1. Introduction

Problems arise from surcharging of sewers in the Barnham area in most wet winters. This generally commences after a long period of high rainfall and continues for several weeks thereafter. Surcharging does not occur as a result of heavy summer rainfall. It would therefore appear to be related to infiltration of groundwater under high water table conditions; but may be exacerbated by inundation resulting from poor land drainage and use of soakaways, and by high sewage flow rates.

The aim of this short report is to outline the geology and hydrogeology of the area, and to examine potential causes of surcharging, in particular the relationship to groundwater levels in the Chalk aquifer. Ideally recommendations will be made regarding monitoring of groundwater levels that could allow prediction of the onset of surcharging.

2. Geology

Barnham lies over the Chichester Syncline. The geology consists of London Clay overlain by a complex and variable series of superficial deposits, including alluvium, brickearth, head gravels and raised beach deposits. A typical progression might be of 1 to 3 metres of brickearth (silt) underlain by 3 to 5 metres of raised beach deposits (sands and gravels), in turn underlain by the London Clay. Some alluvial deposits are present along the minor watercourses (headwaters of the Lidsey Rife). The Chalk is present beneath the London Clay.

Excerpts from the relevant 1 to 50,000 geological map is presented as Figure 1. A schematic cross section is also included as Figure 2.

3. General Hydrogeology

The groundwater flow regime in the area is indicated schematically on Figure 3. The superficial deposits form a minor aquifer, hydraulically isolated from the Chalk by the London Clay. Both are recharged by precipitation: falling on the South Downs in the case of the Chalk, and by local rainfall in the case of the superficial deposits. In addition there may be some overflow of groundwater from the Chalk into the superficial deposits at the point where the Chalk becomes confined by the Reading Beds clays. This would only occur during periods of high groundwater levels.

Recharge of the superficial deposits could also occur as a result of leakage from the minor watercourses into the gravels, although this is unlikely to be substantial as the channels have cut through the brickearth, sands and gravels into the underlying clays. Under most conditions it is more likely that groundwater will feed the watercourses.

4. Site Specific Hydrogeology

4.1 Relationship with groundwater in the Chalk

Comparison of the maximum groundwater levels in the Chalk aquifer with the elevation of the base of the superficial deposits at the Chalk / Reading Beds interface clearly indicates that overflow of groundwater from the Chalk into the superficial deposits cannot occur in the area to the north of Barnham, and is only likely to be significant west of Tangmere. In effect the superficial deposits will therefore be acting as an isolated minor aquifer.

4.2 Groundwater level monitoring

Groundwater levels are monitored in the Chalk at a number of locations in the area around and to the north of Barnham. Unfortunately levels in the superficial deposits are only monitored at two points:, Church Lane, Eastergate; and Tangmere Sheepwash, Aldingbourne. The Eastergate well shows a limited seasonal variation of little more than 0.35 metres, from around 7.3 to 7.7 metres above Ordnance Datum (0.9 to 0.5 metres below ground level). The Aldingbourne well shows a greater variation of around a metre, from around 7 to 8 maOD (1.75 to 0.75 mbgl). Otherwise the two wells show a good correlation.
Hydrographs for the two wells are attached.

4.3 Detailed flow regime

Groundwater flow in the superficial deposits is isolated from that in the Chalk. The effective aquifer consists of 1 to 5 metres of sands and gravels (head gravels to the north and younger raised beach deposits further south. These are highly variably in thickness and nature. Over much of the area the sands and gravels are overlain by up to 3.5 metres of silty brickearth deposits.

The detailed groundwater flow regime will be controlled by a number of factors, outlined below.

- Recharge pattern (rainfall variations and presence of low permeability brickearth cover);
- permeability and thickness of sands and gravels;
- interaction with surface water system, particularly groundwater discharge to streams;
- artificial effects including soakaways, leakage of groundwater into, or sewage from sewers.

Because of the above factors the exact flow regime will be complex and difficult to predict. Groundwater flow will generally be from north to south, although flow direction is likely to be influenced locally by Hpresence of discharge zon(ise. streams) and the other factors given above.

