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Survey of Broad Haven Primary School and adjacent land, Haverfordwest, Pembrokeshire, Wales

Geology and Landscape Wales, & Shallow Geohazards & Risks Programmes

Open Report OR/08/063

BRITISH GEOLOGICAL SURVEY

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Survey of Broad Haven Primary School and adjacent land, Haverfordwest, Pembrokeshire, Wales

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National Grid Reference

SW corner 186200,213200
Centre point 186400,213400
NE corner 186700,213600

Map

Sheet 227, 1:50 000 scale, Milford

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Foreword

This report is the published product of a study made by the British Geological Survey (BGS) in response to a public concern regarding geohazards affecting Broad Haven Primary School, Broad Haven, Haverfordwest, Pembrokeshire. BGS Enquiry IDA 165862.

Acknowledgements

The authors would like to thank Mr & Mrs A Clark (Field Landowner) for reporting their concerns to the British Geological Survey and for their assistance in the field. Thanks also to Mr S L Thomas (Headmaster, Broad Haven Primary School) for his assistance.

Summary

A survey of Broad Haven Primary School was made by BGS in response to concerns of public safety following recent flooding at the school during September 2008. The survey found evidence for severe soil erosion on the field above the school and deposition of that sediment on the school grounds. The survey did not find substantial volumes of coal waste in the field immediately east of the school, nor did it find any evidence for slope instability in the field above the school. The desk study, undertaken before the site walkover, did however yield information suggesting there is a history of underground coal mining within the area. The actual extent of historic mine workings under the hillside, above the school, remains generally unknown. Furthermore the influence of mine drainage on local groundwater conditions and the potential contribution of mine water to the flood hazard are unclear due to a current lack of information on the extent of workings. It is recommended that improved surface water management of the field and school site is required to mitigate the existing flood hazard. Additional mine-related hazards have also been identified. Any future development or engineering activity affecting the slope should take into consideration the potential impacts on slope stability. Further specialist investigation may be required to better understand the extent of historic mine workings, and thus the potential mine related hazards in the vicinity of the school.

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FIGURES

Introduction

1.1 BGS ENQUIRY

An enquiry (NGRC Ref - IDA 165862) by Mr A. Clark, a farmer of Haverfordwest, highlighted a potentially serious problem regarding drainage and ground stability in an area bordering the village of Broad Haven on the south Pembrokeshire coast. His enquiry concerned the possibility of old mine-workings in an area of land that he farmed adjacent to Broad Haven Primary School, where there had been problems with flooding after several periods of heavy rainfall during the wet summer and autumn of 2008. The headmaster of the school had voiced concerns over the safety of the site after one incident in September 2008, in which considerable amounts of silt and sand had been washed from Mr Clark's field into the school precinct and the car park of the nearby Royal Hotel; culverts were blocked by sediment and ponding of floodwater occurred within the school grounds. During a site visit by Dr J.R. Davies of the British Geological Survey (BGS) on 11th October, it was noted that there was continuing substantial run-off from the adjacent field into the school site. Remedial measures by the Local Authority had involved construction of a shallow ditch to carry the surface water southwards from the bottom of the field to the nearby watercourse, but this appeared to be of only limited efficiency.

The school lies in the floor of a shallow valley (Fig 1A), down-slope and immediately west of the field from which run-off occurred. Although the school grounds have been partially landscaped, it is evident that the field boundary marks the former course of a stream which has been diverted to the western side of the valley where it now runs in a culvert to the sea. A stone wall, which separates the school grounds from adjoining properties at the lower (northern) end of the site, appears to have impounded the surface water (Fig 2), thereby compounding the drainage problem. Run-off may have also been directed towards the school site by recent ploughing of the field in a down-slope direction (Fig 3).

1.2 BACKGROUND TO SURVEY

In view of the sensitive nature of the enquiry, in an area historically mined for coal with the attendant risk of ground instability from workings and spoil, the BGS undertook a geological survey of the site. The survey involved an inspection of geological maps (Fig 1B) and historical records held by BGS, together with a walk-over of the site on 15th October 2008 to determine the nature of the surface deposits and identify any potential geological hazards. Although surface run-off had ceased at this time, there were still pockets of standing water and the ground was noticeably wet in places, particularly towards the southern side of the field (Fig 3); in this area also, runnels were generally deeper and more numerous, suggesting that overland flow and associated soil erosion had been particularly vigorous hereabouts.

