonment plans for the former Druridge, Radar South and Wallis surface mines have been obtained from the Coal Authority and a summary of the recorded details is given in **Table 1**. The location of the backfilled excavations is recorded on the 1/10,560 scale Old Workings Plans, extracts of which are presented in **Appendix D**.

Site Name, Drawing Ref. No. and Coaling Dates	Notes
Druridge (OE/COMP/02/173) Coaling from 17th September 1951 to 20th January 1954.	Coal recovered from the Top Ulgham or Top Yard Top Leaf (G230), Top Yard (G210) and Bottom Yard (G120/G110) seams.
Radar South (OE/COMP/02/190) Coaling from September 1954 to March 1956.	Coal recovered from Top Ulgham or Top Yard Top Leaf (G230), Top Yard (G210), Bottom Yard (G120/G110), Top Bensham (H200), Bottom Bensham (H100), Little Wonder (J300/J200), Top of Radar (J100), New of Radar (K200) and Main of Broomhill (K100) seams.
Wallis (OE/COMP/02/190) Coaling from July 1951 to March 1954.	

Table 1 Summary of Details Shown on Surface Mine Abandonment Plans

Site investigations have confirmed that the backfill is largely confined within the areas shown on the abandonment plans, though some was spread during the course of their restoration.

2.6.2 Underground Mining

Records show that there are abandoned underground workings in the Ashington (4D00), High Main or Diamond (E000), Top Main (F200), Yard (G210/G120), Bottom Yard (G120/G110) and Little Wonder (J300/J200) seams within the site boundary. The workings extend from the former Linton, Ellington and Ferneybeds Collieries (**Figure 4**, **Appendix D**). The proposed excavations have been designed to avoid the more intensely worked areas and will not extend to the Little Wonder (J300/J200) seam. Uncharted workings and mine openings (i.e. abandoned shafts and drifts) have not been found on the site.

3. HYDROLOGY

3.1 Rainfall

The long term average annual rainfall for Highthorn site is approximately 667mm (NERC, 1999).

3.2 Catchment and Drainage

3.2.1 Flood Estimation Handbook

By far the majority of the site is drained by Hemscott Burn and a study has been carried out using the Flood Estimation Handbook (NERC, 1999) to determine the catchment characteristics (**Figure 5**, **Table 2**). The study has also been extended to include the areas occupied by Cresswell Ponds Site of Special Scientific Interest (**SSSI**) and Druridge Pools Local Wildlife Site, both of which are of ecological importance.

3.2.2 Blakemoor Burn

Cresswell Ponds SSSI lies in the catchment of Blakemoor Burn. This rises on agricultural land some distance to the south of Highthorn site, but may extend from land lying to the south-west of the A1068 (**Figure 6**). Little or no flow has been observed in the upper reaches of the burn during various inspections, but surface runoff must supply the large areas of wetland that have been created by mining subsidence (**Photograph 1**), some of which are clearly ephemeral (**Photograph 2**). Flow along the original watercourse channel has been completely interrupted and was observed to be dry on the 7th March 2015. Mining subsidence has also occurred in the area to the north-east, but the channel shows little evidence of recent or historic flow **(Photographs 3**, **4** and **5**).

Blakemoor Burn is supplied by an unnamed watercourse that is sourced in the area around Warkworth Lane caravan site. A steady flow was being maintained on the 7th March 2015, despite the overgrown nature of the channel in its upper reach (**Photograph 6**). A deep, artificial channel has been cut downstream (**Photograph 7**). The watercourse has again been affected by mining subsidence (**Photograph 8**), but a steady flow can be maintained to the point of confluence (**Photographs 9** and **10**). Most of the freshwater supply to the Cresswell Ponds site appears to be derived from this tributary.

The combined watercourse flows across open fields (**Photograph 11**) and feeds a small freshwater pond (**Photograph 12**) before entering the main lagoon. Both of these waterbodies have been created by mining subsidence. The lagoon discharges into the North Sea by way of a small channel at Grid Ref. 428470 594330 (**Photograph 13**) which is crossed by the C110. The channel is routinely blocked by longshore drift and the accumulation of sand in Druridge Bay. During high spring tides, however, marine water is pushed up the channel and into the lagoon to create brackish conditions (**Photographs 14**, **15** and **16**). None of the other ponds on the SSSI is thus affected and this is the only source of saline water. The flow of freshwater into the lagoon is weather dependent and the variation in salinity is therefore unlikely to be consistent.

Parameters	Catchment								Description
	1	2	3	4	5	6	7	**BL	
AREA	1.92	0.5	0.68	0.52	0.95	0.31	4.13	2.92	Catchment drainage area (km^2).
FARL	1	1	1	1	1	1	0.953	0.813	Index of flood attenuation due to reservoirs and lakes.
PROPWET	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	Index of proportion of time that soils are wet.
ALTBAR	20	12	19	19	22	21	17	16	Mean catchment altitude (m above sea level).
ASPBAR	82	69	51	81	104	82	81	13	Index representing the dominant aspect of catchment slopes.
ASPVAR	0.68	0.79	0.87	0.9	0.48		0.6	0.48	Index describing the invariability in aspect of catchment slopes.
BFIHOST	0.316	0.446	0.318	0.312	0.315	0.314	0.353	0.358	Base flow index derived using the HOST classification.
DPLBAR	1.42	0.81	0.95	0.83	1.26		2.38	2.05	Index describing catchment size and drainage path configuration (km).
DPSBAR	16.1	12.8	18.4	21.7	18.1		15.3	16.6	Index of catchment steepness (m/km).
LDP	3.2	1.91	1.63	1.42	2.58		4.77	3.66	Longest drainage path (km).
RMED-1H	8.8	8.7	8.7	8.7	8.8	8.7	8.7	8.7	Median annual maximum 1 hour rainfall (mm).
RMED-1D	32.2	32	32.1	32.2	32.2	32.2	32.1	31.7	Median annual maximum 1 day rainfall (mm).
RMED-2D	39.5	39.2	39.4	39.5	39.4	39.4	39.4	38.9	Median annual maximum 2 day rainfall (mm).
SAAR	668	662	666	667	667	667	666	664	1961-90 standard period average annual rainfall (mm)
SAAR4170	661	652	660	661	661	659	658	650	1941-70 standard period average annual rainfall (mm)
SPRHOST	39.5	33.8	39.5	39.7	39.5	39.6	37.9	37.7	Standard percentage runoff derived using HOST classification.
URBCONC	-999999	-999999	-999999	-999999	-999999	-999999	-999999	-999999	Index of concentration of urban and suburban land cover.
URBEXT1990	0	0	0	0	0	0	0	0	FEH index of fractional urban extent (1990)
URBLOC	-999999	-999999	-999999	-999999	-999999	-999999	-999999	-999999	Index of location of urban and suburban land cover.

Note. UK soils have been delineated according to their hydrological properties to produce the twenty-nine class Hydrology of Soil Types (HOST) classification. The HOST dataset is available as a 1km grid which records, for each grid square, the percentage of the 1km x 1km area given to each HOST class present. Boorman et al. (1995) give standard percentage runoff (SPR) and base flow index (BFI) values for each HOST class.

* Data derived from other catchment characteristics. ** BL - Blakemoor Burn catchment.

Table 2 Catchment Characteristics

3.2.3 Hemscott Burn

The source of Hemscott Burn lies in the agricultural fields around Lances Hill, adjacent to the southern perimeter of Highthorn site (**Figure 6**). However, there is little or no flow in the watercourse until it is supplied by two drainage discharge points (recorded as 'issues') some distance to the north-east. The water is conducted along two excavated channels (**Photographs 17**, **18**, **19** and **20**), but the supply is known to be ephemeral. Downstream, the flow in Hemscott Burn is also affected by the prevailing weather conditions and by mining subsidence (**Photographs 21** and **22**) and its course has been modified to form a straight channel. The supply of water is supplemented by the discharge of an agricultural drainage channel at Grid Ref. 427396 594544. A number of flow measurements were taken at this location in 1988 using V notch weir plates. The results are presented in **Table 3**. It is not possible to carry out a detailed analysis of these data because they do not provide a continuous record, but it is clear that the drainage system can take a flow rate of at least 138 l/s without flooding. The flow in both watercourses is clearly ephemeral and weather dependent. The groundwater contribution is expected to be very low, bearing in mind the nature of the substrate (i.e. glacial till of low conductivity).

Hemscott Burn discharges into the first of two subsidence ponds at Grid Ref. 427628 594715 (**Photograph 23**). This is linked to the second pond by way of a narrow causeway penetrated by short sections of concrete pipe. The burn discharges at two points from the second pond shown in **Photograph 24** (Grid Refs. 427757 594927 and 427855 594984). The artificial channels cross an area of relatively level ground and combine to form a single structure at Grid Ref. 427855 595218. A straight course is then maintained to the C110 road bridge (**Photograph 25**) from which it continues to the outfall (**Photographs 26** and **27**). The flow velocity is quite low and discharge is often impeded by longshore drift and the accumulation of sand. Sand is periodically extracted from this area under the terms of an existing permission to maintain the drainage function. It is anticipated that this practice will have to be continued during the operation of the proposed surface mine. Some indication as to the scale and frequency of the work can be gauged from that required to maintain the outfall from the Cresswell Ponds site. It will depend upon the weather and tide conditions and the rate of sediment deposition.

Marine water penetrates the lowermost reach of Hemscott Burn during high spring tides, as was observed on the 21st and 22nd March 2015. **Photographs 25**, **26** and **27** confirm that there was adequate banks full containment capacity at this time. It is reported that the dunes were actually breached in 1990, but only limited and localized flooding occurred during the storm surge of December 2013.

3.2.4 Druridge Pools

Druridge Pools Local Wildlife Site is located to the north of the proposed development. The various ponds have been formed in an area of poorly drained ground and in voids created during the operation of the former Radar North surface mine. The largest pond is supplied by Dunbar Burn which flows in an easterly direction from a point close to Low Chibburn. It discharges into the North Sea along a channel that extends from the north-eastern corner of the pond.

Hemscott Burn at Grid Ref. 427396 594536						
Date	**Reading (mm)**	**Flow (l/s)**	**pH**	**Suspended Solids (mg/l)**	**Total Iron (mg/l)**	**Chloride (mg/l)**
22-Apr-88	NA		8.21	2	0.50	
29-Apr-88	45	0.61	8.14	4	1.10	
09-May-88	46	0.64	7.50	10	0.10	
16-May-88	31	0.24	7.80	3	0.60	
25-May-88	25	0.14	7.80	4	0.40	
01-Jun-88	56	1.05	7.92	12	0.70	
08-Jun-88	12	0.02	8.34	7	0.30	
16-Jun-88	0	0.00				
22-Jun-88	0	0.00				
30-Jun-88	0	0.00				
07-Jul-88	75	2.18	8.11	24	1.30	
13-Jul-88	81	2.63	7.44	6	0.80	
20-Jul-88	28	0.19	6.80	15	0.40	56
27-Jul-88	46	0.64	7.30	7	0.40	54
01-Aug-88	86	3.05	7.50	5	0.40	
03-Aug-88	80	2.55	7.60	11	0.50	
14-Aug-88	35	0.33	7.71	1	0.60	
18-Aug-88	36	0.35	8.01	7	0.50	
24-Aug-88	65	1.53	7.79	6	2.30	
07-Sep-88	49	0.76	7.54	2	0.70	
14-Sep-88	25	0.14	7.79	40	1.10	
21-Sep-88	0	0.00				
28-Sep-88	9	0.01	7.90	522	7.30	
05-Oct-88	3	0.00	7.47	27	0.90	
12-Oct-88	80	2.55	7.08	53	1.60	
19-Oct-88	234	36.58	7.02	37	1.30	
26-Oct-88	190	21.75	7.68	12	0.70	
02-Nov-88	61	1.31	7.80	4	0.50	
09-Nov-88	110	5.59	7.58	6	0.60	
11-Nov-88	90	3.41	7.36	3	0.60	
16-Nov-88	2	0.00	7.86	3	0.40	
23-Nov-88	140	10.17	7.72	2	0.50	
30-Nov-88	530	73.31	6.61	298	9.40	
08-Dec-88	NA		7.82	11	0.60	
14-Dec-88	65	1.53	8.01	1	0.40	

