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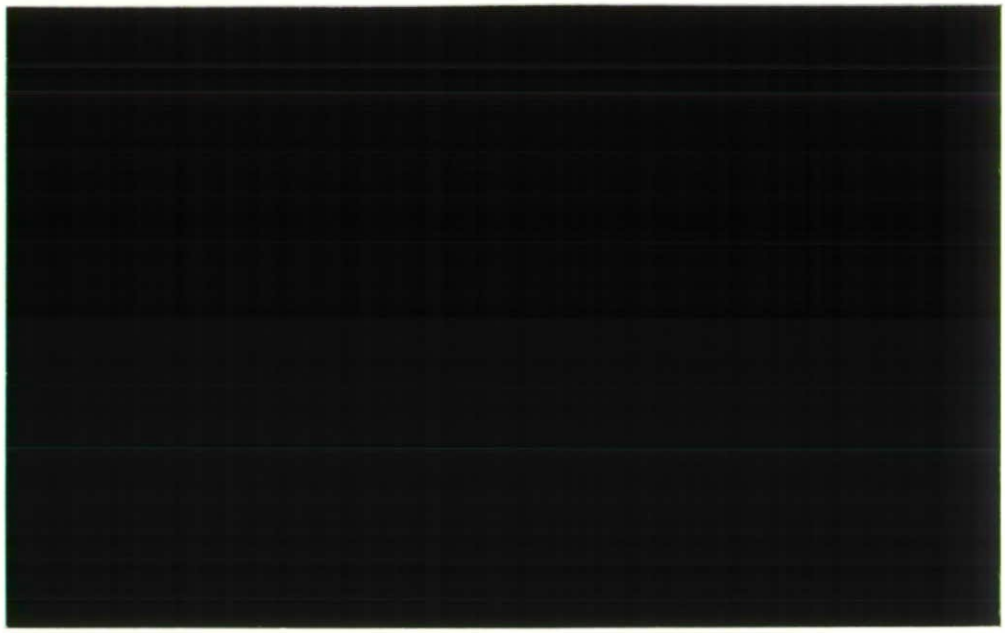

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Terrestrial and Freshwater Sciences

ANALYSIS OF HYDROGEOLOGICAL EVIDENCE RELATING TO PROPOSED SAND AND GRAVEL EXTRACTION NEAR VICARAGE MOSS SSSI, WREXHAM

Report to Countryside Council For Wales

CCW Contract Report No. 45

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Background

Vicarage Moss (SJ 359541) is a basin mire located in a kettle-hole on the Wrexham Delta Terrace. The exceptionally deep sand and gravel deposits of the Terrace have been heavily exploited for aggregate in recent years, and proposals for mineral extraction have now approached close to the southern boundary of the SSSI, with a proposal from Bodfari Quarries Ltd to extract sand and gravel from the Holt Estate.

Concern over possible interference with the water table in the gravels, and hence with the hydrology of Vicarage Moss, has led to hydrogeological studies which have indicated that the Moss is hydraulically isolated from the main groundwater body in the gravels, and should not suffer any effects as long as its surface water catchment is undisturbed. The Institute of Hydrology was commissioned to re-examine and comment on the data and conclusions contained in the two hydrogeological reports.

Hydrogeology

The 1:50000 geological map (Sheet 121 Wrexham - Solid) records that Vicarage Moss lies over the boundary between the Erbistock Beds of the Upper Coal Measures to the west, and the Lower Mottled Sandstone of the Bunter group to the east. The area of most interest, to the south and south-west of the Moss, is mapped as boulder clay up to about 400 m from the edge of the mire, with glacial sands and gravels beyond.

The hydrogeological investigations (Aspinwalls 1991 & 1994) describe a more complex system, in which there are lenses of gravel and clay, two boulder clay layers and a tendency for the gravel to become more silty with depth. The topographic complexity of the natural ground surface, with its groups of elliptical kettle-holes, some containing mires or open water bodies, is therefore matched by a below-ground complexity which has important implications for the movement and levels of groundwater.