2 Bedrock and Superficial Deposits

2.1 BEDROCK

The town of Broad Haven lies within the western part of the Pembrokeshire Coalfield, a geologically complex region of folded and faulted coal measures, comprising interbedded mudstones, sandstones, seatearths (fireclays) and coal seams. Much of the material at surface in the field east of the school comprises a firm to stiff sandy silt and sandy clay, with abundant angular clasts of brown sandstone, grey, shaly mudstone and fragments of coal, representing the weathered, largely *in situ* bedrock (regolith) of the Carboniferous Coal Measures that crop out over the Broad Haven area. The regolith (weathered bedrock) may be up to 1m thick in places, but is generally impenetrable by hand augering below 0.5m.

2.2 SUPERFICIAL DEPOSITS

Bedrock is overlain locally by a thin Quaternary glacial deposit (till), probably nowhere more than 1m thick, comprising a silty to sandy clay containing rounded pebbles and small fragments of acid and basic igneous rock, limestone, chert, quartz, and reddened sandstone, as well as clasts of local coal measure sandstone and mudstone. In places, particularly in the upper part of the field, there are small areas of dark grey soil with an abundance of dark grey mudstone clasts that represent the remains of spoil from coal workings or material dug during the construction of mine shafts (see Coal Mining History below).

The school is situated on a flat-lying field that may represent an area of accumulated hill wash (colluvium), or sediment deposited in a narrow alluvial floodplain by the stream which formerly flowed through the grounds; most of this area has been subsequently landscaped and built upon.

3 Coal Mining History

3.1 BACKGROUND

Mining within the Pembrokeshire Coalfield appears to have reached its zenith in the latter half of the 18th Century, from when it rapidly declined. As a result, sources of information are lacking for large parts of the coalfield, and the relationships between coal seams within different areas are not fully understood. Much of the coal was worked in a piecemeal manner from opencast pockets ('slashes' or 'slatches') as, and when, they were discovered, although underground working also took place.

In the Broad Haven area, both methods were in operation at various times. Large opencast workings for 'Culm' (crushed and tectonised coal) took place in the valley immediately north of the Royal Hotel, whereas to the east and south-east, coal was worked at depth from a number of mine shafts (Fig 1A & B). In this area, which extends as far as Broadway, coal was worked from at least three closely-spaced seams; these are, in descending order, the Foxhill, Migrement and Coal veins. The seams were exploited over a wide area, and, as a result, were considered to be uneconomic when investigated for their opencast resource potential in the late 1940's. Figure 4 presents a schematic cross-section to illustrate the general distribution of geological units and mine related features across the site.

3.2 MINE WORKINGS

The mines east of Broad Haven were drained by a 'level' shown in Figure 1B which was driven from a point [^{1}86336, ^{2}13333] within Mr Clark's field eastwards towards Foxhill Farm [^{1}87258, ^{2}13075] and then north-eastwards towards Broadway. Figure 1A shows the estimated position of the level and shafts highlighted on the 1907 geological map (shown in Fig 1B), these have been reproduced on the current 1:10,000 OS map for clarity. At depth, in the upper part of the field, the level intersects the Foxhill Vein. At the time of the last geological survey (1907) the mouth of the level was open, draining westwards into the stream via a shallow culvert. A number of shafts are situated along the line of the level, and at least four of these are shown on the 1907 geological map (Fig 1B) within Mr Clark's field [^{1}86391,^{2}13365], [^{1}86459,^{2}13354], [^{1}86550,^{2}13339], [^{1}86594,^{2}13332]. The two westernmost airshafts are shown as dashed circular features on the 1889 OS map (the base map for the 1907 geological survey, Fig 1B), and it is possible that these had collapsed or were partially filled by this time. The map also shows two further mineshafts in the upper part of the field, close to its south eastern boundary [^{1}86625,^{2}13316], [^{1}86642,^{2}13336] and more occur nearby within adjacent fields. Small areas of spoil that previously surrounded these features are also shown on the geological map (Fig 4). They are now recognisable by areas of dark soil within the upper part of the field. An area of tipped and partially re-excavated material at [^{1}86613, ^{2}13315] may represent the remains of one of the spoil heaps. The survey of 1907 also shows a 'hole', which was probably a 'crown hole' (a circular depression caused by collapse above a void) in the upper part of the field at [^{1}86538, ^{2}13385]. However, none of the features identified on the geological map (drainage level, shafts or crown hole) are visible at surface at present, and it is likely that they have been filled in and ploughed over.