Unnamed Tributary at Grid Ref. 427384 594348							
Date	**Reading (mm)**	**Flow (l/s)**	**pH**	**Suspended Solids (mg/l)**	**Total Iron (mg/l)**	**Chloride (mg/l)**	**Combined Flow (l/s)**
22-Apr-88	NA		8.20	5	1.00		
29-Apr-88	21	0.09	8.23	1	0.40		0.70
09-May-88	19	0.07	7.00	10	0.10		0.72
16-May-88	19	0.07	8.16	5	0.30		0.31
25-May-88	15	0.04	8.24	3	0.30		0.18
01-Jun-88	18	0.06	7.71	6	0.20		1.12
08-Jun-88	13	0.03	8.63	17	0.40		0.05
16-Jun-88	12	0.02	8.57	8	0.30		0.02
22-Jun-88	12	0.02	8.02	9	0.20		0.02
30-Jun-88	19	0.07	7.45	17	0.30		0.07
07-Jul-88	35	0.33	7.50	8	0.60		2.50
13-Jul-88	34	0.30	7.38	14	0.70		2.93
20-Jul-88	21	0.09	7.00	17	0.30	38	0.28
27-Jul-88	33	0.28	7.60	12	0.20	68	0.93
01-Aug-88	86	3.05	7.70	9	0.20		6.10
03-Aug-88	75	2.18	7.90	5	0.10		4.73
14-Aug-88	39	0.43	7.83	52	1.60		0.75
18-Aug-88	51	0.84	7.70	21	0.10		1.19
24-Aug-88	46	0.64	8.03	19	0.80		2.17
07-Sep-88	14	0.03	7.74	21	1.30		0.79
14-Sep-88	0	0.00					0.14
21-Sep-88	0	0.00					0.00
28-Sep-88	31	0.24	7.59	4	0.60		0.25
05-Oct-88	22	0.10	7.53	11	0.70		0.10
12-Oct-88	162	14.61	7.06	147	5.30		17.17
19-Oct-88	208	27.26	7.03	117	3.80		63.84
26-Oct-88	180	19.00	7.26	60	2.20		40.75
02-Nov-88	15	0.04	8.00	21	0.60		1.35
09-Nov-88	98	4.21	7.30	43	1.70		9.80
11-Nov-88	100	4.42	7.36	3	0.60		7.83
16-Nov-88	6	0.00	8.15	5	0.40		0.00
23-Nov-88	115	6.24	7.71	7	0.50		16.41
30-Nov-88	470	65.01	7.03	337	10.20		138.32
08-Dec-88	45	0.61	7.89	4	0.60		0.61
14-Dec-88	50	0.80	7.98	5	0.40		2.33
13-Feb-89	20	0.08	7.90	1	0.50		

Flow rates determined using the formula provided in BS 3680 (1981). NA – not available
For V notch readings of less than 50mm, the flow rate was determined using the formula: $Q = 1.42H^{5/2}$ where H is the height of the water above the invert.

Table 3 Volumetric Flow Rates as Measured on Hemscott Burn and its Principal Tributary

3.2.5 Catchment Boundaries

The catchment boundaries for Blakemoor and Hemscott Burns and Druridge Pools have been determined using Ordnance Survey topographic contours and the results are shown in **Figure 6**. The boundaries closely resemble those provided by the Flood Estimation Handbook (**Figure 5**).

The catchment for Cresswell Ponds SSSI occupies 304.2 hectares. Two areas lie within the proposed Highthorn site. These cover approximately 6.6 hectares (2.2% of the total) and are shown as hatched in **Figure 6**. They will be partly or wholly occupied by topsoil storage mound TSM4 and drift storage mound DRM1. Cut-off ditches will be constructed along the toes of these mounds to prevent any uncontrolled discharges from the working parts of the site, but elsewhere surface runoff will continue to supply Cresswell Pond. The net loss to the catchment is estimated to be 1.85 hectares or 0.6% of the total. The effects on the SSSI will be negligible and in any event only temporary.

The catchment for Druridge Pools extends for some 294 hectares. An area of approximately 1.9 hectares (0.6% of the total) lies within the northern part of Highthorn site, though this assumes that there is no interception of surface flow along the C116 public road. Again, any impact on the water supply will be negligible and only temporary.

3.3 Greenfield Runoff Rates

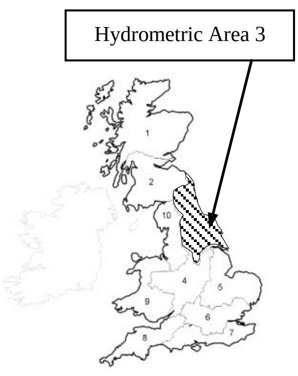
The catchment characteristics presented in **Table 2** show that there is little variation in the long term average annual rainfall and standard percentage runoff values for the various catchments and sub-catchments that extend across Highthorn site. The greenfield runoff rates for the site have been estimated using the relevant data and the methodology described in the Institute of Hydrology Report No. 124 (NERC, 1994). The calculations are detailed in **Table 4**.

Area 323 hectares or 3.23 km^2 Average Annual Rainfall (SAAR) 667mm
Soil Factor 0.41 Average flow (QBAR) 0.892 m^3/s from 323 hectares or 2.8 l/s/ha.

NERC. 1975

UK growth curve factors

Region	Hydrometric Area	Return period 2	5	10	25	50	100	500
NW	1	0.90	1.20	1.45	1.81	2.12	2.48	3.25
	2	0.91	1.11	1.42	1.81	2.17	2.63	3.45
	3	0.94	1.25	1.45	1.70	1.90	2.08	2.73
	9	0.93	1.21	1.42	1.71	1.94	2.18	2.86
	10	0.93	1.19	1.38	1.64	1.85	2.08	2.73
SE	4	0.89	1.23	1.49	1.87	2.20	2.57	3.62
	5	0.89	1.29	1.65	2.25	2.83	3.56	5.02
	6/7	0.88	1.28	1.62	2.14	2.62	3.19	4.49
	8	0.88	1.23	1.49	1.84	2.12	2.42	3.41
Ireland		0.95	1.20	1.37	1.60	1.77	1.96	2.40



Return Period (Years)	2	5	10	25	50	100	500
Growth Factor (Hydrometric Area 3) Flow rate (l/s/ha)	0.94 2.6	1.25 3.5	1.45 4.0	1.70 4.7	1.90 5.2	2.08 5.7	2.73 7.5

Table 4 Estimated Greenfield Runoff Rates

3.4 Flood Risk

A relevant extract of the Environment Agency's Flood Map for the Highthorn area has been taken from the Envirocheck reports and is presented in **Appendix E**. By far the majority of the proposed site lies in Flood Zone 1 [i.e. in an area assessed as having less than 0.1% annual exceedence probability (**AEP**) of flooding], but Hemscott Burn, one of its minor tributaries and the adjacent agricultural land are subject to extreme coastal flooding (Flood Zones 2 and 3). This is because marine water can flow up the burn and overtop the various channels during extreme conditions. The area of flooding appears to be defined by the 4m AOD contour. The soil storage mounds along the north-eastern perimeter of the proposed excavations are required for essential screening purposes, but have been designed to lie at a minimum level of 4.5m AOD wherever possible. Marine water will still be able to enter the working area along Hemscott Burn so that the excavations can compensate for any loss of storage capacity. These points were discussed with the Environment Agency during a pre-planning consultation.

A flood risk assessment has been carried out in accordance with the National Planning Policy Framework (Department for Communities and Local Government, 2012) using the Planning Policy Guidance document, *'Flood Risk & Coastal Change'* (Department for Communities and Local Government, 2014). The assessment concludes that the proposed development will not increase the risk of downstream flooding and a copy is provided in **Appendix E**.

Consent will be sought from the Environment Agency and LLFA to discharge treated water from the site. The LLFA has agreed that the discharge flows will be based on greenfield runoff rates. These have been calculated using IoH 124 (NERC, 1994), as detailed in Section 3.3.

3.5 Licensed and Unlicensed Surface Water Abstractions

The Landmark Envirocheck reports (**Appendix A**) make reference to only one licensed surface water abstraction (**Table 5**). This concerns to the washing of sand and gravel by British Coal, though it was probably for the treatment of run-of-mine coal at the former Ellington Colliery which closed in 2005.

Licence Holder (Reference No.)	Recorded Grid Ref.	Distance from Centre of Site (m)	Abstraction Source	Purpose of Abstraction (Permitted Maximum Rate)
British Coal Corporation (01/22/4/007)	427600 591600	3,015	River Lyne	Sand and gravel washing (coal washing) Maximum daily rate 1,309m^3 Maximum annual rate 272,760m^3

Table 5 Summary Details of Licensed Surface Water Abstraction

The Environment Agency internet website (Environment Agency, 2015) confirms that there are no licensed surface water abstractions on the proposed site or within at least 1km of its perimeter. Northumberland County Council's Environmental Health Department has confirmed that there are no unlicensed (private) water abstractions. A copy of the correspondence is provided in **Appendix B**.

3.6 Discharge Consents

The Envirocheck reports (**Appendix A**) provide details of nine discharge consents in the Highthorn area, some of which have been revoked. A summary is provided in **Table 6**.

Operator (Reference No.)	Recorded Grid Reference	Distance from Centre of Site (m)	Discharge Type	Receiving Watercourse
Druridge Bay Estate Management Co., Sewage Disposal Works, Farm Court, Druridge Bay, Morpeth, Northumberland, NE61 5EC (224/0963).	427470 596010	1,604	Sewage discharges - final/treated effluent	Hemscott Burn
Mr W Storey, High Chibburn Farm, Widdrington, Morpeth, Northumberland (224/G/0359). **Revoked**.	427400 596100	1,663	Unspecified	Dunbar Burn
William Bell, Sewage Disposal Works, The Calico Barn, Hemscott Hill, Widdrington, Northumberland, NE61 5EQ (224/0971).	428010 595080	1,272	Sewage discharges - final/treated effluent	Hemscott Burn
William Bell, Sewage Disposal Works, The Farmhouse, Hemscott Hill, Widdrington, Northumberland, NE61 5EQ (224/0972).	428030 595040	1,274	Sewage discharges - final/treated effluent	Hemscott Burn
Northumbrian Water Limited, Widdrington Combined Sewer Overflow, Widdrington, Morpeth, Northumberland (224/0995).	425690 593610	1,489	Sewage discharges – storm overflow/storm tank	Linton Burn (River Lyne)
Northumbrian Water Limited, Ferneybeds Lane Sanitary Sewage Overflow, Widdrington, Northumberland (224/A/0592).	424950 594040	1,976	Sewage discharges – storm overflow/storm tank	Houndalee Letch
Mr A Fairclough. Ellington Caravan Park, Ellington, Morpeth, Northumberland (224/A/1021). **Revoked**.	427620 593300	1,439	Sewage discharges - final/treated effluent	Blakemoor Burn tributary
Mr A Fairclough. Ellington Caravan Park, Ellington, Morpeth, Northumberland (224/A/1021). **Revoked**.	427500 593400	1,292	Sewage discharges - final/treated effluent	Blakemoor Burn tributary
Ellington Caravan Parks Ltd., Ellington Caravan Park, Warkworth Lane, Ellington, Morpeth, Northumberland (224/1000).	427620 593290	1,448	Sewage discharges - final/treated effluent	Blakemoor Burn tributary

Table 6 Summary of Discharges Consents in the Highthorn Area

3.7 Surface Water Quality

There are no details of surface water quality in the Envirocheck reports. However, Hemscott, Blakemoor and Dunbar Burns are described as having a moderate ecological quality on the Environment Agency's internet website (Environment Agency, 2015). The coastal water and the main lagoon at Cresswell Ponds SSSI have the same classification. In contrast, the quality of River Lyne is considered to be poor.

Table 3 provides an indication as to the variable chemical quality of the water in Hemscott Burn and its principal tributary. Attention is drawn to the sometimes very high concentrations of iron and suspended solids during or shortly after periods of high surface flow and following periods of little or no rainfall.

The Environment Agency website indicates that no pollution incidents have occurred within at least 1km of the site boundary. However, attention is drawn to an incident recorded at the outfall of Druridge Pools (Dunbar Burn). This is numbered 259999 and was described as, *'significant'*, on the 17th August 2004, but no further details are provided as to the nature of the pollutant.

The Envirocheck reports (**Appendix A**) provide details of a number of other pollution incidents to controlled waters. A summary is provided in **Table 7**.

Location (Reference No.)	Recorded Grid Ref.	Category	Date	Pollutant
Surface water sewers, Widdrington Station (224/001086).	425700 593700	Category 2 - Significant Incident	12/02/1992	Sewage - other in Linton Burn
Water company sewage - storm overflow, Widdrington Station (NN950160).	425700 593600	Category 3 - Minor Incident	23/05/1995	Sewage - storm overflow in Houndalee Letch
Industrial premises - Forest Hall (235/001687)	427900 593900	Category 3 - Minor Incident	13/01/1993	Industrial general spillage
Water company sewage - Ellington sewage treatment works (224/001994).	427600 593200	Category 3 - Minor Incident	08/07/1993	Private sewage treatment works
Water company sewage - Ellington sewage treatment works (224/000671).	427600 593400	Category 2 - Significant Incident	29/05/1991	Private sewage treatment works

Table 7 Summary of Pollution Incidents to Controlled Waters

None of the recorded incidents is related to surface mining activity in the area.

Bathing water quality at Cresswell was described as, *'higher'*, by the Environment Agency in 2011. This means that the water meets the criteria for the stricter UK guideline standards of the European Bathing Water Directive. These are based on the number of faecal and streptococci coliform counts per 100ml.