Drilling of exploratory boreholes on the Holt Estate has been carried out in three phases:

1. six out of ten boreholes (CI01 - CI10) drilled for stratigraphic purposes in August 1989 were screened, but no water was observed on drilling or since. Subsequent water level measurements demonstrate that these boreholes were screened up to 26 m above the water table.

2. four boreholes (CI11 - CI14) were drilled in November 1990, and these were used to prepare a water table map (Figure 8 of Aspinwalls 1991) which suggested a very steep south-north hydraulic gradient, levelling out towards Vicarage Moss at about 20 m below the water level in the Moss and 30 m below the level of the ponds adjacent to the woodland Vicarage Gorse.

3. nine more boreholes (EA15 - EA23) drilled in June 1994, together with CI11-14, formed the basis of a new water table map (Figure 2 of Aspinwalls 1994). Largely as a result of the infilling of the sparse network of four boreholes, and especially by the addition of borehole EA15, the steep hydraulic gradient has changed to southwest-northeast, but the overall form of the water table is similar to that shown by the earlier map. For the four boreholes that have been monitored at monthly intervals, there have been small changes in water level that hardly change the form of the

groundwater contours - between December 1990 and November 1994, the most westerly borehole (CI11) has fluctuated over a range of 0.84 m, while the eastern boreholes have shown rather greater ranges of 1.20 m (CI12), 1.23 m (CI13) and 2.14 m (CI14).

The addition of borehole EA15 has made a significant change to the water table map in the western area of the site. To illustrate the development of the water table over the period from December 1990, four water table maps have been prepared using the Origin plotting package, for water level data collected on 21 December 1990, 12 August 1993, 24 June 1994 and 18 November 1994 (Figures 1 to 4). Apart from the changes to the map resulting from the inclusion of the new boreholes, there are no significant variations in the directions of flow or the overall form of the water table.

The water table map confirms that groundwater flow is from south to north below the Moss, and that the Moss is perched about 20 m above the main groundwater table. The shallow ponds near Vicarage Gorse are around 30 m above the water table, but other open water bodies, notably Tommy's Wood and Coed yr Bychan Pools, are close to the water table and presumably in hydraulic connection with the groundwater body.

Without further information it is impossible to come to a firm conclusion about the cause of the irregularity of the water table surface, especially the sudden change in hydraulic gradient. Only one borehole, EA17, records a water level that is definitely anomalous - other water levels measured in this area (including the dry well CI01 which is screened from 61.1 mOD upwards) are consistent with a west-east gradient, with the hint of a plateau resulting perhaps from a locally increased transmissivity. The water table map could be altered in detail if one or more boreholes were added to the network, but radical explanations such as the perching of the groundwater body west of borehole CI12 are not consistent with the stratigraphic information, and can be considered unlikely. The more plausible explanation, advanced by Aspinwalls (1994), is that there are variations in the saturated depth of the gravel aquifer and in its particle size distribution, sufficient to require dramatic changes in the hydraulic gradient necessary to drive flow across the Terrace.

The fluctuations in the water level of the Vicarage Gorse pools, recorded in Figure 5 of Aspinwalls (1994) can be accounted for by seasonal drawdown due to evapotranspiration superposed on the effects of a dry summer in 1991 and a dry winter in 1991/2. There is no overall trend in the water level in the pools.

Groundwater level fluctuations (Figures 7 & 8 of Aspinwalls 1994) are less easy to explain: there is a clear declining trend in the more easterly boreholes (CI12 - CI14) which is not reflected in borehole CI11. Short-term variations in the level of boreholes CI13 and CI14 in summer 1991 are consistent with increased groundwater abstractions, possibly from farm boreholes immediately to the east of the site during this dry summer, but the overall trend suggests long-term over-exploitation of the aquifer.