4 Drainage

4.1 SURFACE DRAINAGE

The stream which flows north westwards through Broad Haven to the sea has been diverted at the southern end of the school site to run in a culvert on the western side of the valley, immediately below the Baptist Chapel. Its original course, along the lowest level of the valley, appears to have been through the school grounds and car park of the Royal Hotel, generally following the field boundary to the cottages at the northern end of the site. Diversion of the stream was probably undertaken in the 19th Century or even earlier, when it was incorporated into the scheme to drain the mines to the east. The reasons for the diversion are not known; presumably it was to avoid flooding that would inevitably occur within the Culm Pits immediately north of the site, due to the substantially increased discharge from the mines. The drainage level in Mr Clark's field was connected to the diverted stream by a short culvert of which there is now no trace; however, it was clearly in existence at the time of the 1907 geological survey when a record of 'red water issuing from level' was made (Fig 1B and Fig 2).

4.2 FLOODING AT BROAD HAVEN PRIMARY SCHOOL

The flooding within the school precinct (Fig 2) is considered to have resulted from severe rainfall onto ground already saturated during a prolonged period of wet weather. In these circumstances, groundwater levels would be generally high and the infiltration capacity of the soil was consequently limited. Overland flow and interflow conditions (lateral movement of water through the soil zone) probably occurred (Fig 4). The run-off inevitably found its way to the lowest point within the valley, i.e. along the former stream course within the school grounds. The location of the school, on deposits of colluvium and/or alluvium in the bottom of the valley (Fig 4), is in an area where a naturally high water table level would be anticipated, even in periods of dryer weather. The combination of geographical and geological conditions makes the primary school susceptible to flooding, particularly over the wetter winter months.

4.3 SOIL EROSION

The walk-over survey noted that the field had been recently ploughed in a down slope direction (Fig 3). The ploughing and tyre tracks created artificial gullies along which rain water run-off was preferentially diverted, scouring out rivulets and exacerbating soil erosion. The absence of vegetative cover resulted in the erosion of large quantities of silt and sand from the field. The accumulated sediment blocked drainage inlets, and filled hollows, thereby adding to the severity of flooding.

4.4 MINE-WATER DRAINAGE

A significant question is the degree to which water, leaching from flooded mine workings, contributed to the high water table and levels of saturation in the soil. The deeper runnels and relatively wetter southern part of the field suggests that saturation and concomitant run-off may have been enhanced by water emanating from the level and shafts. However, on the day of the inspection there was no obvious discharge from these features. A phenomenon such as this is difficult to assess without knowledge of the extent to which the old mine workings in the vicinity remain open.

5 Ground Instability

The walk-over survey also sought to identify any potential hazards relating to ground instability in the field east of the school. The sloping field is underlain by bedrock of generally low permeability, at a relatively shallow depth, under a thin cover of glacial till and/or regolith. The soils are generally coarse grained (sandy) and are reasonably free draining. Although the surface of the field undulates along its length, slope angles are generally low (10° or less).

5.1 FINDINGS

There was no visual evidence of any recent ground displacement (e.g. tension cracks, ground deformation) that might indicate a previous or imminent mass movement event. The walk-over survey also found no evidence of any substantial accumulation of colliery waste on the field above the school.

5.2 MINING RELATED GROUND HAZARDS

It is unknown whether any further collapse of the shafts could have a direct influence on ground stability in the vicinity of the school. The contribution of mine drainage on local groundwater conditions and the severity of flooding, is unclear.

Several mine-related hazards were identified by the survey. One is the possibility of mine shaft collapse, which could lead to the migration of a void to the surface, or subsidence where the material filling the shaft was loaded, for example by heavy farm machinery. An additional hazard is that of mine water discharge through the adit (Fig 4), especially if water had backed up in the level or workings; in extreme circumstances, this could cause an outburst. The potential for such mining hazards to exist warrants further investigation. The use of non-intrusive ground investigation techniques (e.g. shallow geophysics) could be used to locate shallow subsurface voids, and may be used to map the extent of any mine workings.

6 Conclusions and Recommendations

1. The flooding at Broad Haven Primary School during September 2008 appears to have resulted from a period of prolonged heavy rainfall when the soil was saturated, and the infiltration capacity of the soil was exceeded by the rate of rainfall.

2. The high rainfall, overland flow conditions and lack of vegetation on the field resulted in rapid soil erosion that transported large amounts of silt and sand down slope. There is no drainage provision or barrier to water between the school grounds and the field, and little vegetation to intercept sediment at the base of the field. Therefore, water and sediment entered the school grounds directly.

3. The school grounds lie along the old course of a stream into which surface run-off is preferentially directed. The water table is expected to be naturally high in this area, and would restrict the natural drainage. The solid, generally impermeable (mortar) walls at the northern and western school boundaries create an artificial bund that further impound surface water.