5. Factors influencing surcharging of sewers

Surcharging will occur when flow in sewers exceeds the hydraulic capacity, and will thus be controlled by the inflows. These are as follows.

5.1 Foul sewage discharges from properties.
5.2 Surface/roof water discharges (permitted or wrong connections).

5.3 Groundwater ingress.
Any sewer that is not fully watertight will be subject to ingress of groundwater whenever the groundwater level in the surrounding strata is greater than the water level within the sewer. The magnitude of this ingress will depend on the following.

- Relative difference in water levels;
  This may be locally influenced by the presence of soakaways, and variations in the detailed geology.
- permeability of the surrounding strata;
- "leakiness" of the sewer.

It appears likely that groundwater ingress will occur over most of the area during high groundwater level conditions. The key controls as to whether this will be substantial will be the integrity of the sewers, and the strata into which the sewers are set: if flaws are present and the sewer is set in sands and gravels then substantial inflow is likely; whereas for sewers set in the lower permeability brickearth infiltration will be limited.
It should be noted that infiltration can occur into lateral as well as main sewers; and indeed the former are often subject to less rigorous construction quality and maintenance.

CONCLUSIONS

The geological and hydrogeological setting of the site has been defined above. From this information the following conclusion can be drawn with a good degree of confidence.

(1) Surcharging occurs principally as a result of groundwater infiltration into sewers. There appears to be potential for such infiltration to occur over the Barnham area in most winters.

(2) Substantial infiltration will occur where sewers are not properly sealed, and where they are set in relatively high permeability strata: i.e. sands and gravels.

(3) Onset of surcharging will not be directly related to groundwater levels in the Chalk aquifer.

(4) Controls on infiltration will be locally variable. Monitoring of groundwater levels in the sands and gravels may give some warning, however this will be limited because of the small seasonal fluctuation.

(5) Infiltration to sewers will be driven by local groundwater levels, which will in turn be affected by surface water drainage including use of soakaways.

(6) Surcharging is likely to be exacerbated by high flow rates in the sewers, particularly by surface water loads either where the sewers take combined foul and surface water; and by improper surface water connections to the foul system.