Impact of development of surrounding land

The hydrogeological work clearly indicates that Vicarage Moss is perched above the general level of the major water table in the gravels. If the hollow occupied by the Moss were sufficiently deep to be initially in hydraulic connection with the groundwater body, either as a water table lake or a recharge area, erosion and deposition of boulder clay fines by surface

runoff from the slopes of the topographic catchment would rapidly build up a seal of silt on the floor of the hollow, enabling the water level in the hollow to rise above the water table. Recharge to the groundwater body would then take place by infiltration through the lake bottom and by overspill from the lake basin above the seal (Reynolds 1979, p111). As a rise in water level would bring into play a larger area of thinner, more permeable deposits for recharge, the water level in the resulting lake would be controlled by a dynamic balance between inputs and outputs, with an annual range that depended largely upon seasonal imbalances between rainfall and evaporation. It is likely that mire development started from the margin of an open water body, and that there are large vertical gradients of major ion composition within the peat resulting from lateral inputs from the slopes underlying the oligotrophic waters of the mire expanse. The water level of the mire, and therefore the balance between the oligotrophic waters and the more mineral-rich surface runoff-derived waters, therefore depends upon the maintenance of a reliable supply of water from the topographic catchment.

The conclusion drawn by Aspinwalls (1994) is that the perching of Vicarage Moss and the group of pools to the south is sufficient to prevent any impact of mineral working. They also suggest limiting the depth of extraction so as to prevent interference with the hydrology of pools that are more intimately connected with the groundwater body.

The safeguards proposed by Aspinwalls are based on a consistent and reasonable interpretation of the available hydrogeological data. Groundwater supply to the Moss from the minor perched aquifer surrounding probably has its source in the topographic catchment, which is outlined on Figure 2 of the Aspinwalls (1991) report. Provided that this catchment is preserved as a source of both groundwater and surface water, there will be no effect on the water budget of the Moss.

References

Aspinwall & Co. (1991) Hydrogeological survey - Borras Smallholdings, Report to Clwyd County Council.

Aspinwall & Co. (1994) Hydrogeological assessment of the Holt Estate, Wrexham, Report to Bodfari (Quarries) Ltd.

Reynolds, C.S. (1979) The limnology of the eutrophic meres of the Shropshire-Cheshire plain, *Field Studies 5(1)*, 93-173.