4. HYDROGEOLOGY

4.1 Environment Agency Classifications

The Environment Agency classifies most of the soil cover at Highthorn site as having a, '*low leaching potential in which* [any] *pollutants are unlikely to penetrate the soil layer because either water movement is largely horizontal, or they have the ability to attenuate diffuse pollutants'*. In the absence of any other information, soils of high leaching potential are assumed to be present in the areas of backfilled surface excavations (i.e. the former Druridge, Radar South and Wallis sites).

The glacial cover on the site is considered to represent unproductive strata whilst the Coal Measures are described as a, '*Secondary Aquifer A'*. The latter, '*can be fractured or potentially fractured rocks, which do not have a high primary permeability, or other formations of variable permeability including unconsolidated deposits. Although not producing large quantities of water for abstraction, they are important for local supplies and in supplying base flows to rivers'*.

4.2 Superficial Deposits

4.2.1 Wind Blown Sand

Deposits of wind blown sand are present to the north-east of the site along the perimeter of Druridge Bay. These are founded on a thin layer of peat and underlying glacial till. Studies carried out by Wardell Armstrong (2013) have shown that perched groundwater is present in the sand. This is apparently unaffected by tidal variation and will not be impacted by the proposed surface mining operations.

4.2.2 Glacial Deposits

The hydrogeology of the glacial deposits at Highthorn site can be summarized as follows:

(i) the presence of downward drainage profiles and the development of near surface negative pore pressures during periods of prolonged dry weather;

(ii) under-drainage because the groundwater in the bedrock lies at a lower level due to historic drawdown; and

(iii) localized accumulations of perched groundwater where there are uncommon, discrete layers of silt, sand and gravel confined within less permeable glacial till.

Under-drainage has been present in the Highthorn area for at least one hundred years due to the widespread development of underground coal workings and the associated pumping operations. The groundwater is still drawn down despite the closure of the last remaining colliery at Ellington in 2005 (**Figure 4**).

Generally speaking, little or no groundwater is observed to flow from glacial till when it is exposed in surface excavations. This is because of its very low conductivity (typically less than 10^{-9} m/s) and despite the common occurrence of fissuring at or close to ground surface. Flow from interbedded granular materials can be more significant, but is commonly restricted by the limited size of the deposits and the consequent lack of storage. Most of the superficial cover at Highthorn comprises glacial till.

Surface water infiltration will be impeded where glacial till is present and it will support large volumes of surface water in the form of ponds and lakes where, for example, mining subsidence has occurred (e.g. Cresswell Ponds).

4.2.3 Made Ground

The deposits of made ground on the site comprise surface mine backfill. The hydraulic conductivity will be variable owing to the heterogeneous nature of the material, but studies carried out by Reed (1986) indicate that it could fall within the range 10^{-4} to 10^{-6} m/s. The lower value is commonly achieved where the proportion of clay and the degree of self-weight compaction are at their highest. Experience gained at numerous sites in Northumberland and Durham has shown that infiltrating surface water can accumulate along the interface with the underlying in situ bedrock. Perched systems may also form where layers of predominantly cohesive fill are present.

4.3 Bedrock Strata

4.3.1 General

Groundwater flow in undisturbed Coal Measures strata is almost exclusively controlled by natural joints and fissures. Studies carried out by British Coal indicate that the hydraulic conductivity generally ranges from 10^{-6} to 10^{-7} m/s. The interbedded nature of the succession, which influences the development of natural joints, gives rise to strong anisotropy. Vertical conductivity is typically one or two orders of magnitude lower than for horizontal flow.

4.3.2 Effects of Underground Mining

4.3.2.1 General

The hydraulic properties of the strata are radically changed by the presence of old workings. This is due to the following factors:

(i) the presence of open voids along which groundwater can flow quite freely;

(ii) brittle failure and the creation of a large number of fractures where the roof strata have failed; and

(iii) the dilation of natural joints and the separation of bedding planes due to the collapse of the underlying strata.

Some of the land on and around the site has been extensively undermined. The 1/10,560 scale Old Workings Plans (**Appendix D**) show the degree and extent of coal extraction in a number of coal seams. The workings are interconnected by shafts and cross-Measures drifts and consequently the effects of mine water abstraction can be far reaching.

Large scale abstraction in the Northumberland Coalfield has shown that the groundwater is compartmentalized by the major WSW-ENE faults (i.e. the Causey Park, Grange Moor and Stakeford Faults, **Figure 4**). Substantial hydraulic gradients can develop across the faults because groundwater flow is restricted. However, there is always some measure of leakiness which may be enhanced by the presence of mine headings. The Coal Authority (person. comm., 2015) reports that the headings that connect the workings at Newbiggin Colliery with those located to the south of the Stakeford Fault, were sealed with large concrete plugs.

4.3.2.2 Archive Information

The efficient control of groundwater was an important factor in the development of the Northumberland coalfield and became more critical as the area of exhausted workings increased. Pumping stations were established to protect the remaining centres of production. The continued closure of collieries in the decades following nationalisation meant that the cost of this pumping was shared by fewer centres of production. Various studies were therefore undertaken to determine the means of optimizing the cost and assessing the likely effects of groundwater recovery. Reference has been made to some of the archive information. Particular attention has been paid to the area lying between the Grange Moor and Stakeford Faults.

The National Coal Board's 'Underground Water Survey for Northumberland' (1966) indicates that the five collieries that formed 'B' Group, namely Ashington, Ellington, Lynemouth, Newbiggin and Woodhorn (**Figure 4**), abstracted mine water at a rate of 1,231 gallons per minute (**gpm**) or 93 l/s in 1965. Ashington Colliery was by then linked to the workings at Pegswood ('C' Group) at 61 and 162m below OD. Workings in the Ashington, Woodhorn and Newbiggin Collieries were also connected. Ellington and Lynemouth Collieries were eventually operated as a single entity and the workings in the latter were, in turn, connected to those at Woodhorn.

The collieries at Linton, Longhirst and Pegswood constituted 'C' Group. In 1965, mine water was abstracted at a rate of 1,626 gpm (123 l/s) and it was predicted that if pumping was stopped, it would flow through various old workings to Ellington and Ashington. Many of the workings at Pegswood were extended beneath those in the higher seams at Ashington. It was concluded that if pumping was stopped at Pegswood, the water would fill up all the workings to the north-east and south-east, and would then flow towards Ashington Colliery.

4.3.2.3 Effects of Pumping at Ellington Colliery

The various collieries mentioned in the National Coal Board's 1966 report were progressively closed so that by the late 1980's only Ellington remained. There is direct connection between Ellington and the workings of the former 'B' and 'C' Group collieries and large scale dewatering was therefore required to protect the mining operations.

The pumps at Ellington were located on the main roadway (47 standage) and in the No. 3 shaft prior to 1992. The water was discharged into a small stream south of Cresswell and then flowed into the sea. Abstraction was also carried out at Morpeth Moor (about 1.5km north-east of the town), and at Lynemouth, Woodhorn and Ashington Collieries. However, all inland pumping was stopped following the closure of Ashington Colliery in 1988 and a review of the Ellington operations in 1992. Pumping operations were then centred on the offshore workings.

Large areas of old workings were affected by the dewatering operations at Ellington because of the degree and extent of interconnection. The water levels were shown to rise at Carl shaft (Ashington Colliery) and at the former Newbiggin and Woodhorn Collieries following the cessation of inland pumping, but the rate of recovery was observed to slow as the water overflowed to fill other areas of old workings. The water levels around Highthorn site were affected, but a significant element of drawdown was maintained.

Ellington Colliery closed in February 2005 and all pumping operations were terminated in August of that year. There was an immediate and rapid recovery of groundwater levels in the offshore workings following the cessation of pumping, but the recovery rate then began to fall as the flooding extended inland. It is now partly controlled by cross-Measures drifts and interconnecting shafts and the overflow levels between the various workings. Nevertheless, rebound is being felt over a very wide area, extending southwards through Ashington and Pegswood, northwards through Highthorn and westwards to Linton and Longhirst. The effect is partly confined by major faults and by unworked strata to the west (i.e. beyond the outcrop of the Brockwell (T) seam shown in **Figure 4**).

4.3.2.4 Pumping Operations at Lynemouth

Reference has already been made to the compartmentalization of the Northumberland Coalfield by the major WSW-ENE trending faults. The Coal Authority has been advised that groundwater levels in that area bounded by the Grange Moor and Stakeford Faults will have to be controlled to prevent the discharge of mine water at inland locations (International Mining Consultants/White Young Green, 2000 & 2005). An abstraction well has therefore been established at the former Lynemouth Colliery site (**Figure 4**) with the intention of maintaining water levels at about 34m below OD. Pumping operations commenced in February 2015 at a rate of 25 l/s. This had no impact on the rate of groundwater recovery and it was therefore increased to 50 l/s from March. Unfortunately, the groundwater is still rising at Ashington Carl shaft and it is planned to further increase the abstraction rate; first to 75 l/s and then progressively to the 110-120 l/s when it is expected that recovery will cease. This will still fall within the capacity of the submersible pump currently deployed at Lynemouth. A standby pump has also been provided. Once the optimum pumping rate has been established, the Coal Authority will examine ways of minimizing the operating costs. The water is being treated in two lagoons prior to its discharge into the North Sea in accordance with an Environment Agency permit. Further comment on the quality of the abstracted water is given in Section 4.6.

4.3.3 Groundwater Monitoring

4.3.3.1 Down-the-hole Geophysical Logs

Most of the exploratory boreholes on Highthorn site were drilled in the 1980's and were logged using dual density-natural gamma tools. These were interpreted to determine the coal seam thicknesses and base depths and the standing water level. The boreholes were usually logged at least one day after drilling so that in most cases the groundwater was known to have equilibrated. The recorded level provides only an average piezometric head for each of the strata penetrated, although there is some degree of interconnection due to the presence of natural joints and in some cases mining induced fractures. Nevertheless, the data do provide a broad picture of the groundwater conditions on the site, in particular the effect of the Grange Moor Fault. A summary of the information is provided in **Table 8**.

South of Grange Moor Fault	North of Grange Moor Fault
Water levels of -22 to -36m AOD from west to east in the area immediately adjacent to the fault falling to between -35 to -46m AOD in a north-easterly direction along the south-eastern perimeter of the site.	Water levels of -11 to -14m AOD extending across a broad area of previously unworked strata.
Comment. The recorded water levels show the extent of drawdown created by abstraction at Ellington Colliery in the 1980's. The effect was more pronounced in closer proximity to the abandoned mine workings.	Comment. The water levels would otherwise be expected to lie at or close to sea level. The limited drawdown, which is still present, indicates that there is some measure of flow or leakiness across the fault. This is occurring where the adjacent strata is further fractured and penetrated by backfilled surface excavations (e.g. at Radar South site) or mine headings as at Stobswood Colliery.

Table 8 Summary Observations and Comments on the Interpreted Geolog Water Levels

4.3.3.2 Borehole Monitoring Installations

A number of piezometers have been installed on Highthorn site to assess the groundwater conditions. Most of the installations were established when the site was investigated by British Coal, but a further six (nos. PZ1 to PZ6) have been constructed to target the strata that will now be excavated. Reference has also been made to the monitoring results from the adjacent Ferneybeds site. Details of the installations are summarized in **Table 9** and their locations are shown in **Figure 7**.

Figure 8 shows the monitoring records for two piezometers installed in the Top Yard Top Leaf or Top Ulgham (G230) seam to the north (no. 1347) and south (no. 1497) of the Grange Moor Fault. There is a significant difference in the piezometric head, but changes in the pumping activities at Ellington Colliery are reflected in both installations. Some measure of drawdown occurs around 1992 following the cessation of inland pumping and an increase in offshore activities, but after the turn of the century and the subsequent closure of the colliery in 2005 there has been continued recovery. This is quite pronounced in recent times, but some of the data may not be accurate.

The difference in piezometric head across the fault is also reflected in the monitoring results for the Top Bensham (H200) seam and the Top Bensham sandstone (**Figure 9**). Borehole nos. 1346, 1364 and 1374 are located to the north of the fault, whilst the remainder are situated on the downthrow side. Those installations which provide the longest records (nos. 1346, 1364 and 2200) confirm that recovery has occurred on both sides of the fault.

Sadly, the monitoring records for the sandstone above the Little Wonder (J300/J200) (**Figure 10**) are relatively short, but borehole no. 1784 again shows continued recovery. The same applies with regard to the strata below the Bottom of Broomhill (L200) (**Figure 11**), which lies a short distance below the section shown in **Figure 3**.

The Highthorn records have been compared with those obtained from a number of Coal Authority monitoring stations centred on the former ‘B’ and ‘C’ Group collieries described in Section 4.3.2.2. There has been a dramatic rise in groundwater levels since the closure of Ellington Colliery and the cessation of all pumping operations (**Figure 12**). This is reflected in the Highthorn data. The rate of recovery is increasing as the various worked horizons are inundated and a best fit line has been determined using regression analysis in an effort to predict future groundwater levels. Recovery and inundation will continue until such time that the Authority achieves its target level of -34m AOD by renewed pumping at the Lynemouth Colliery site. It is important that groundwater recovery is checked; otherwise all the workings on Highthorn site will become inundated.