4. The school site is susceptible to flood hazards. Flooding is likely to be a recurring problem on the site if no action is taken to improve the current drainage provision within and outside the school. A vegetative cover on the field would reduce soil erosion during periods of high rainfall. Improved interception of sediment could be achieved by improving vegetation cover at the boundary between the field and school grounds.

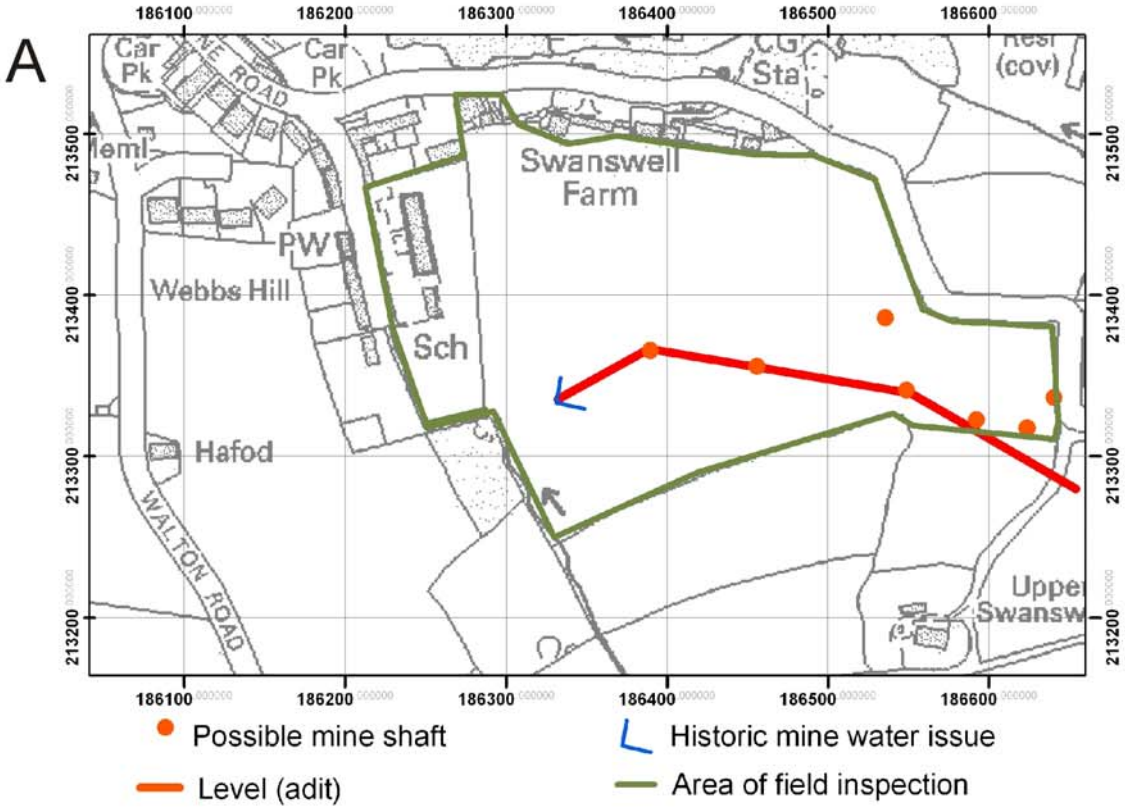
5. Any future engineering activities (e.g. deep excavation) which interact with the slope should consider the potential impact on local slope stability, and well as the hydrogeological context of the site as a whole.

6. The state of the mine entrances presents a separate, but linked problem. An outburst from the adit might carry substantial quantities of water and debris down the valley into the school grounds. The possibility of a mine shaft collapse causing subsidence on the field is an additional identified hazard. The likelihood of these hazards occurring (hazard susceptibility) can not be assessed due the lack of information currently available about the state of the mine workings. In order to understand the potential geohazards it is necessary to determine whether voids are present at depth beneath the hill and, if present, whether such voids are water-filled. The BGS can advise on novel ground investigation techniques to efficiently locate and better characterise subsurface voids (e.g. mine shafts).

7 Reference

Cantrill, T.C., Dixon, E.E.L., Thomas, H.H. and Jones, O.T. 1916. *The geology of the south Wales coalfield. Part XII, The country around Milford.* Memoir of the Geological Survey of Great Britain. Sheet 227 England and Wales. 185pp.

8 Figures



Extract of 1907 field slip mapped by O.T Jones.

