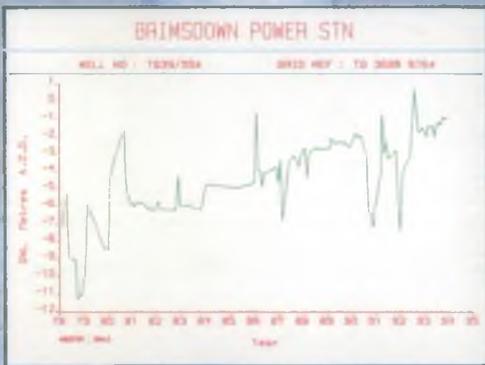


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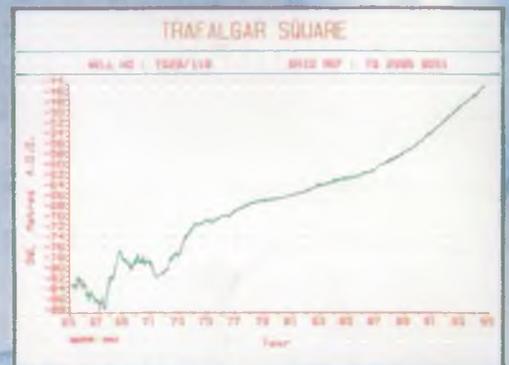



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**RISING GROUNDWATER LEVELS IN THE
CHALK-BASAL SANDS AQUIFER OF THE
CENTRAL LONDON BASIN**

- March 1996 -

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1. INTRODUCTION

The 1996 report is the fifth annual report on rising groundwater levels beneath London. There has been relatively little new work undertaken during 1995 with no improvements to the borehole monitoring network which is now considered to be adequate and no further modelling of the confined Chalk aquifer.

2. CHANGES TO THE MONITORING NETWORK

There have been no new observation boreholes (obh's) added to the London Basin monitoring network during 1995. Thames Water Utilities Ltd (TWUL) have concluded their drilling and testing programme for assessing the water resource potential of rising Chalk groundwater in London. TWUL continue, however, to work closely with London Underground Ltd (LUL). During 1995 they have carried out test pumping at TWUL sites to assess the effectiveness of controlling levels at some of LUL's high risk zones. LUL are dealing with the threat of rising levels at a number of sites.

Several previously monitoring boreholes have become defunct this year due to outside organisations reducing their monitoring network and frequency of monitoring, or, new development works preventing accessibility to boreholes.

Two new Chalk observation boreholes will be drilled by the NRA in 1996 to fill gaps in the monitoring network. These are to be located at Hainault Country Park and Thornwood Common in north-east London.

The NRA Thames Region will continue to monitor all observation boreholes in the area although the frequency of observation at some boreholes may be reduced in future years. Where ground investigations offer the opportunity of obtaining 'one off' or short term groundwater data, they will be utilised wherever possible. People and organisations are asked to contact the NRA Thames Region Hydrogeology Group (Tel. 01734-535111) if Chalk groundwater level data can be made available.

3. GROUNDWATER LEVEL AND RATE OF RISE

The following two maps have been assembled from the groundwater level data collected for this report.

- i) Chalk groundwater levels of January 1996.
- ii) Average annual rate of rise of Chalk groundwater, December 1993 to December 1995.

3.1 Chalk Groundwater Levels at January 1996

Figure 1 shows the Chalk groundwater level map of the London Basin for January 1996. An enlarged area of Central London drawn at 5 metre

groundwater contour intervals is shown in Figure 2.

The pattern of groundwater contours is very similar to those of the past few years (see Figure 3 for the January 1995 groundwater level map), with the centre of the cone of depression situated in the area to the south-east of Regent's Park. The groundwater level at the centre of the cone is now at approximately -49 metres above ordnance datum (maod).

The cone is elongated along an east-west axis, with groundwater levels rising more steeply up the dip-slope of the Chalk to the north-west and south.

Unfortunately, we have not been able to obtain a level this year for Abbey House, TQ 28/77, at the centre of the groundwater depression.

The groundwater level at Trafalgar Square, TQ 28/119, is now at -41.71 maod and continues to rise steadily at 2.0 to 2.5 metres per year (see Figure 4).

A shallower cone of depression centred around Wansted in NE London/Essex remains, with groundwater levels now at around -21.5 maod.