Bh. No. (Status)	Grid Reference	Ground Level (m AOD)	Depth of Tip (m bgl)	Standpipe Height (m)	Horizon of Tip	Type	Range of Recorded Water Levels		Date Installed	Last Reading
							Depth (m bcl)	Level (m AOD)		
1320 (D)	427095 594978	112.34	128.50	0.47	19.01m below base of Bottom of Broom hill (L200) seam.	P	40.10-45.06	-32.25 to -27.29	09/02/86	05/01/88
1321 (D)	426845 595019	115.08	80.00	0.77	36.90m below base of Top of Radar (J100) seam north of Grange Moor Fault.	P	26.07-43.79	-27.94 to -10.22	10/02/86	05/01/88
1343 (D)	427887 595365	103.89	85.00	0.52	8.79m below base of Top of Radar (J100) seam in sandstone.	P	15.55-23.26	-18.85 to -11.14	21/03/86	25/05/04
1346 (W)	427887 595363	103.89	51.80	0.50	1.80m above Top Bensham (H200) seam in sandstone.	P	6.30-23.22	-18.83 to -1.91	21/03/86	08/05/15
1347 (D)	427886 595362	103.93	26.30	0.38	2.66m above Top Yard Top Leaf (G230) in sandstone.	P	15.49-23.20	-18.89 to -11.18	21/03/86	25/07/08
1364 (D)	427095 594976	112.51	54.00	0.30	Top Bensham (H200) seam.	P	6.70-49.37	-36.56 to 6.11	10/04/86	02/10/14
1367 (D)	427183 595098	111.65	83.50	0.50	1.08m below the base of the Bottom of Broom hill (L200) seam.	P	25.56-31.83	-19.68 to -13.41	01/05/86	22-10-91
1374 (D)	427184 595096	111.63	28.00	0.50	Approximately 2.47m above Bottom Bensham (H100) seam.	P	24.24-Dry	<-16.37 to -12.44	02/05/86	22-10-91
1493 (D)	427788 595098	103.93	120.00	0.57	9.50m below base of Top of Radar (J100) seam in sandstone.	P	38.28-47.97	-43.47 to -33.78	21/04/86	15/01/12
1495 (D)	427870 595226	103.50	114.30	0.71	21.92m below base of Top of Radar (J100) seam in sandstone.	P	16.68-24.70	-20.49 to -12.47	22/04/86	20/01/99
1497 (W)	427789 595096	103.92	57.90	0.44	3m above Top Yard Top Leaf (G230) in sandstone.	P	39.19-55.72	-51.36 to -34.83	18/04/86	08/05/15
1498 (D)	427789 595094	103.95	84.00	0.61	Approximately 1.30m above Top Bensham (H200) in sandstone.	P	58.27-58.55	-53.99 to -53.71	18/04/86	05/01/88

bcl – below collar level S – Standpipe P – Piezometer W – Fully functioning D – Damaged, blocked or removed

Table 9 Summary of Standpipe and Piezometer Installations

Bh. No. (Status)	Grid Reference	Ground Level (m AOD)	Depth of Tip (m bgl)	Standpipe Height (m)	Horizon of Tip	Type	Range of Recorded Water Levels		Date Installed	Last Reading
							Depth (m bcl)	Level (m AOD)		
1499 (D)	427867 595224	103.49	49.90	0.65	Approximately 0.80m above Top Bensham (H200) seam in sandstone.	P	38.56-41.68	-37.54 to -34.42	21/04/86	04/08/98
1673 (D)	425747 595004	131.53	107.20	0.68	1.05m below Bottom of Broomhill (L200) seam.	P	25.46-30.81	1.40 to 6.75	25/02/84	09/03/87
1674 (W)	425747 595003	131.55	36.20	0.52	0.90m above base of opencast backfill.	S	19.55-26.24	5.83 to 12.52	25/02/84	08/05/15
1783 (W)	425746 595006	131.48	109.00	0.28	2.81m below base of Bottom of Broomhill (L200) seam in siltstone sequence.	P	28.60-40.57	-8.81 to 3.16	02/11/87	08/05/15
1784 (W)	425746 595009	131.51	79.00	0.30	2.06m above Little Wonder (J300/J200) seam in sandstone.	P	31.66-43.74	-11.93 to 0.15	04/11/87	08/05/15
1786 (D)	425692 595204	133.52	58.00	0.30	5.73m below base of Bottom of Broomhill (L200) seam in sandstone/siltstone sequence.	P	38.21-44.88	-11.06 to -4.39	06/11/87	21/08/07
1787 (D)	425692 595206	133.53	45.00	0.27	2.73m below interpreted base of opencast backfill.	S	38.36-41.06	-7.26 to -4.56	09/11/87	17/09/96
2129 (D)	426493 594946	121.08	108.30	0.60	Approximately 2m below base of Bottom of Broomhill (L200) seam.	P	46.94-50.93	-29.25 to -25.26	13/12/85	22/10/91
2142 (D)	426493 594944	121.14	57.30	0.58	Top Bensham (H200) seam.	P	47.05-50.90	-29.18 to -25.33	13/12/85	22/10/91
2143 (D)	426494 594942	121.10	76.00	0.50	Sandstone above Little Wonder (J300/J200) seam.	P	46.69-50.54	-29.94 to -25.09	13/12/85	22/10/91
2200 (D)	427868 595225	103.50	71.30	0.70	Approximately 1m above Top Bensham (H200) seam in sandstone.	P	41.00-48.70	-44.50 to -36.80	22/04/86	25/07/88
2404 (D)	426389 593495	121.42	137.30	0.23	Approximately 10.07m below base of Cheeveley (M000) seam in sandstone.	P	50.86-54.73	-33.08 to -29.21	23/07/87	25/08/93

bcl – below collar level S – Standpipe P – Piezometer W – Fully functioning D – Damaged, blocked or removed

<u>Table 9 cont'd. Summary of Standpipe and Piezometer Installations</u>

Bh. No. (Status)	Grid Reference	Ground Level (m AOD)	Depth of Tip (m bgl)	Standpipe Height (m)	Horizon of Tip	Type	Range of Recorded Water Levels		Date Installed	Last Reading
							Depth (m bcl)	Level (m AOD)		
2407 (D)	426387 593494	121.49	115.00	0.23	Approximately 2.18m below Bottom of Broomhill (L200) seam in mudstone/siltstone sequence.	P	50.86-55.96	-34.24 to -29.14	26/07/87	25/08/93
2408 (D)	426385 593494	121.51	79.00	0.18	Approximately 2.59m above Little Wonder (J300/J200) seam in sandstone.	P	73.68-75.85	-54.16 to -51.99	26/07/87	27/10/88
2409 (D)	426382 593493	121.53	64.00	0.19	Top Bensham (H200) seam.	P	51.01-56.89	-35.17 to -29.29	28/07/87	25/08/93
2410 (D)	426353 594183	122.50	114.00	0.15	Approximately 2.18m below Bottom of Broomhill (L200) seam in mudstone/siltstone sequence.	P	48.00-51.69	-29.04 to -25.35	30/07/87	26/10/93
2411 (D)	426357 594182	122.40	72.00	0.17	Approximately 1.75m above Little Wonder (J300/J200) seam in sandstone.	P	51.01-54.45	-31.88 to -28.44	30/07/87	26/10/93
2412 (D)	426359 594180	122.34	55.66	0.26	Top Bensham (H200) seam.	P	49.12-51.33	-28.73 to -26.52	31/07/87	26/10/93
2577 (D)	427053 594484	113.21	140.50	0.30	9.86m below base of Bottom of Broomhill (L200) seam.	P	42.21-51.40	-37.89 to -28.70	22/10/87	22/10/91
2578 (D)	427053 594486	113.18	94.00	0.33	2.44m above Little Wonder (J300/J200) seam.	P	47.44-53.85	-40.34 to -33.93	23/10/87	22/10/91
2580 (D)	427053 594487	113.18	75.00	0.25	Top Bensham (H200) seam horizon (washed out or faulted).	P	36.15-49.24	-35.81 to -22.72	27/10/87	22/10/91
2581 (D)	427053 594480	113.15	56.50	0.33	Bottom Yard (G100) seam.	P	45.95-51.71	-38.23 to -32.47	28/10/87	22/10/91

bcl – below collar level S – Standpipe P – Piezometer W – Fully functioning D – Damaged, blocked or removed

Table 9 cont'd. Summary of Standpipe and Piezometer Installations

Bh. No. (Status)	Grid Reference	Ground Level (m AOD)	Depth of Tip (m bgl)	Standpipe Height (m)	Horizon of Tip	Type	Range of Recorded Water Levels		Date Installed	Last Reading
							Depth (m bcl)	Level (m AOD)		
PZ1 (W)	427811 594423	6.81	37.50	0.28	Diamond (E000) seam.	P	33.31-33.78	-26.69 to -26.22	22/09/14	08/05/15
PZ2 (W)	427811 594423	6.81	49.00	0.27	Top Main (F200) seam.	P	46.01-47.84	-40.76 to -38.93	22/09/14	08/05/15
PZ3 (W)	427811 594423	6.81	65.50	0.28	Bottom Yard (G100) seam.	P	54.64-55.75	-48.66 to -47.55	22/09/14	08/05/15
PZ4 (W)	427459 594042	13.00	68.00	0.20	Bottom Yard (G100) seam.	P	58.90-60.58	-48.61 to -46.93	4/11/14	08/05/15
PZ5 (W)	427459 594042	13.00	38.00	0.18	Diamond (E000) seam.	P	41.54-42.06	-30.11 to -29.59	4/11/14	08/05/15
PZ6 (W)	427811 594423	6.81	46.85	0.23	Top Main (F200) seam.	P	50.23-53.36	-38.23 to -41.36	4/11/14	08/05/15
Ferneybeds Site										
FPZ1	426076 593371	28.20	0.50	38.22	Bottom Yard (G100) seam.	P	37.44-Dry	Dry to -8.74	03/10/11	20/04/15
FPZ2	426043 592758	22.40	0.41	49.28	Bottom Yard (G100) seam.	P	26.41-32.88	-10.07 to -3.60	12/12/11	20/04/15
FPZ3	426263 592722	28.32	0.41	26.26	Bottom Yard (G100) seam.	P	25.33-Dry	Dry to 3.40	31/10/11	20/04/15

bcl – below collar level S – Standpipe P – Piezometer W – Fully functioning D – Damaged, blocked or removed

Table 9 cont'd. Summary of Standpipe and Piezometer Installations

The monitoring records for piezometer nos. PZ1 to PZ6 are relatively short, but the data have been plotted in **Figure 12** and further details are given in **Table 10**. Clearly, the water levels will have to be drawn down to create safe working conditions and allow the recovery of the mineral reserve. The volume of stored water will be relatively low where longwall workings are present because of the degree of subsidence, but high inflows might occur around collapsed headings and pillared workings. The water levels could be drawn down by pumping at the site. However, talks have been held with the Coal Authority with a view to creating further drawdown at Lynemouth so that the strata can be dewatered. This is the preferred strategy, though some groundwater will still be encountered when the Grange Moor Fault is exposed along the northern margin of the proposed excavations.

Seam/Old Workings Horizon	Recorded Groundwater Level (m AOD)	Proposed Minimum Level of Excavation (m AOD)
Ashington (4D00)	NA	-25.00
Diamond (E000)	-26.50	-34.00
Top Main (F200)	-40.00	-40.00
Bottom Yard (G100)	-48.00	-63.00

Table 10 Recorded Groundwater Levels and Proposed Minimum Levels of Extraction

Studies carried out in the Northumberland Coalfield have shown that where mine workings are being dewatered, the hydraulic gradients generally range between 1v in 1000h (0.06°) and 1v in 500h (0.12°). Given that Highthorn site lies approximately 4.6km from the Coal Authority's pumping station at Lynemouth, the water levels would have to be drawn down to between -68m and -73m AOD, if the old workings are to be dewatered to the required levels. This assumes that similar gradients could be created and that there are no obstructions that might otherwise prevent groundwater flow. A higher level of abstraction would be required than that currently estimated by the Authority to control the water levels at -34m AOD (110-120 l/s). There would also be implications with regard to water treatment (Section 4.6).

Finally, the groundwater levels recorded at the permitted Ferneybeds site (borehole nos. FPZ1, FPZ2 and FPZ3) are thought to represent localized accumulation, possibly confined around some of the installations themselves, rather than evidence of any recovery. There is presently no requirement for specific pumping and further drawdown at this site.

4.4 Licensed and Unlicensed Groundwater Abstractions

The Envirocheck reports (**Appendix A**) show that there are no licensed groundwater abstractions within the search areas. The Environment Agency internet website (Environment Agency, 2015) also confirms that there are no such abstractions on the proposed site or within at least 1km of its perimeter. Northumberland County Council's Environmental Health Department holds no records of any unlicensed (private) water abstractions (**Appendix B**).

4.5 Landfill Sites and Waste Management Facilities

4.5.1 General

The Envirocheck reports (**Appendix A**) refer to a number of landfill sites and licensed waste management facilities (**Table 11**).