Figure 1. (A) Current 1:10 000 scale Ordnance Survey map with the location of the mine level and shafts shown on the 1907 geological map. (B) Extract from the 1907 geological map (field slip) made by O.T. Jones, marking 'red water issue from mine', 'level cuts Fox v. (vein) hereabouts', and several air shafts and mine shafts.

Figure 2. Photograph of the northern boundary of the school field with free-standing water after a high rainfall event. Taken 11th October by Dr J R Davies, looking northeast from [BNG ^{1}86248, ^{2}13865].

Figure 3. Photograph of field east of school showing sediment accumulation at base of the field, and rivulets formed on the slope, locally cutting depressions made by tractor tyres. Taken on 10th October by Dr J.R. Davies, looking east from [BNG ^{1}86287, ^{2}13414].

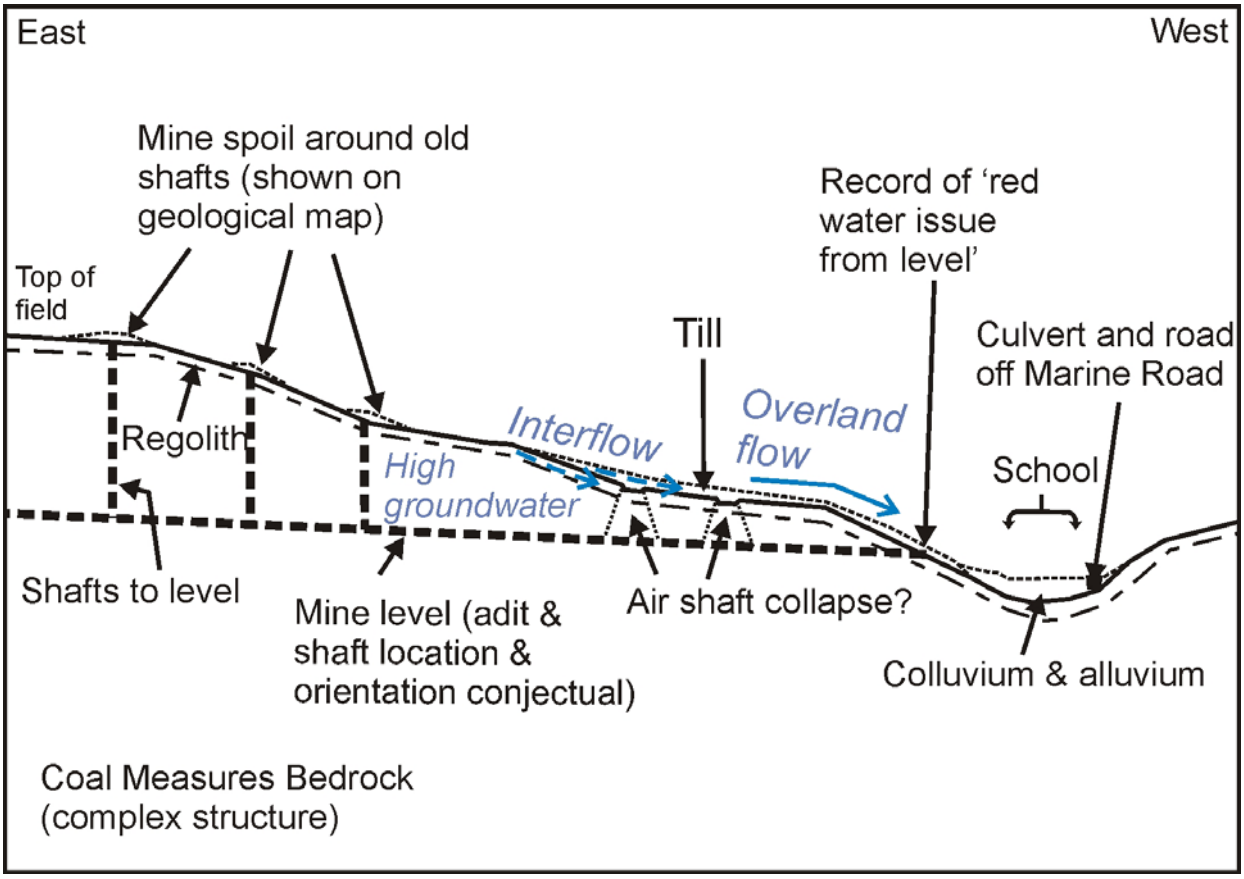


Figure 4. Schematic cross-section through the survey area showing the general relationships between slope morphology, geological units, water conditions and mine features. Not to scale, for illustrative purposes only.