Groundwater levels in the unconfined Chalk of the Chilterns and North Downs have, in general, declined in the past year due to the particularly dry period March to December 1995. Recovery to slightly below average levels are expected after the Winter recharge period.

3.2 Average Rate of Rise, December 1993 to December 1995

The average annual rate of rise of Chalk groundwater levels in the London Basin for the period December 1993 to December 1995 is shown in Figure 5. The previous rate of rise map for the period December 1992 to December 1994 is shown in Figure 6.

The rate of rise appears to be fairly uniform over this period near the centre of the cone of depression beneath the centre of London. During the past two years, and similar to the period December 1992 to December 1994, the most rapid recovery of groundwater levels has occurred at St Agnes Well in Hyde Park, TQ 28/153. The well is currently rising by an average rate of 3.33 metres per year, (calculated over a two year period) but this rate has tailed off somewhat during 1995 (see Figure 7).

There would appear to have been an increase in groundwater recovery rates in the Ealing - Southall area of West London during the past two years. The rate of rise has, in general, increased by between 0.2 and 0.7 metres per year. Figure 8 shows the well at Windmill Lane, Southall, TQ 18/61A, where a significant increase in the rate of rise has occurred each year since 1993.

Groundwater levels in the Isle of Dogs - Bow - West Ham area have been affected by localised pumping from the Chalk aquifer. This pumping is

temporary dewatering of the Chalk in connection with the construction of the Jubilee Line Extension. Here, levels have fallen by up to 4.2 metres per year since December 1993. The level in London Underground Ltd's Rotherhithe observation borehole (Figure 9) has been reduced by approximately 9 metres since January 1994 as a result of pumping in the vicinity of the tube tunnel network. It is expected that dewatering will cease on completion of the new line and groundwater levels will rapidly return to being between 0 and -10m aod.

A small cone of depression has developed in the Streatham - Merton area as a result of several weeks of test pumping carried out by Thames Water Utilities Ltd at Merton Abbey PS in 1995. This source had previously not been in use since 1987.

Rates of rise in the Lee Valley area are also being affected by variations in abstraction rates and by the use in the late summer of 1995 of Thames Water's North London Artificial Recharge/Abstraction Scheme to meet very high peak demands. Pumping has caused a reduction of up to 2.5 metres in the past year in the Enfield - Waltham Abbey area. With the cessation of pumping levels are recovering rapidly. Further to the south, levels are continuing to rise naturally.

4. THE CURRENT SITUATION

In the central London cone of depression groundwater levels are currently around -41m aod, having risen from a low of -90m aod in 1967. The current rate of rise is being maintained at just over 3m per year in the centre of the depression. As stated in the 1995 report, (1) TWUL do not see the availability of rising groundwater as a significant resource and they are therefore unlikely to abstract more groundwater than their current quantities. TWUL continue to work closely with London Underground Ltd (LUL) at a few sites but any pumping is unlikely to affect large areas of London.

The current situation and predictions have not significantly changed since the comprehensive statement issued in the 1995 report (see Appendix 1 which reproduces the concluding sections of that report). The area of greatest uncertainty still remains the identification of those buildings which comply to the very specific set of conditions which will make them vulnerable to settlement or structural damage due to differential settlement with adjacent buildings. The property insurance industry is considering withdrawing cover for this specific risk as a means of encouraging asset owners to obtain a vulnerability survey from competent consultants.

The main thrust of activity during the last year has been through the Rising Groundwater Level Working Group (GARDIT) which has sought to bring the problems associated with rising levels to a much wider audience. A major step forward was achieved early in 1996 when the group gave a presentation to the All-Party Parliamentary Water Group at the House of Commons. As a result of this meeting, a paper was prepared giving a comprehensive picture of the history of groundwater abstraction under London and the current rising level situation. These

actions resulted in questions being put to the Secretary of State for the Environment on the problem of rising levels and his written answer was reported in full in Hansard on the Business of the House for 29th February 1996. In summary the answer said *"It is the responsibility of owners of existing and new structures to ensure adequate protection of their assets"*.

The message therefore is quite clear. There is no legislation which requires the DoE or the NRA (or the future Environment Agency) to assume responsibility for this problem and at this stage there is no indication of any public money being made available to control rising levels. There is a clear directive to the NRA to monitor and report on rising groundwater levels annually. Through the GARDIT group this is being promulgated widely to asset holders. As previously stated (App. 1) the NRA is satisfied that it has sufficient powers under Section 30 of the Water Resources Act 1991, through the issue of Conservation Notices to control pumping for the purposes of controlling groundwater levels but it cannot force anyone to carry out pumping.