Operator/Licence Holder (Licence or Ref. No.)	Recorded Grid Ref.	Distance from Centre of Site (m)	Waste Type	Notes
Historical Landfill Sites				
Warkworth Lane (EAHLD06356). Mr D. Moore, Ellington, Morpeth, Northumberland.	427564 593041	1,484	Deposited waste included inert waste	Waste first input 31st January 1982. Last input 31st July 1994
Chibburn Preceptory (EAHLD06461). Not Supplied Widdrington, Northumberland	425702 596575	2,357	Deposited waste included inert, industrial, commercial and household waste.	Waste first input – date not supplied. Last input 31st December 1976
Licensed Waste Management Facilities				
Mr D. Moore (67311) Ellington Caravan Park, Warkworth Lane, Ellington, Morpeth, Northumberland.	427600 593000	1,693	Landfills taking other wastes (construction, demolition, dredgings).	Licence issued 19th October 1982, and surrendered 15th August 1994.
Registered Landfill Sites				
R Million (Nbl 052 (N 52)) Warkworth Lane, Ellington, Morpeth, Northumberland. (R. Million, 29 Summerson Way, Bedlington, Northumberland.)	427650 593000	1,715	Construction and demolition wastes, excavated natural materials, mine and quarry wastes.	No known restriction on source of waste. Licence issued 19th October 1982 and surrendered 15th August 1994. Input rate 25,000-75,000 tonnes p.a.
Local Authority Recorded Landfill Sites				
Northumberland County Council (PD24) Chibburn Preceptory, Widdrington, Northumberland.	425700 596600	2,380	Household and builders' waste.	Date of closure 31/12/1976

Table 11 Summary of Historical and Local Authority Recorded Landfill Sites and Licensed Waste Management Facilities in the Highthorn Area

4.5.2 Hemscott Hill Foot and Mouth Disease Carcass Pyre

4.5.2.1 General

When a veterinary inspector spotted suspected symptoms of Foot and Mouth Disease (**FMD**) at an abattoir in Essex on February 19th 2001 and this was confirmed the following day, it triggered an unprecedented scale of animal culling in a vain attempt to prevent the spread of the epidemic. By the time it ended in September over 2,000 premises had been affected with animals culled at over 10,000 farms.

Foot-and-mouth disease virus is acid, alkali and heat labile, but can survive for long periods at neutral pH and under low temperature conditions. **Tables 12**, **13** and **14** provide details of the survival times for the virus for a range of conditions (Department for Environment, Food and Rural Affairs, pers. comm., 2002). It can be seen that the virus will not survive long term burial and/or incineration.

Material	Time
Wool	14 days
Cow’s Hair	4-6 weeks
Houseflies	10 weeks
Contaminated footwear	11-14 weeks
Wood, hay, straw, feed, etc.	15 weeks

Table 12 FMD Virus Survival Times in Common Localities

pH	Time
2.2	<15 seconds
4	<15 seconds
6	2 minutes
7	Several weeks
9	1 week
10	14 hours
12.5	<15 seconds

Temperature (ºC)	Time
60	5 seconds
56	<30 minutes
50	1 hour
37	1 day
22	8-10 weeks
4	4 months
-5	>1 year

Table 13 FMD Virus Survival Times in Tissue Culture Suspensions at Various Temperatures and pH Levels

Product and Condition		Time
Lymph and haemal nodes at 4ºC		120 days
Bone marrow at 4ºC		210 days
Skeletal muscle (pH <6) at 4ºC		2 days
Frozen carcass (no *rigor mortis*)		6 months
Milk under the following conditions:		
pH	Temperature ºC	
2	4	1 minute
4	4	2 minutes
5.5	4	30 minutes
5.8	4	18 hours
7	4	15 days
11	4	2 hours
12	4	25 minutes
7	56	30 minutes
7	63	2 minutes
7	72	40 seconds
7	80	<5 seconds

Table 14 FMD Virus Survival Times in Animal Products

The most commonly used methods of disposing of slaughtered animals were burning, rendering and burial on farms and at licensed waste disposal sites. In practice, problems were experienced with all the methods used.

4.5.2.2 Carcass Pyres

Following the 1967 FMD epidemic, a national inquiry chaired by the Duke of Northumberland recommended the burial of culled livestock on affected farms. However, this was long before bovine spongiform encephalitis (BSE) was recognized in older cattle. Initially, the burning of carcasses was the preferred method of disposal when the disease broke out again in 2001 because of the risk of groundwater pollution. Typically, the carcasses were burned using a mixture of straw, wooden pallets, railway sleepers, coal and diesel oil. The size of the pyres varied with the number of carcasses to be destroyed but a medium size pyre would amount to some 400 tonnes of material and leave approximately 60 tonnes of ash.

Standing instructions (Department for Environment, Food and Rural Affairs (**DEFRA**)/State Veterinary Service, 2001) for pyre construction varied widely during the outbreak with considerable innovation to ease construction and improve burn rates and overall loading of stock. Multiple pyres were used on some sites to burn carcasses from neighbouring farms. One of the largest was at Hemscott Hill in Northumberland. However, many smaller sites were used to dispose of animals from neighbouring farms as well as those from the farm on which the pyre was located. The first pyre was lit on the 25th February 2001.

Material for pyre burning became increasingly difficult to obtain as the epidemic ensued. Rapid price inflation was observed for sleepers and other fuel wood. Some poor quality coal made it difficult to achieve complete combustion and with less manual labour available, fire watching and tending were reported to be less efficient than in 1967 (Scudamore et al., 2002). The pyres produced acrid smoke, particularly when the burn rate was slow, containing particulate matter, sulphur dioxide, nitrogen dioxide and other products of combustion such as dioxins, furans, polycyclic aromatic hydrocarbons (**PAH**'s) and polychlorinated biphenyls (**PCB**'s). There were also concerns that prions from carcasses affected by BSE might also be present in the ash and airborne particulates. Record keeping at the start of the epidemic was poor so that the age of the cattle burned at a particular location was not known. Some pyres were observed to burn or smoulder for several weeks which implies that they were either built incorrectly or that the materials used were unfit for the purpose. This only served to increase public concerns regarding the visual and environmental impacts of pyre burning. Guidance from the Department of Health (Department of Health, 2001), issued at the end of April 2001, was that large pyres (1,000 or more cattle equivalents) should generally be built 3 km or more from local communities, such as villages. However, the use of pyres was eventually discontinued on 7 May 2001 when the epidemic had subsided to about seven new outbreaks a day and the efficiency of carcass processing by other means had improved.

After the epidemic, it was confirmed that concentrations of particulate matter, sulphur dioxide, nitrogen oxides, PAH's, dioxins and PCB's had been elevated above rural background levels at distances of up to 2km from pyre sites. The Department of Environment also commented that pyres lit during the first 6 weeks of the outbreak released 63g of dioxins into the atmosphere. This is equivalent to 18% of the UK's average annual emissions. Nonetheless, concentrations were comparable with the levels typically found in industrial urban conurbations and the Department of Health did not consider that they represented a cause for concern.

(Note. Dioxins are a group of chemically-related compounds that are persistent environmental pollutants. They are the by-products of certain industrial processes such as smelting, waste incineration and pesticide manufacture. They are also produced by volcanoes and forest fires. Dioxins bioaccumulate in living organisms and are found in red meat and dairy produce, poultry, fish and on unwashed fruit and vegetables. Fish accumulate dioxins through exposure to water, whilst animals are usually exposed to those settling on their food from the atmosphere.)

The Food Standards Agency implemented a programme for monitoring of dioxins and dioxin-like products on herbage and in agricultural produce, such as milk and eggs produced in the vicinity of pyres (Foods Standards Agency, 2001). The Agency advised that there were no implications for human health from their consumption. Rose et al (2005) have also reported that with few exceptions, *'concentrations of polychlorinated dibenzofurans (**PCDD/F**'s) and PCB's were within the expected ranges as predicted by reference data. No accumulation over time was evident from a repeat milk sampling exercise. Where elevated concentrations of PCDD/F's and PCB's were found in chickens and eggs, they were in samples not destined for the food chain. Elevated levels in some samples of milk from Dumfries and Galloway were not found in earlier or later samples and may have been found as a result of a temporary feeding regime. Elevated concentrations in lamb from Carmarthenshire were from very young animals which would not have entered the food chain. There was no evidence of any significant increase in dietary exposure to PCDD/F's and PCB's as a result of the FMD pyres.'*

The Environment Agency also reviewed the environmental impact of disposal operations and in an interim report concluded that the FMD disposal activities caused minimal adverse impact on the environment in the short term and appeared not to have harmed public health in any way (Environment Agency, 2002).

The risk of BSE prions existing in ash was deemed imperceptible, but it was not until May 2001 that the Spongiform Encephalopathy Advisory Committee (SEAC) recommended the burial of ash in licensed, engineered landfill sites as the most practical safe disposal option. In a report for the UK government, Anderson (2002) recommended that, *'burning animals on mass pyres should not be used again as a strategy for disposal'.*

4.5.2.3 Hemscott Hill Pyre Site

The FMD pyre at Hemscott Hill was located along the landward perimeter of the sand dunes, extending from a point just north of the farm towards Druridge on the north-eastern side of the C110 public road (i.e. not on Highthorn site and some distance from the proposed working area).

The location of the pyre met with considerable local opposition because of the smell and the smoke that was generated. This was made worse by the easterly winds that blew the smoke inland during the early stages of its operation. An agreement was reached between the former Castle Morpeth Borough Council, Newcastle Disease Emergency Control Centre and DEFRA that the last lorry would enter the pyre site on the 26th April 2001, some four days earlier than anticipated and that the burning would be completed by 29th of that month. The final cleaning of the site to remove an estimated 3,000 tonnes of ash was then scheduled to start the following day. The area would then be ploughed and sprayed, fences restored and all temporary buildings removed in time for the Bank Holiday weekend. During the wind-down of operations, it was further agreed that only carcasses that could not be burnt in the locality of an outbreak would be taken to Hemscott Hill.

The removal of ash was delayed, but it was reported on the 25th June that specialist contractors would be starting work on site very shortly. The material would then be taken in sealed containers by lorry to a rail freight depot in Middlesbrough, from where it was to be transported by train to a landfill site, yet to be identified in the UK. According to DEFRA, the material was not considered to be harmful and this had been determined by suitable testing. In September, approximately 600 tonnes of ash-laden soil were removed when contractors returned to complete the job. However, the Council had to grant DEFRA more time to clear the site following a previously agreed deadline of 15th October to confirm that the site was clear of any contamination. .

Concern regarding the continued contamination of the site continued and on 24th February 2003, a question was tabled in the House of Commons by Alan Beith, Member of Parliament for the Berwick constituency. The Secretary of State for the Environment, Food and Rural Affairs was asked whether the burning of carcases of cattle over five years old on the Hemscott Hill site precluded its use for animal grazing in 2003 (i.e. because of the increased risk of BSE prions being present in the soil); and if she would publish the risk assessment carried out into the site by Dr. Kirkup, the Regional Director of Public Health. In response, he was told that veterinary advice confirmed that the burning of carcases of cattle over five years old at the Hemscott Hill site did not preclude its use for animal grazing. The ADAS environmental risk assessment and supporting material, together with a statement by Dr. Kirkup, was given to Castle Morpeth Borough Council, the Food Standards Agency and the local liaison committee. Mr. Beith later expressed his doubts as to thoroughness of DEFRA's investigations.

Despite the controversy that surrounds the actions of central government and its agencies during the FMD epidemic and the local authority's inability or reluctance to accept the assurances it was given, the fact remains that the proposed development will not disturb any part of the former pyre site. If particulates had blown onto the adjacent fields during its operation, any adverse effects have not been manifested in the last 14 years. There have been no outbreaks of FMD or any reported cases of BSE in the area and no cases of dioxin, furan or PCB poisoning. If any contaminants remain on the site, they are founded on windblown sand that is confined to the east of the C110 road and is underlain by glacial till of low conductivity. Dioxins, furans and PCB's are practically insoluble in water and given the vegetative cover that has been established are unlikely to be mobilized by surface erosion.

4.5.3 <u>Widdrington (Seven Sisters) Foot and Mouth Disease Burial Site</u>

The Environment Agency has drawn attention to the FMD burial site at Widdrington and has requested that an assessment is made of the risk of leachate migration into the proposed surface excavations (Scoping Response letter of 12th January 2015, Ref. No. NA/2014/111783/01-L01).

When the scale of the foot and mouth disease outbreak escalated in Northumberland towards the end of March 2001, a number of potential sites were identified for the burial of carcasses. Part of the restored Sisters surface mine was selected through consultation with the Ministry of Agriculture, Fisheries and Food (**MAFF**), the Environment Agency and Northumberland County Council (**Figure 4**). Infrastructure, earth movement and pit excavations were started on 31st March and the first carcasses were deposited on 3rd April. The site remained fully operational until the end of May, by which time approximately 130,000 sheep and a nominal number of cattle carcasses had been deposited representing about two-thirds of its total capacity. Water Management Consultants Ltd. (**WMC**) was subsequently appointed by DEFRA to undertake a hydrological and hydrogeological study at the burial site, and assess the likely impacts of any leachate.