RECOMMENDATIONS

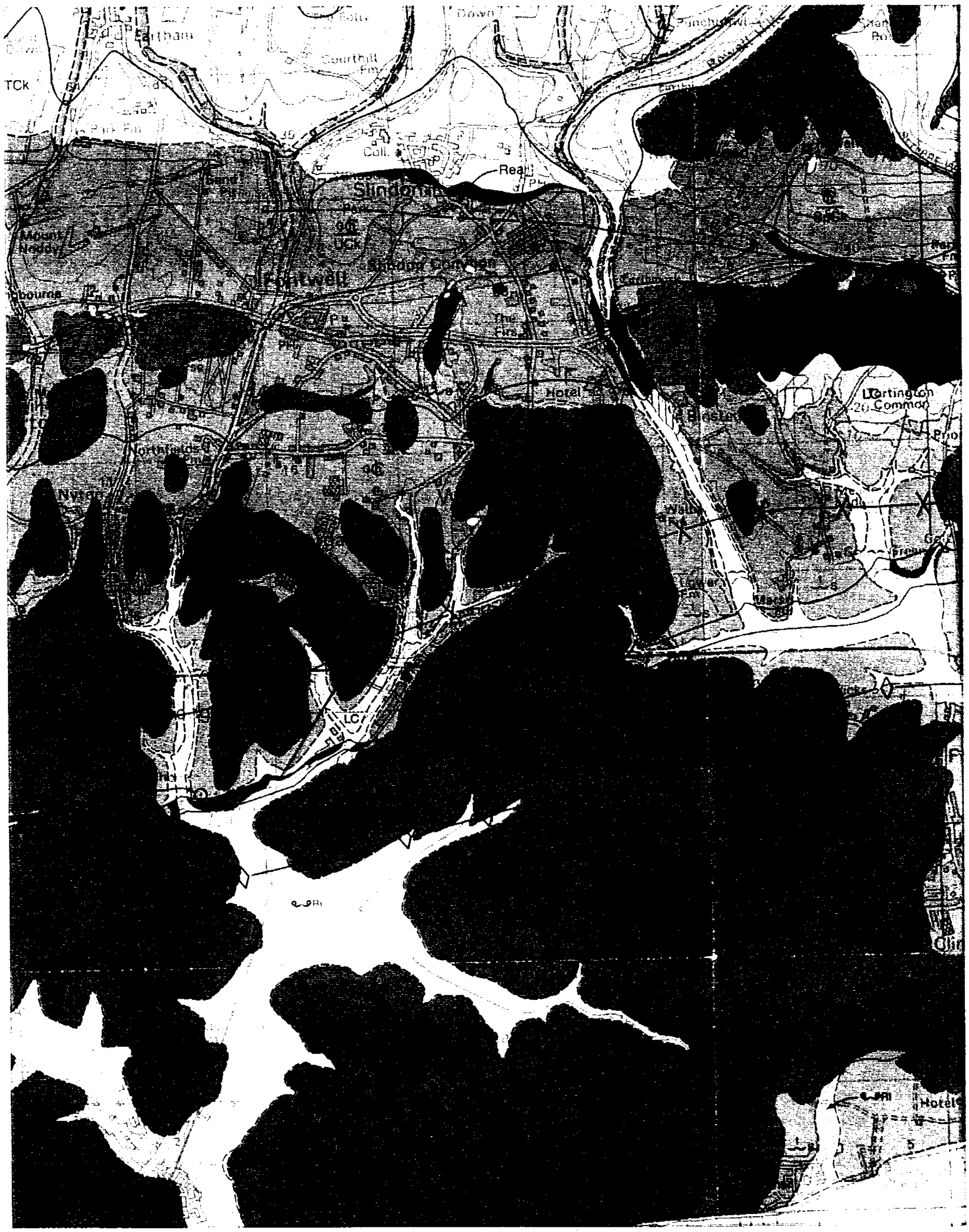
(1) On the basis of the above it does not appear that installation of boreholes to allow monitoring of local groundwater levels is justified. Information obtained would be difficult to interpret, and it is unlikely that any substantial advanced warning would result.

(2) Excessive hydraulic loading can only be exacerbating the problem. Improper surface water connections should be identified and rectified. Consideration should be given to installation of a surface water drainage system where one is not present. This would also reduce reliance on soakaways which cause elevated local groundwater levels and hence increasing ingress to sewers.

(3) The overall problem is only likely to be solved by sealing of leaking lateral and main sewers. As substantial sections of laterals will be the responsibility of private individuals and/or the District Council this may prove difficult. However there does not appear to be a realistic alternative.

Finally it is highly likely that those lengths of sewer which are subject to groundwater ingress during the winter months will allow leakage of raw sewage into groundwater during summer and autumn. this may be resulting in pollution of the local groundwater resource and may constitute an offence under the Water Resources Act 1991 by whoever is responsible for their maintenance.

FIGURE 1
Excerpt from Geology Map
(see overleaf for key)



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Chichester & Bognor, Solid & Drift Geology

KEY

DRIFT

- Made ground on surface
- Made ground in disused quarry

QUATERNARY

- Landslip
- Head: variable deposits of impure clays, silts and sands, locally gravelly: chalky and flinty in dry valleys
- Head Gravel: clayey gravel
- Clay-with-flints: clays with numerous pieces of flint
- Blown Sand: medium-grained sand
- Aeolian Deposits ('Brickearth'): mainly silts, in part contaminated with gravel
- Peat: soft organic detritus
- Alluvium: clays, silts and sands, locally organic, with gravels
- Alluvial Fan Deposits ('Fan Gravels'). clayey gravels
- River Terrace Deposits, 1 to 7, as numbered, of River Rother (Ro) or of River Arun (Ar), or undifferentiated: sands with gravels
- Marine Deposits, undifferentiated: silty clays, sands and gravels
- Storm Beach Deposits: sands and gravels
- Tidal River Deposits: silty and sandy clays with sands and gravels
- Raised Beach Deposits, 1 or 2, as numbered: sands and gravels
- Raised Storm Beach Deposits, 1 or 2, as numbered: gravels and gravelly sands