The NRA is in favour of a co-ordinated approach to controlling levels rather than a piecemeal, site by site "free for all". Asset holders are therefore invited to contact the Chairman of the GARDIT Group, Rob Sage, Thames Water Utilities, Nugent House, Vastern Road, Reading, RG1 8DB to learn more about co-ordinating some action.

5. CONCLUSIONS

1. Groundwater levels in the Chalk-Basal Sands aquifer continue to rise under Central London at rates up to 3m/year.
2. The continuing control of rising levels at some of LUL's assets will not by any means protect large areas of London away from these sites.
3. The requirement for surveys of the potential risk to assets is becoming necessary. The threat of withdrawal of insurance cover for this risk is now felt needed to encourage asset owners to act.
4. The Government has sent a clear message to asset owners that it is their responsibility to protect their assets.

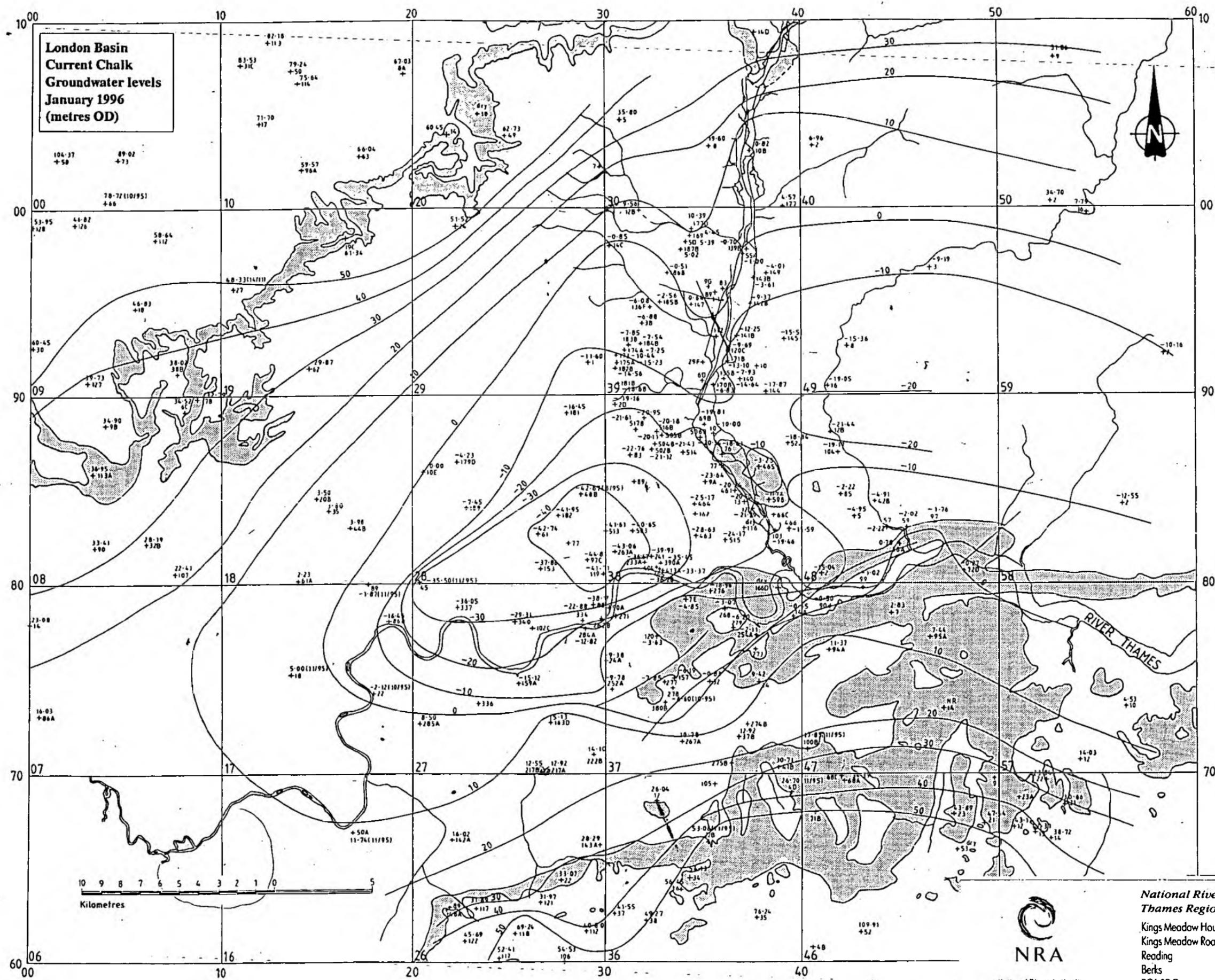
Acknowledgements

Numerous organisations have supplied information to enable this report to be compiled and the NRA gratefully acknowledges this help.