Figures

Figure 1 - Water level map 21 Dec 1990

Figure 2 - Water level map 12 Aug 1993

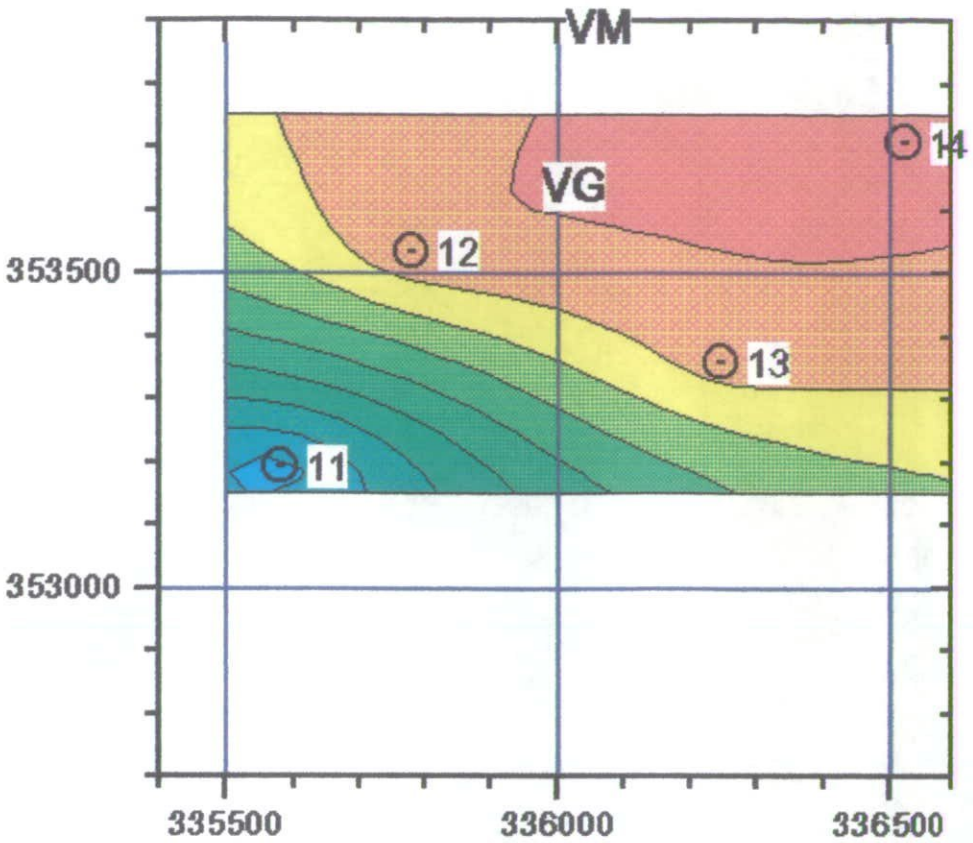
Figure 3 - Water level map 24 June 1994

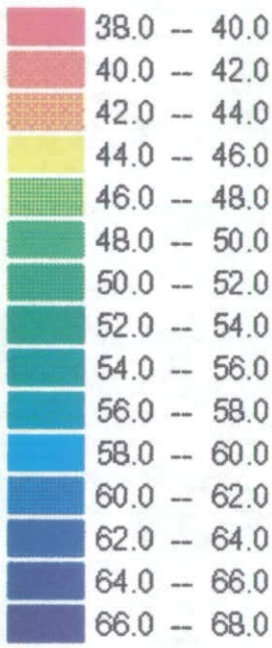
Figure 4 - Water level map 18 Nov 1994

Figures 1 to 4 were prepared using the Origin graphics package, and so represent objective (but hydrogeologically uninformed) contour maps from the water level data. On each figure the approximate positions of Vicarage Moss and the Vicarage Gorse pools are plotted as

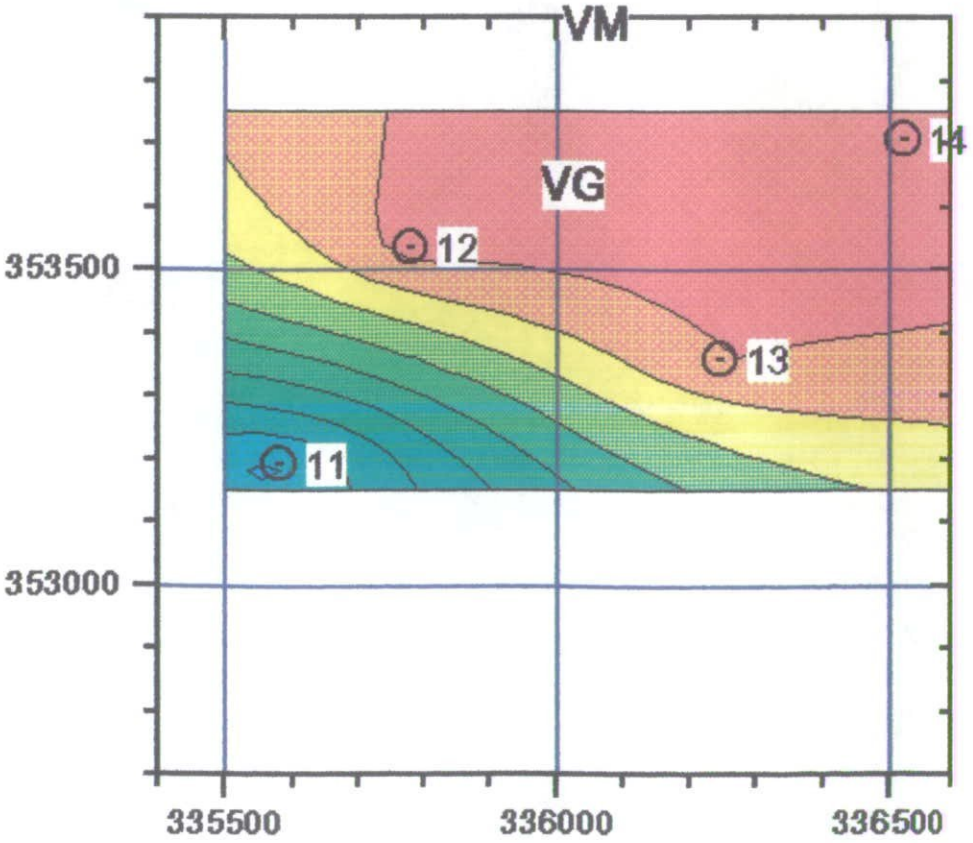
"VM" and "VG" respectively. Note the declining trend in levels in the eastern area, which is shown particularly by the change in position of the light red (40 to 42 mOD) contour band. The change in the contour pattern resulting largely from the inclusion of borehole EA15, shown up clearly by the movement of the yellow (44 to 46 mOD) contour band, is confirmed by the final map (Figure 4) which also takes account of borehole EA19.