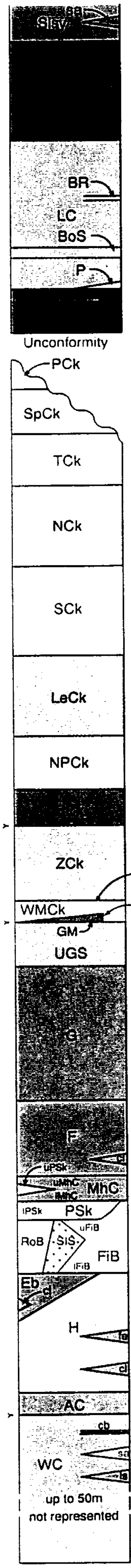
Drift deposits are not listed above in order of superposition

For Solid symbols and colours see Generalized Vertical Section

- 5 — Generalized dip of inclined strata, dip in degrees
- Marked break in slope, arrowheads on uphill side
- Geological boundary, Drift
- Geological boundary, Solid
- Fault, crossmark on downthrow side
- Axial plane trace of anticline
- Axial plane trace of syncline
- Borehole
- LC — Symbol indicates the Quaternary deposit at surface and the Solid formation at rockhead; other Quaternary deposits may intervene

GENERALIZED VERTICAL SECTIONS

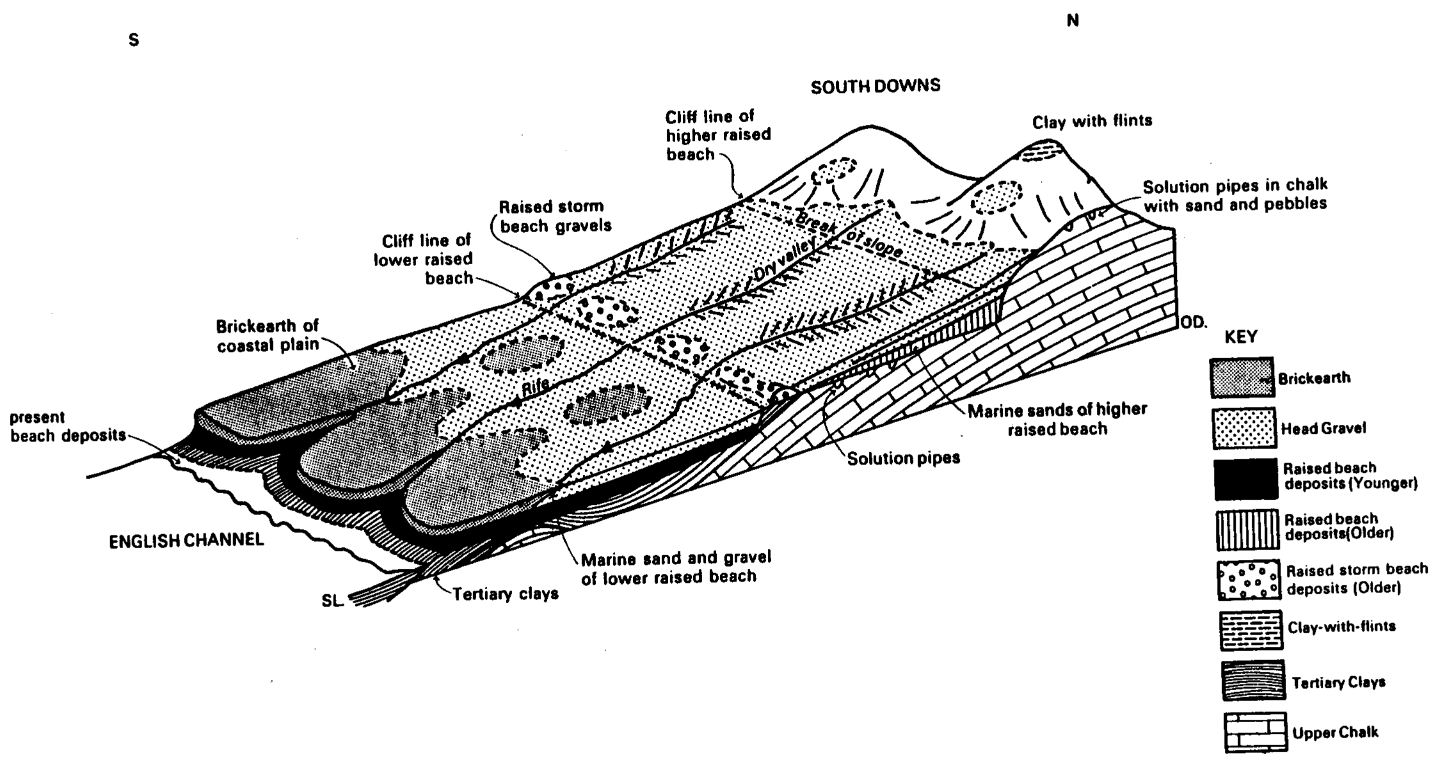
Scale 1:4000 (1cm to 40m)