The carcasses were deposited in trenches of 3.5 and 5m in depth formed within the surface mine backfill. None of the backfill was compacted during the mining operations, but appreciable self-weight compaction has occurred since its deposition in the late 1970's and early 1980's. This will have reduced the hydraulic conductivity, possibly to within the range 10^{-4} to 10^{-6} m/s (Reed, 1986).

Two separate site investigations were carried out by WMC to confirm the hydrogeology of the site. These comprised a total of eleven groundwater monitoring boreholes, five of which (nos. 1, 2, 3, 4 and 5)[*] were drilled within the burial area (**Figure 13**), and a comprehensive programme of sampling and analysis. The following conclusions were drawn by WMC based on the results of the investigations and those carried out at other burial sites in the UK.

(i) The burial site at Widdrington was designed and constructed using the principle of, *'dilute and disperse'*, and all carcasses were deposited in unlined trenches.

(ii) A large pollutant load formed within 2 months of carcass burial and this was characterized by very high levels of chemical and biological oxygen demand (**COD** and **BOD**), potassium, chloride and ammoniacal nitrogen.

(iii) Following the initial flush of leachate, the carcasses continued to produce a reduced and gradually declining pollutant level. This was expected to last around 10 years after burial (i.e. until 2011). It was estimated that the pollutant load would fall from 40.2 to 6.0 m^3/day taking into account surface water infiltration (WMC, 2002).

([*] Note. With the exception of borehole no. 8, all the installations lie to the north of the Grange Moor Fault. Most of the deep piezometers previously installed on the site by British Coal were destroyed during the earthworks excavations for the burial site.)

(iv) Any dissolved contaminants draining from the base of the burial site would be subject to the following processes that control their rate of migration and concentration: advection, dispersion, dilution, retardation and degradation.

(v) Perched groundwater was recorded in the surface mine backfill at approximately 4 and 15m AOD. This intercepted a proportion of pollutant load and held it up in the unsaturated zone. Monitoring in borehole no. 5, which was drilled to 30m below ground level, suggested that the pollutants were migrating laterally from the burial site before draining down into the underlying fill and old workings. No definitive evidence of any pollutants was found in borehole nos. 2 and 3, but elevated ammoniacal nitrogen concentrations were found in borehole no. 1. All these boreholes were drilled to 65m below ground level.

(vi) The main groundwater table was located at about 14m below OD.

(vii) No evidence of any surface water contamination was found and this was confirmed by regular sampling and analysis.

(viii) A relatively flat, hydraulic gradient was present and this was directed towards the south-west. Groundwater flow was controlled by cross-Measures drifts that extend from the old workings beneath the burial site towards the former Stobswood Colliery site (**Figure 4**). An abstraction well was previously established in this area to facilitate the recovery of shallow coal reserves at the former Stobswood surface mine.

(i) The quality of the groundwater was relatively poor prior to the burial of the carcasses and was characterized by elevated sulphate concentrations.

(ii) There was no evidence to suggest that any pollutants from the burial site were present in the water abstracted from the Stobswood well. This was despite the direct interconnection of water along a number of mine headings that extended through the Grange Moor Fault and into the former Stobswood site. The estimated travel times through the saturated zone ranged from 18 to 228 years.

It was concluded that the overall impact of the burial site was less than had been expected (WMC, 2002) which might be a consequence of:

(a) a higher degree of dilution and attenuation in the Sisters surface mine backfill than was predicted;

(b) the pollutant travel time is longer than was previously estimated;

(c) the migration pathways are short circuited around the deeper monitoring boreholes because of the heterogeneity of the surface mine backfill.

Point (a) was considered to be the most likely explanation and it was expected that pollutant concentrations would continue to be diluted by surface infiltration (pers. comm., 2005).

Since that time all pumping operations at the Stobswood surface mine have been terminated and the site has been restored. A large excavation was also formed immediately to the north of the burial site in February 2008 as part of the Steadsburn surface mine development (i.e. in an area with direct hydraulic interconnection). Despite the continued development of this site and the abstraction of large volumes of groundwater from the bedrock, mine workings and surface mine backfill, no evidence of significant pollution was encountered. Coaling operations were completed during the early part of 2011. The site has now been restored and a large lake has been formed.

Monitoring has been continued at the burial site by Schlumberger Water Services Ltd. and details of the recorded groundwater levels are shown in **Figure 14**. As expected, there has been marked recovery in some of the boreholes to levels observed before the development of Steadsburn surface mine. Those recorded in borehole no. 8 (south of the Grange Moor Fault) have also shown a slight rise since June 2012. The following observations can be made with regard to the quality of the groundwater, details of which are given in **Appendix F**:

(i) apart from a low number of anomalous readings, the pH has remained within the range 6.5 to 8 (i.e. neutral to slightly alkaline of neutral) both within and outwith the burial site, although some of the initial results for borehole no. 1 were slightly alkaline;

The pH of the discharge water at the former Steadsburn surface mine falls within the EA's discharge consent limits.

(ii) the conductivity has fallen from relatively high levels in some of the boreholes and now range from 1,0000 to 3,000 μS/cm at all locations;

The record includes a number of measurements taken at the former Steadsburn site discharge point. The single very high value recorded in borehole no. 2 is likely to be anomalous. The levels recorded in borehole no. 8 have remained at around 1,000 μS/cm and are considered to be more typical of shallow of Coal Measures strata. It implies that the Grange Moor Fault is inhibiting the movement of leachate from the burial site and that the levels recorded in the other boreholes are still elevated because of the lingering effects of carcass decomposition. Borehole nos. 4, 5 and 6 record a recent rise in conductivity above that observed in borehole no. 8.

(iii) the groundwater temperatures appear to show strong seasonality within the range 7 to 14°C, although the recorded range for borehole no. 8 is now more restricted (8 to 9°C);

(iv) discounting some of the intial readings, there has been a general reduction in the level and range of dissolved oxygen concentrations in all the boreholes since monitoring began;

This includes borehole no. 8 and may indicate the continued effect of carcass decomposition and bacterial activity.

(v) the magnesium concentrations in borehole no. 8 have remained at around 50 mg/l throughout the monitoring period, whilst those in borehole nos. 2 and 5 have fallen from initial high levels only to show a slight recovery in more recent years.

If the concentration of magnesium in borehole no. 8 is considered to be typical of that found in Coal Measures strata and opencast backfill, it implies that the concentrations in the other boreholes are elevated due the burial of carcasses. The effect is felt down-dip towards the east, but the Grange Moor Fault appears to be preventing migration to the south. The concentrations presently remain well below those observed shortly after the burial site was closed, but the recent increases in borehole nos. 2, 3, 5, 6 and 9 may have resulted from continued groundwater recovery in and around the burial site and the inundation of additional volumes of contaminated fill.

(vi) after an initial rise from 5 mg/l at the end of 2013, the concentrations of potassium in borehole no. 8 have remained at 15 mg/l, whilst those recorded in borehole nos. 2, 4 and 5 have shown a marked decrease;

The recorded concentrations presently lie within the range 5 to 35 mg/l. Some have risen in recent years, possibly for the same reason as for magnesium.

(vii) in general, there has been a significant reduction in iron concentrations since monitoring was commenced, but the record is inconsistent;

(viii) the chloride concentrations in borehole nos. 3, 5 and 8 remained elevated well above those observed at other locations until the end of 2005 and now fall within the range 30-70 mg/l;

There is some evidence of a slight recovery in chloride concentrations in borehole nos. 3 and 5 since the start of 2013.

(ix) the alkalinity recorded in borehole nos. 4 and 5 was initially very high, but since the end of 2005 it has generally remained within the range 250 to 750 mg/l in common with the other boreholes;

The data for 1st June 2014 appear to be anomalous for all samples, but there is evidence of a subsequent rise in borehole nos 3, 4 and 5.

(x) some of the calcium concentrations were initially very high and having fallen there is evidence to suggest a more recent increase, possibly as a consequence of groundwater recovery;

The concentrations measured in borehole no. 8 were slightly elevated in 2002/3, but have since remained at around 90mg/l showing a very slight increase in the last two years, but remaining well below those recorded at other locations.

(xi) some of the initial results for biological oxygen demand were quite elevated, but although there are a number of spikes in the record, there appears to have been a general reduction with time;

The concentrations for borehole no. 8 have remained relatively low since 2003, having shown an initial period of slight elevation.

(xii) the concentrations of ammoniacal nitrogen appear to have fallen from initial highs in 2002/3 only to rise again;

The trends observed in borehole nos. 1, 2 and 3 are noteworthy in this respect. The concentrations recorded in borehole no. 8 located to the south of the Grange Moor Fault are variable, but there may be other sources of contamination.

(xiii) the weathering of inherent sulphide minerals in Coal Measures strata and opencast backfill will elevate the sulphate concentrations and there is generally sufficient buffering capacity to counter any associated acidification, but those recorded at the Widdrington site remain elevated due to burial of carcasses;

The concentrations recorded in borehole no. 8 are presently very low (approximately 25 mg/l) and whilst the levels in some of the other boreholes have fallen since 2002-2004, others have remained high. There is evidence to suggest that concentrations have risen in borehole nos. 2, 3, 4, 6, 9 and 10 since the end of 2012 or earlier.

(xiv) the record for nitrate is dominated by a number of elevated concentrations, but there are no clear trends;

(xv) the concentrations of sodium in borehole nos. 4 and 5 were initially elevated, but have fallen to within the range 20 to 60 mg/l in common with the other installations;

There is some evidence of a slight rise in sodium concentrations in borehole nos. 2, 3, 4, 5 and 6 from the end of 2012.

(xvi) there are no clear trends with regard to the data for manganese, but if the concentrations in borehole no. 8 represent background levels for Coal Measures strata and opencast backfill (i.e. less than 0.1 mg/l), those recorded in the other installations are clearly elevated.

To summarize, most of the monitoring results show some improvement in groundwater quality since the burial site was closed. However, there is evidence to suggest a slight deterioration in the last two years or so, possibly as a consequence of groundwater recovery and the mobilization of additional contaminants. Contamination has extended beyond the perimeter of the burial site and down-dip, but the Grange Moor Fault is impeding migration to the south for the majority of the chemical constituents.

It is not thought that the Widdrington FMD burial site will impact the proposed Highthorn development for the following reasons:

(i) the flow paths are extremely long and apart from the area around the Stobswood Colliery mine headings and backfilled surface workings at Radar South, flow is impeded by the Grange Moor Fault (see **Figure 4**);

(ii) no pollution was observed during the abstraction of groundwater at the former Stobswood surface mine;

(iii) pollutant migration will be significantly hastened by the presence of mine workings, but the mine headings that extend across the Grange Moor Fault are in seams that lie in lower stratigraphic horizons than those that will be excavated at Highthorn site;

(iv) there will be significant dilution by other groundwater, most especially where flooded mine workings are present;

(v) the excavations at Highthorn site will be extended to the Bottom Yard (G100) seam, which is presently dewatered up-dip of the proposed excavation area on the downthrow side of the Grange Moor Fault;

(vi) a relatively short section Radar South backfill and the Grange Moor Fault will be exposed at Highthorn site to allow the safe recovery of the coal reserves on the downthrow side, but in the absence of old workings inflow rates will be quite low and additional drawdown both temporary and restricted;

(vii) there will be significant dilution by surface runoff in the proposed excavations.

(viii) apart from a small area of workings in the Little Wonder (J300/J200) seam, as shown in **Appendix D**, the strata underlying the Bottom Yard (G100) seam is unworked at Highthorn site and contaminant migration through the proposed excavation pavement is considered highly unlikely because of the very low conductivity;

(ix) the coal seams that overlie the Bottom Yard (G100) pavement seam all outcrop within or close to the site and this determines the extent of historic underground extraction (**Appendix D**).

The section of Grange Moor Fault and Radar South backfill that will be exposed along the northern perimeter of the excavation area will represent the only means by which leachate can migrate onto the site, but the risk is considered to be low and the dilution rates will be high. There will be no risk of FMD re-infection for the reasons set out in **Tables 12**, **13** and **14**.

4.5.4 Sisters Waste Disposal Site

The same comments and conclusions can be drawn with regard to the former Sisters waste disposal site. The waste repository was formed in the final void of Sisters surface mine a short distance to the south-west of the FMD burial site (**Figure 4**). It was bounded to the north by backfill materials and to the south by in situ Coal Measures strata. Approximately 60,000m^3 of colliery spoil was taken from the former Stobswood Colliery pit heap and placed in the void prior to the deposition of waste materials. The deposit extended up to 23m above the excavation pavement, which had been formed on the floor of the Bottom Widdrington Fivequarter (Q210) seam, and left a void capacity of some 645,000m^3. The spoil was not compacted, but it was tipped and spread in layers prior to trafficking by heavy plant. Substantial self-weight compaction will have occurred following its placement and subsequent surcharging by the waste materials. An additional 95,000m^3 of colliery spoil was stockpiled and later used as daily cover.