21 December 1990

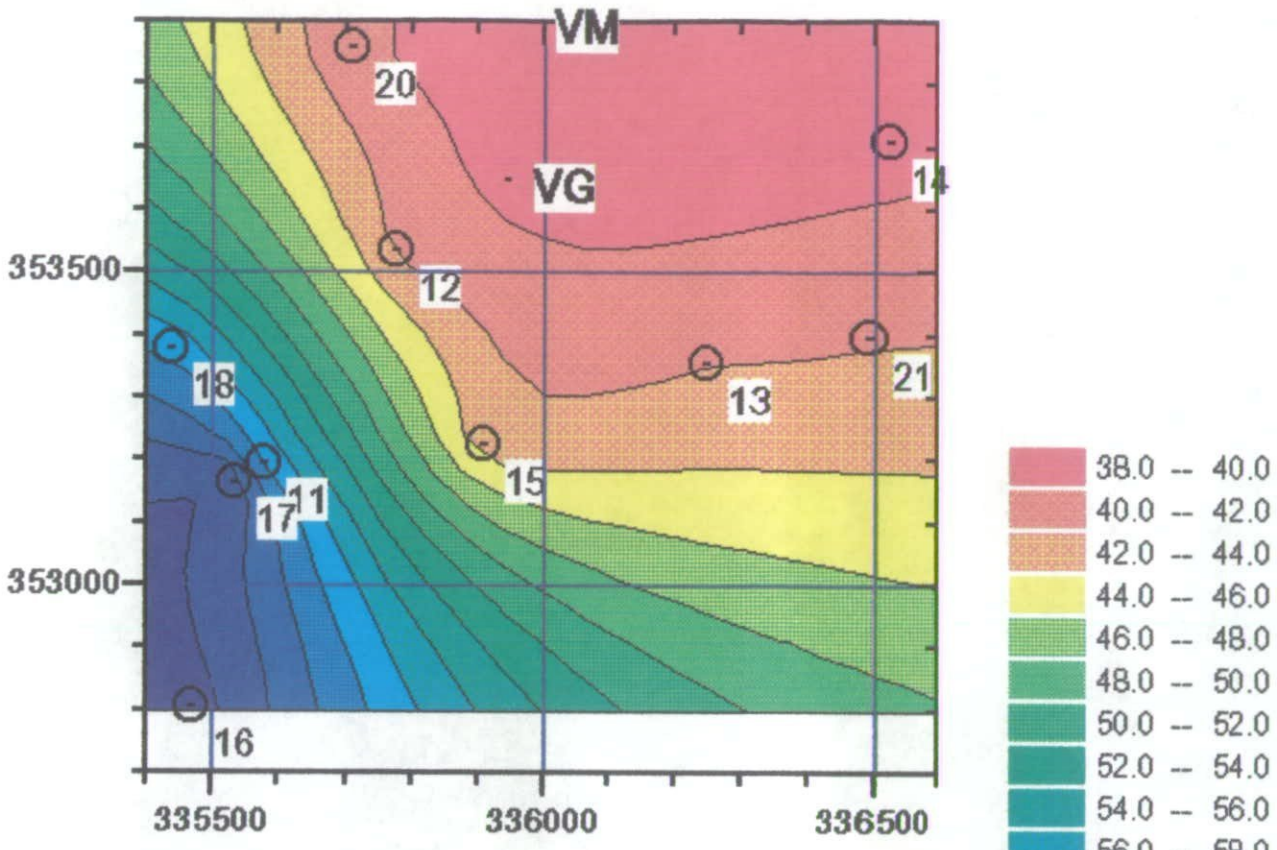




12 August 1993



24 June 1994



18 November 1994