Sandstone		SELSEY SAND FORMATION Sands, silts and clays
		MARSH FARM FORMATION Sands, silts and clays
		EARNLEY SAND FORMATION Sands and silts
		WITTERING FORMATION Sands, silts and clays
Barn Rock Member Glauconitic fine-grained sands		LONDON CLAY FORMATION Silty clays and sands
Bognor Sand Member Glauconitic fine to medium-grained sands		
Pebble bed Gravel of flint pebbles		
		READING FORMATION Mottled clays, locally sandy
Portsdown Chalk Member White chalks with flints and many thin marl beds		UPPER CHALK (UCk)
Spetisbury Chalk Member White chalks with flints		
Tarrant Chalk Member White chalks with flints		
Newhaven Chalk Member White chalks with flints and many thin marl beds		
Seaford Chalk Member White chalks with flints		
Lewes Nodular Chalk Member Hard, nodular chalks with flints		
New Pit Chalk Member White chalks with many thin marl beds		MIDDLE CHALK (MCk)
Holywell Nodular Chalk Member Hard nodular chalks, some shelly		
Zig Zag Chalk Member Grey chalks		LOWER CHALK (LCk)
West Melbury Marly Chalk Member Marly chalks and thin limestones		
Glauconitic Marl Glauconitic clayey sandstones and siltstones		
		UPPER GREENSAND FORMATION Siltstones and fine-grained sandstones
		GAULT FORMATION Clays
Clay		FOLKESTONE FORMATION Fine to coarse-grained sandstones
Marehill Clay Member Silty clays and clayey silts		SANDGATE FORMATION
Pulborough Sandrock Member Fine-grained soft sandstones		
Rogate Member/Selham Ironshot Sands Member		
Fittleworth Member Sandy clays and clayey sands		
Easebourne Member Fine to medium-grained sandstones with calcareous nodules		
Fuller's earth		HYTHE FORMATION Glauconitic fine to coarse-grained sandstones
Clay		
		ATHERFIELD CLAY FORMATION Silty clays and clayey silts
Clay ironstone		WEALD CLAY FORMATION Mudstones
Sandstone		
Limestone		

Scale 1:20 000 (1cm to 200m)

FIGURE 2
Schematic Geological Block Section



Reproduced from Mineral Assessment Report 138
The sand and gravel resources of the country around Chichester and north of Bognor Regis, Sussex, J.H. Lovell and P.H.A. Nancarrow
Published by Institute of Geological Sciences (now British Geological Survey).

FIGURE 3
General Groundwater Flow Regime