Waste was first received in September 1982 and comprised a mixture of commercial, industrial, household and inert materials. The site was operated by Northumberland Waste Management Ltd. and later SITA plc. An impervious clay capping was placed over the top of the deposited waste and the site was closed in the late 1990’s. Measures were taken to drain landfill gases and a number of monitoring boreholes were drilled along the site perimeter. Additional investigations were carried out by British Coal as part of the Steadsburn surface mine development, but no evidence of leachate migration was found. This was reported at the time of the planning application (Scott Doherty Associates Ltd., 2005). Similarly, no evidence of contamination could be found in the water abstracted from the surface excavations or the abstraction well located at Stobswood. The colliery spoil must therefore be providing some measure of containment and any migrating pollutants are being diluted to safe or undetectable concentrations.

4.6 Groundwater Quality

The Environment Agency cannot provide any details of groundwater quality in the Highthorn area. There are, however, no records of any groundwater pollution incidents within the Envirocheck search areas (**Appendix A**).

No groundwater samples have been obtained from the glacial cover at Highthorn, but it is unlikely that any contaminants are present. This is because of the land use history (Section 1.4) and the fact that most of the deposits comprise glacial till of low conductivity. Experience gained at other development sites in Northumberland suggests that the pH levels will be neutral. Sulphate concentrations will be variable, but relatively low reflecting the mineralogy of the till.

A single groundwater sample was taken from the backfill in the western part of the former Radar South surface mine where the excavations were only extended to the Bottom Yard (G100) seam (**Table 15**). In common with other backfilled sites in Northumberland, weathering of the sulphide minerals has increased the concentration of dissolved iron and sulphate, but there is sufficient buffering capacity in the strata to neutralize any acidity. This minimizes the solubility of heavy metals.

Site	**Radar South**
Coaling Operations **Pavement Seam Name**	**1966-1971** **Bottom Yard (G100)**
Standpipe No. **Date**	**1674** **08/90**
pH	6.80
Suspended solids	ND
Total Dissolved Solids	860
Total Alkalinity	486
Alkalinity at pH 8.5	Nil
Total Hardness	555
Total Iron	**12**
Chloride	61
Sulphate	151
Calcium	132
Magnesium	**54**
Sodium	ND
Manganese	ND

All figures in mg/l except pH. ND – Not determined.
Values shown in bold exceed threshold levels for Drinking Water Standards.

Table 15 Analysis Result for Groundwater Sample taken from Surface Mine Backfill at Radar South Site

The groundwater in undisturbed bedrock is also known to be pH neutral and generally representative of the, '*shallow (sulphate) zone*', defined by Glover and Chamberlain (1976). The concentrations of iron and sulphate generally fall around those required for drinking water, but they are very elevated where mine workings are present. This is reflected in the quality of the water currently being measured at the Coal Authority's Lynemouth pumping station. The iron concentrations measure approximately 50 mg/l, most of which is being removed by simple aeration, precipitation and settlement in two settlement lagoons. The treated water is then discharged into the North Sea. The current Environment Agency permit allows for a maximum discharge flow of 165 l/s and an iron loading (i.e. flow x concentration) of 150 kg/day. This means that any increase the discharge flow, as would be required to create further drawdown, would have to be matched by a decrease in iron concentration. The pH of the mine water has remained at neutral levels.

The chloride concentrations in the mine water currently lie at around 6,000 mg/l and this may be the result of seawater ingress or inflows from halite bearing Permian strata far offshore, although similar concentrations were observed at Hauxley when pumping was being carried out by UK Coal Mining Ltd. (**Figure 4**). Here, the abstraction was very much confined to Coal Measures strata and mining subsidence had been observed along the foreshore.

In the early 1980's a number of groundwater samples were taken from exploratory boreholes located to the north of the Grange Moor Fault to investigate the possibility of sea water contamination due to long term drawdown. The results are presented in **Table 16** and confirm that there is no such contamination. The sodium and chloride concentrations are not in stoichiometric proportions and are most likely derived from clay minerals.

Borehole No.	Coordinates	Sodium (mg/l)	Chloride (mg/l)
1056	West 426611 595384	111	56
1059	427031 595269	112	68
1088	427089 595007	141	49
1214	427098 595568	89	132
1201	427180 595866	130	192
1069	427327 595357	108	60
1076	427371 595049	102	40
1229	427570 595383	186	190
1000	427754 595662	114	136
1092	East 427823 595213	146	228

Table 16 Recorded Sodium and Chloride Concentrations in Boreholes Located to the North of the Grange Moor Fault

5. LIKELY EFFECTS OF THE SURFACE MINE DEVELOPMENT AND MITIGATION MEASURES

5.1 Surface Water Resources

5.1.1 Temporary Changes in Catchment Areas and Surface Water Flows

The proposed development will not only affect the catchment of Hemscott Burn, but most of its present course will be removed as part of the surface mining process. There will be increased infiltration when unsaturated bedrock is exposed, but flows in its lower reach around Hemscott Hill Farm will be maintained by the discharge of treated water. It is planned to re-instate Hemscott Burn as part of the restoration to agriculture and areas of ecological interest. As the existing landform will be largely replicated, it follows that the catchment and greenfield runoff rates will be re-established. The ecological impacts of the proposed development are considered elsewhere in the Environmental Statement.

The very minor and temporary losses to the Druridge Pools and Cresswell Ponds catchments detailed in Section 3.2.5 and shown in **Figure 6** are unlikely to have an adverse impact on the hydrology and the level of water in the various wetland features.

5.1.2 Flood Risk

A Flood Risk Assessment has been carried out in accordance with the NPPF and NPPG document, *'Flood Risk & Coastal Change'* (Department for Communities and Local Government, 2012 and 2014) and a copy is provided in **Appendix E**. The main conclusions of the assessment are summarized below.

(i) By far the majority of the site, and in particular the proposed working area, lies in Flood Zone 1. There is presently negligible risk of flooding from streams or rivers. However, some parts of the site are flooded by surface water during prolonged wet weather and the eastern part of the site is subject to coastal flooding.

(ii) The surface excavations and the soil and overburden storage mounds have been designed to exclude those areas at risk of coastal flooding. Where this has not been possible because of other environmental considerations (i.e. essential visual and acoustic screening) any loss of storage capacity will be compensated by the excavations on the site. It will still be possible for marine flood water to flow up Hemscott Burn and into the working area. The risk and consequence of such flooding are accepted by the developer and will not impact adjacent properties.

(iii) There will be negligible risk of flooding by groundwater because it is planned to dewater the strata either by pumping at Lynemouth and/or at the site.

(iv) Surface runoff from the site will accumulate in the excavations, although some may also pond at ground surface, especially where the soils have been stripped. There is a risk that during extreme weather conditions the rate of surface runoff will exceed the capacity of the drainage channels and the pumps that are deployed. The excavations could then become partly inundated. However, the risk is fully accepted by the developer and will not have any impact outside the site.

(v) Discharges of treated water from the site will be controlled at or below greenfield rates and consequently there will be no increased risk of downstream flooding.

(vi) The land use and drainage of the restored site are such that the long-term runoff characteristics can be maintained at not greater than greenfield rates. Additional attenuation will be provided by creating a number of ponds.

(vii) There are no proposals for flood defences or mitigation measures that might increase flood risk elsewhere.

(viii) The site is relatively short lived (7 years) and the predicted long term effects of climate change during its operation and restoration will be minimal.

5.1.3 Surface Water Abstractions

There are no licensed or unlicensed surface water abstractions within at least 1km of the site.

5.1.4 Surface Water Quality

Cut-off ditches will be excavated to confine all surface runoff within the excavation and the soil and overburden storage areas. There will be no uncontrolled discharges from the site.

Compost like output (**CLO**) material will be imported to promote the establishment of vegetative cover on the overburden mounds. An appropriate licence will be sought from the Environment Agency. Measures will be taken to ensure that the material is of a consistently high quality, although it will contain minor quantities of glass and other contaminants. It will not be allowed to pollute the drainage and water management system on the site. The outer facing slopes of the overburden mounds have been designed not only to minimize visual impact and maintain stability, but also the likely effects of surface erosion. The outer surfaces will be trafficked by dozers and the slopes regularly monitored as part of the routine inspection scheme.

The discharge of treated water will require the consent of the Environment Agency and the LLFA in the form of an environmental permit. The LLFA will determine the discharge flow rate to ensure that there will be no increased risk of downstream flooding, whilst the Agency will define the quality of the treated water. This will ensure that there will be no adverse impact on the lower reach of Hemscott Burn and the two subsidence ponds near Hemscott Hill Farm.

If the groundwater levels in the mine workings are drawn down by pumping at Lynemouth, by far the majority of the water that will require treatment at Highthorn site will comprise surface runoff. The 1/15,000 scale Composite Working Method Plan (Dwg. No. HJB/BA795/PA06) shows the locations of the water treatment areas. If required, additional lagoon capacity can be provided on a temporary basis within the excavation area (i.e. on the advance) or on the newly backfilled workings. Treatment facilities can be constructed in the eastern part of the site in an area not at risk of coastal flooding should more substantial pumping be required to dewater the strata.

It is anticipated that the principal contaminant in the untreated water will be suspended solids and that this can be suitably remediated by simple settlement. The majority will be retained in temporary sumps formed within the excavations. Should further treatment be required to remove iron from mine water, this can be achieved by simple aeration, precipitation and settlement as is presently the case at the Coal Authority's Lynemouth pumping station. The water treatment lagoons will be regularly inspected in accordance with the Quarries Regulations (1999). This will ensure that immediate action is taken to maintain their stability, security and efficient operation. If it is required to use flocculants, their use and dosage rate will be first agreed with the Agency.

The operator will have in place emergency measures to deal with any spillages (e.g. the deployment of absorbent mats and booms). Fuel oil storage areas will be adequately bunded in accordance with Control of Pollution (Oil Storage) (England) Regulations 2001.

Upon restoration, the newly deposited soils may be less permeable than in their undisturbed state. The installation of a comprehensive under-drainage and surface water management system will therefore be given priority to prevent flooding within and beyond the site; to encourage soil structural development; and to ensure the successful establishment of agricultural, woodland and conservation after uses. The water treatment lagoons will be maintained until such time that the suitability of the restoration drainage has been proven and there is no risk of pollution from suspended solids.

5.2 Groundwater Resources

5.2.1 Effects of Drawdown

5.2.1.1 General

The groundwater has been drawn down in the Highthorn area for some considerable time and despite its recent recovery following the closure of Ellington Colliery, it still remains well below natural levels. These lie at and above sea level.

5.2.1.2 Surface Water Features, Natural Vegetation and Agricultural Yields

Because of the degree and extent of drawdown in the Highthorn area, the overlying superficial deposits are under-drained and have remained so for many years. This has not had an adverse impact on natural vegetation and agricultural production because of the very low conductivity of the predominant material: glacial till. Similarly, there has been no adverse impact on areas of ecological interest, in particular those supporting wetland features. Indeed, Cresswell Ponds SSSI has developed during the time the superficial cover has been under-drained and its integrity continues to be maintained by the very low conductivity of the till. The BGS archive borehole logs provided in **Appendix C** confirm the nature and thickness of the material in and around the main lagoon and along the course of Blakemoor Burn where other ponds have been created by mining subsidence (Section 3.2.2, **Figure 6**).

At the Druridge Pools site, it would appear that some of the wetland features are also perched on deposits of cohesive surface mine backfill formed during the final stages of the Radar North surface mine development in the 1970's. Consequently, there is no reason to assume that the hydrology will change if permission is granted to develop Highthorn site.

5.2.1.3 Groundwater Abstractions

There are no licensed or unlicensed groundwater abstractions within at least 1km of the proposed excavations.

5.2.1.4 Landfill Sites

Details of a number of former waste disposal sites in the Highthorn area are given in **Appendix A** and are summarized in **Table 11**. It is highly unlikely that any leachate will migrate from these sites into the proposed excavations for the following reasons:

(i) in the absence of any engineered containment, they are founded on glacial till of very low conductivity or, in the case of the Chibburn site, on partly cohesive surface mine backfill that can support perched groundwater;

(ii) groundwater levels in the underlying bedrock are already drawn down and provide an additional layer of unsaturated strata through which any leachate may be attenuated;

(iii) in the case of the Chibburn site, the wastes are located on strata to the north of the Grange Moor Fault that provides an additional constraint on groundwater flow;

(iv) some of the deposited wastes are inert and the total volumes are unlikely to give rise to substantial quantities of leachate; and

(v) all the landfill sites have been variously restored with clean cover or suitable capping and this will reduce surface water infiltration and leachate production.

In the unlikely event that any leachate should migrate into the groundwater, there will be significant dilution of any potentially harmful substances.

Further comment regarding the FMD burial site and the former Sisters waste disposal site at Widdrington is provided in Sections 4.5.2 and 4.5.3. To summarize and based on the information to hand, it is not thought that these sites are impacting Highthorn site and this situation will not change if it is developed as planned.

5.2.1.5 Mine Gas

Responsibility for the control of mine gas in the abandoned mine workings rests with the Coal Authority. However a mine gas risk assessment has been carried out for the site and the surrounding area (DAB Geotechnics Ltd., 2015b). Any reduction in groundwater levels to dewater the mine workings that have been recently inundated will expose the remaining coal and allow it to oxidize. However, this process is relatively slow and is unlikely to give rise to significant concentrations of mine gas. Furthermore, it is not expected that there will be any mass migration of gas from other areas of dewatered workings. Surface mining will remove some of the old workings and the potential for gas to form. This will minimize the impact of groundwater recovery upon completion of surface mining operations. Most of the properties in the Highthorn area are otherwise protected by the glacial cover upon which they are founded. If this was not the case, the impact of groundwater recovery following the closure of Ellington Colliery would have been more widely felt.

5.2.2 Impact of Surface Mine Backfill on Groundwater Quality

The weighted average ash and sulphur contents of the coal seams that will be recovered at Highthorn site are presented in **Table 16**.

Seam	Seam Code	Average Thickness (m)	Ash (wt %)	Sulphur (wt %)
Ashington	4D20	1.31	7.2	1.46
Diamond	E000	0.91	6.6	1.61
Top Main Top Leaf	F220	0.29	8.5	2.47
Top Main Bottom Leaf	F210	0.26	11.1	3.23
Top Yard Top Leaf (Top Ulgham)	G230	0.18	10.3	2.41
Top Yard Bottom Leaf	G210	0.32	6.6	2.03
Bottom Yard Top Leaf (G120)	G120	0.70	4.7	1.19
Bottom Yard Bottom Leaf (G110)	G110	0.26	6.7	1.53
		Weighted Average for site	7.2	1.82

Table 16 Details of Coal Quality at Highthorn Site

In Scotland, these results would ordinarily trigger the implementation of a backfill risk assessment in accordance with the procedure detailed in Younger and Sapsford (2004). This is because the sulphur content of some of the coal seams exceeds 1.5%. The assessment is based on the assumption that if the sulphur content of the coal seam is high, so too must be that of the roof strata unless chemical analysis can prove otherwise. It can only apply where mudstones are present because sandstones have a low sulphide content. The weighted average sulphur content for all the seams also provides a better indication as to the quality of the backfill because this generally comprises a mixture of all the strata.

There was very little marine influence during the deposition of the Coal Measures in Northumberland and the few marine bands that are recorded are very impoverished[*]. Consequently, there were only limited amounts of soluble sulphate available for sulphate reducing bacteria and hence little sulphide. The majority is concentrated within the coal seams. Furthermore, there are sufficient quantities of carbonate in the succession to provide adequate buffering. This explains why the mine water abstracted at Ellington Colliery has always remained pH neutral in common with all the other collieries in the Highthorn area. (It is also the case at the Coal Authority's Lynemouth pumping station.) Many of its workings were developed offshore in the Diamond (E000), Top Main (F200) and Yard (G200/G100) seams. Part or all of this succession is currently being excavated by UK Coal at its Potland Burn and Butterwell D. P. sites.

Weathering of the strata exposed at Highthorn site will be very limited because of the progressive manner of the excavation works and the continual backfilling of the exhausted void. The backfill slopes will be continually covered by freshly excavated overburden. A significant proportion will comprise glacial till. With regard to the overburden stored above ground, studies have shown that weathering of spoil is restricted to the outer few metres of a colliery tip, even where the material has been loosely deposited and left in an ungraded condition (Spears et al., 1970). The potential for any weathering and acidification of the stored overburden will therefore be extremely limited because the material will be deposited in layers and trafficked by earth moving plant. The outer slopes will be graded and seeded. Groundwater will not issue from the backfill after the site has been restored, even if further recovery is facilitated by the Coal Authority. Surface infiltration will be restricted following the placement of soils and the installation of an agricultural drainage system. Any elevation of the sulphate and iron concentrations in the groundwater is unlikely to be any more severe than in other sections of worked strata in the Northumberland Coalfield. It is therefore concluded that the backfill is unlikely to have an adverse impact on groundwater quality. A conceptual model for the site is presented as **Figure 15**.

[*]The Harvey Marine Band lies at a depth of about 90 to 100m below the Yard seam at Highthorn site. The overlying High Main Marine Band has been removed by erosion.

5.3 Coastal Erosion

The foredunes in Druridge Bay are already subject to undercutting and slumping during periods of adverse weather conditions when tidal levels reach or exceed 4m AOD. This regularly occurs in the winter months and during high spring tides. Sediment transport is directed towards the south by longshore drift and there are notable changes in upper beach levels throughout the year. This process exposes the underlying deposits of peat and glacial till as well as the World War II concrete defence structures. Cliff faces of 1 to 2m in height developed around Cresswell following the winter storms and surge tide of December 2013, but most of the coastal erosion has occurred around Hauxley at the northern end of Druridge Bay where an erosion rate of 0.4 to 0.5m per annum has been recorded. This compares with a rate of 0.1m per annum at Hemscott Hill Farm (Royal Haskoning DHV, 2013). The landward dunes are subject to blowouts and whilst most of the wind blown sand has been stabilized by vegetative cover, it is routinely over-grazed and poached by wintering domestic cattle and horses. The surface mine development will neither enhance nor prevent any of these processes.

It is proposed to discharge treated water into Hemscott Burn subject to the conditions of an Environment Agency permit. The discharge flows will be maintained at greenfield rates as indicated by the LLFA during a pre-planning consultation. (The LLFA will be consulted by the Agency as part of the permitting process.) Consequently, it is not expected that there will be excessive erosion along the outfall channel into the sea. In any event, the outfall has to be cleared on a regular basis to maintain adequate agricultural drainage. This is because of the natural accumulation of sand and the low surface gradients. It is anticipated that this process will have to be continued, possibly on a more frequent basis, during the operation of the site. It will not, however, have any effect on coastal erosion.

5.4 Mining Waste Directive, Stability of the Excavations and Overburden Materials

The implications of the Mining Waste Directive have been considered and reference has been made to the guidance notes provided by the Environment Agency. All the materials that will be placed above ground at the site will be required to backfill and restore the surface excavations and are therefore not considered to represent mining waste. None of the materials are contaminated. There are no plans to import or export waste materials. (The limited use of CLO material is discussed in Section 5.1.4).

The stability of the proposed storage mounds and backfill slopes has already been considered as part of the site design process and a geotechnical assessment report has been compiled in full compliance with the Quarries Regulations (1999) (DAB Geotechnics Ltd., 2015a). Stable overburden storage mounds can be constructed and the safety and security of adjacent properties can be maintained during the operation of the site. The overburden will be used to backfill the excavations in a progressive manner and will be confined by the excavated slopes.

It is not thought that the development will give rise to any renewed subsidence of the existing mine workings which might otherwise impact the surface drainage. Subsidence that arises from longwall mining is largely complete within 12 months of coal extraction, whilst it may remain incomplete where pillared workings are present. Some form of stability is established as the workings become choked with collapsed roof strata, but it is impossible to rule out further, time related subsidence. Whilst it is true that changes in groundwater level and pore pressure can de-stabilize coal pillars, those workings that are likely to be so affected by the surface mine development are confined largely within its boundary. The development of Highthorn site will not impact groundwater levels beneath Cresswell Ponds because the strata lie some considerable distance down dip. Upon completion of mining, the groundwater levels will be determined by the Coal Authority's pumping operations at Lynemouth. Any mining subsidence that might then arise will remain its responsibility.

The proposed surface excavations will remove vertical and lateral confining pressures and de-stress the bedrock strata and superficial cover. There will be further dilation of the natural joints and fractures in the bedrock and the fissures in the glacial till that will be exposed in the excavations. These changes will be almost imperceptible and pre-mining conditions will be largely restored as the excavations are backfilled in a continuous and systematic fashion. Furthermore, their lateral extent will be very limited; probably within a few metres of the excavation slopes. Consequently, it is highly unlikely that fissures will suddenly appear in the foundation of Cresswell Ponds SSSI.

5.5 Settlement of Surface Mine Backfill

The backfill materials at Highthorn site will be tipped, spread and trafficked by earthmoving plant, but it is not planned to undertake systematic compaction. Self-weight compaction and time related creep settlement will occur as the height of the fill is raised, the majority within 1 to 2 years of placement. Collapse settlement will also ensue due to the infiltration of surface water and a rise in groundwater levels following the completion of coal extraction. Further recovery may occur dependent on the Coal Authority's future pumping operations. Nevertheless, the total settlement is unlikely to exceed a few centimetres, most of which will occur at a very early stage, and the restoration drainage system will be designed with this in mind. Particular attention will be paid those areas overlying the excavation highwalls and internal excavation slopes where the differential settlement is likely to be greatest. Provision will also be made to cater for the possible increased levels of rainfall that might occur as a consequence of climate change.

6. SUMMARY

1. H. J. Banks Mining Ltd. has identified shallow coal reserves at its Highthorn site in Northumberland and intends to recover these by surface mining. The site will be worked in a progressive manner.

2. The site occupies an area of agricultural land located within the catchment of Hemscott Burn. This discharges into the North Sea near Hemscott Hill Farm. By far the majority of the site and the proposed working area lie in Flood Zone 1, but some of the land in the east is subject to coastal flooding. A flood risk assessment has been carried out in accordance with the NPPF and the NPPG document, *'Flood Risk & Coastal Change'*. It is concluded that the development will not increase the risk of flooding off-site.
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3. The proposed development will entail the temporary removal of the upper reaches of the Hemscott Burn, for which consent will be sought from the LLFA. The re-instated watercourse channel will be designed to have sufficient banks full capacity for not less than 1 in 100 year storm flows. Allowances will be made for the possible long term effects of climate change, although these will be minimal during the relatively short timescale of the development (7 years).

4. Measures will be taken to contain surface waters during the initial soil stripping phase of the development by forming cut-off ditches, where required, and by constructing a suitable treatment areas. These will comprise interconnected settlement lagoons with storm water capacity. Surface and groundwater will be abstracted from temporary sumps formed in the excavations and discharged through the treatment areas into the downstream reaches of Hemscott Burn which will be retained. Additional storm water capacity will be provided in the excavations. An environmental permit will be sought from the Environment Agency and it will determine the quality of the water. The discharge flows will be controlled at greenfield rates as determined by the LLFA, so that the risk of downstream flooding is not increased. Any loss of supply to Hemscott Burn as a consequence of the temporary changes in its catchment will be compensated by the discharge.

5. The surface excavations will be backfilled in a progressive manner and the existing landform will be largely replicated. The site will be restored to agriculture, together with areas of woodland and ecological interest. Greenfield runoff rates will be re-established and additional attenuation will be provided. There will be no increased risk of downstream flooding.

6. A number of borehole monitoring stations have been established on Highthorn site. These show that groundwater levels in the bedrock are drawn down due to historic pumping at Ellington Colliery, but that limited recovery has occurred since its closure. Some of the workings in the proposed excavations are already inundated and dewatering will be required. This can best be achieved by reducing the groundwater levels at Lynemouth Colliery where the Coal Authority has recently commenced pumping operations as part of its programme of groundwater management in the Northumberland Coalfield. If this is not possible, localized dewatering will be carried out at Highthorn site.

7. There are no known licensed or unlicensed groundwater abstractions within at least 1km of the proposed excavations. Consequently, there will be no derogation of supply.

8. The abstraction of groundwater at the site will not have an adverse effect on natural vegetation or crop yields around the site because the superficial cover is already under-drained. The majority of the superficial deposits comprise glacial till of very low conductivity and storage. Consequently, there will be no derogation of surface water supplies or any adverse impact on areas of ecological interest such as Cresswell Ponds SSSI.

9. A number of landfill sites and waste management facilities have been identified in the Highthorn area, but the risk of leachate migration onto the site is considered to be low or very low and any consequences minimal because of the likely levels of dilution. The Hemscott Hill FMD pyre site does not represent a risk to the proposed development.

10. The drawdown that will be required to facilitate the recovery of the shallow coal reserves will be temporary. The level to which they recover will be determined by the Coal Authority and the measures it is taking to manage the groundwater in the Northumberland Coalfield.

11. The backfill will settle and further settlement may occur as a consequence of any long term recovery in groundwater levels, but the restoration drainage will be designed with this in mind. Allowances will also be made for the possible effects of climate change.

12. Drawdown and recovery will impact the mine gas regime. The impact that will arise as a consequence of the proposed development is considered in a separate report (DAB Geotechnics Ltd., 2015b), whilst that presently affecting a much wider area of the Northumberland Coalfield will remain the responsibility of the Coal Authority.

13. All the overburden and soils on the site will be required to backfill the excavations and carry out the proposed restoration works. They will not represent mine wastes. The backfill will be contained by the excavated slopes. A geotechnical assessment has been carried out in accordance with the legislation (DAB Geotechnics Ltd., 2015a).

14. The operator, H. J. Banks & Co. Ltd., will implement a strict environmental management system throughout the life of the site to ensure that surface and groundwater resources are properly protected. It is also intended to fully comply with any future legislation.

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