References

- (1) NRA, Thames Region, 1991, 1992, 1993, 1994, 1995 Annual Reports - Rising Groundwater Levels with Chalk Basal Sands Aquifer of the Central London Basin.

Figure 1. London Basin Chalk Groundwater Levels, January 1996.



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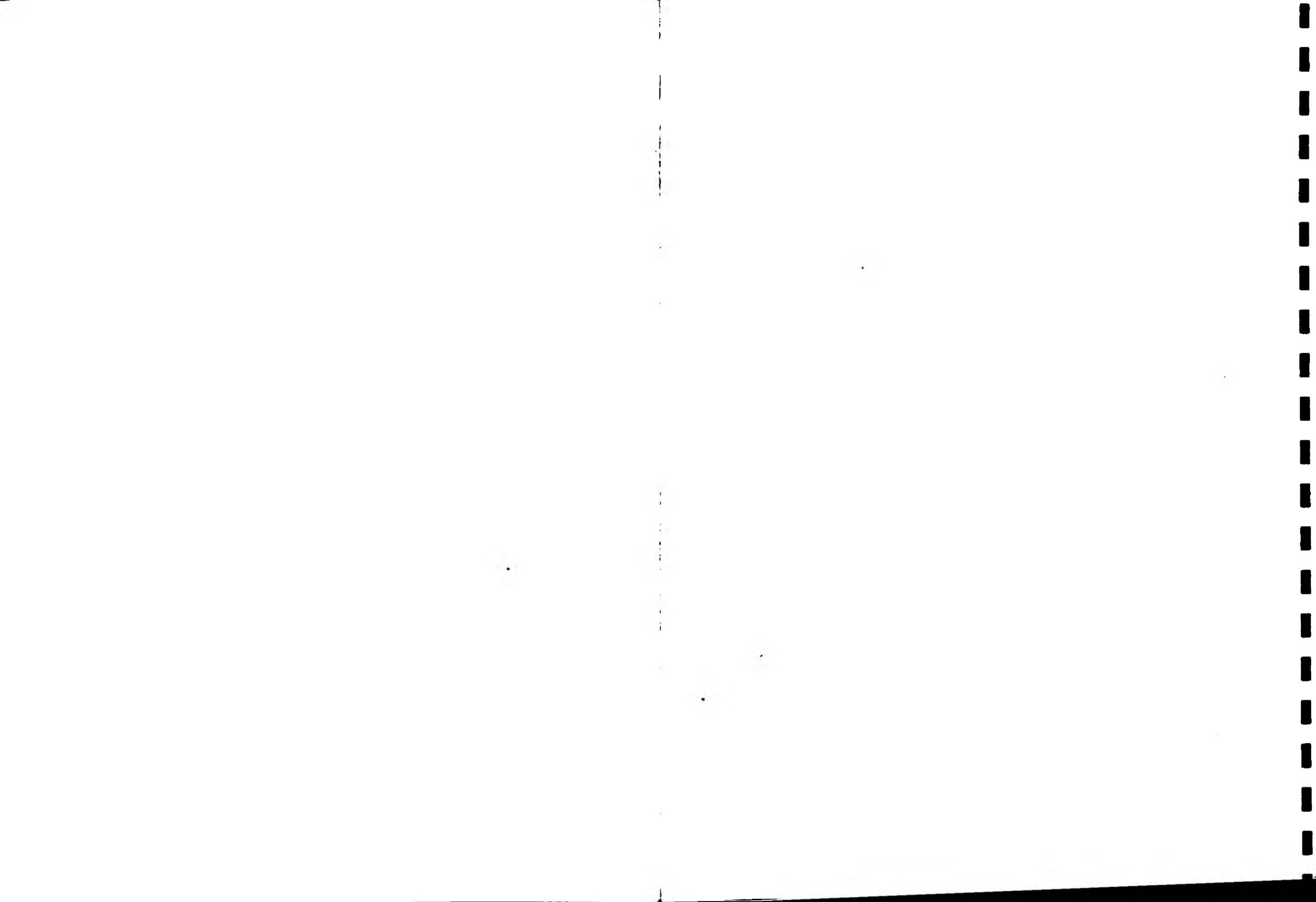
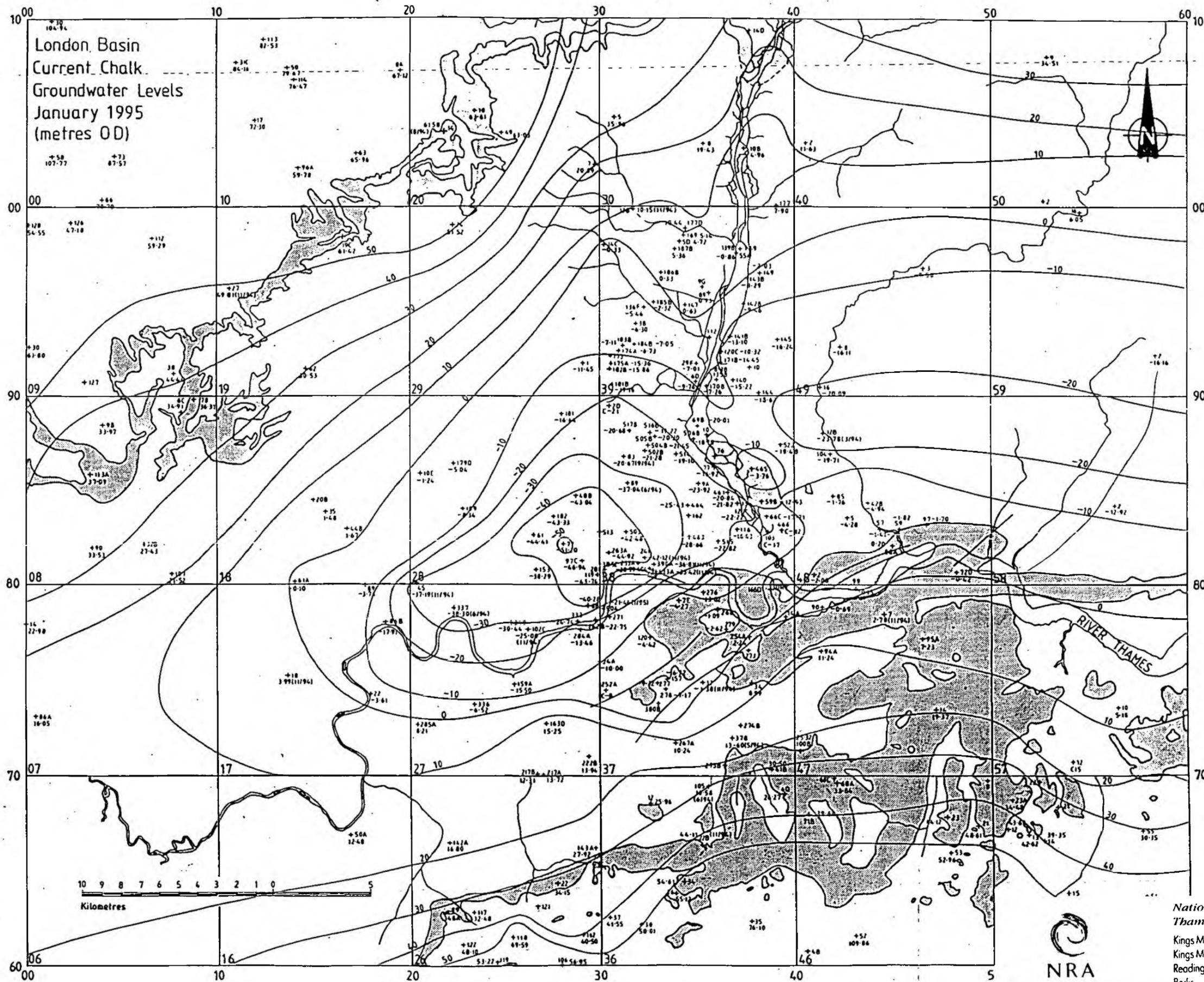


Figure 3. London Basin Chalk Groundwater Levels, January 1995.



London Basin
Current Chalk
Groundwater Levels
January 1995
(metres OD)

10 9 8 7 6 5 4 3 2 1 0 5
Kilometres

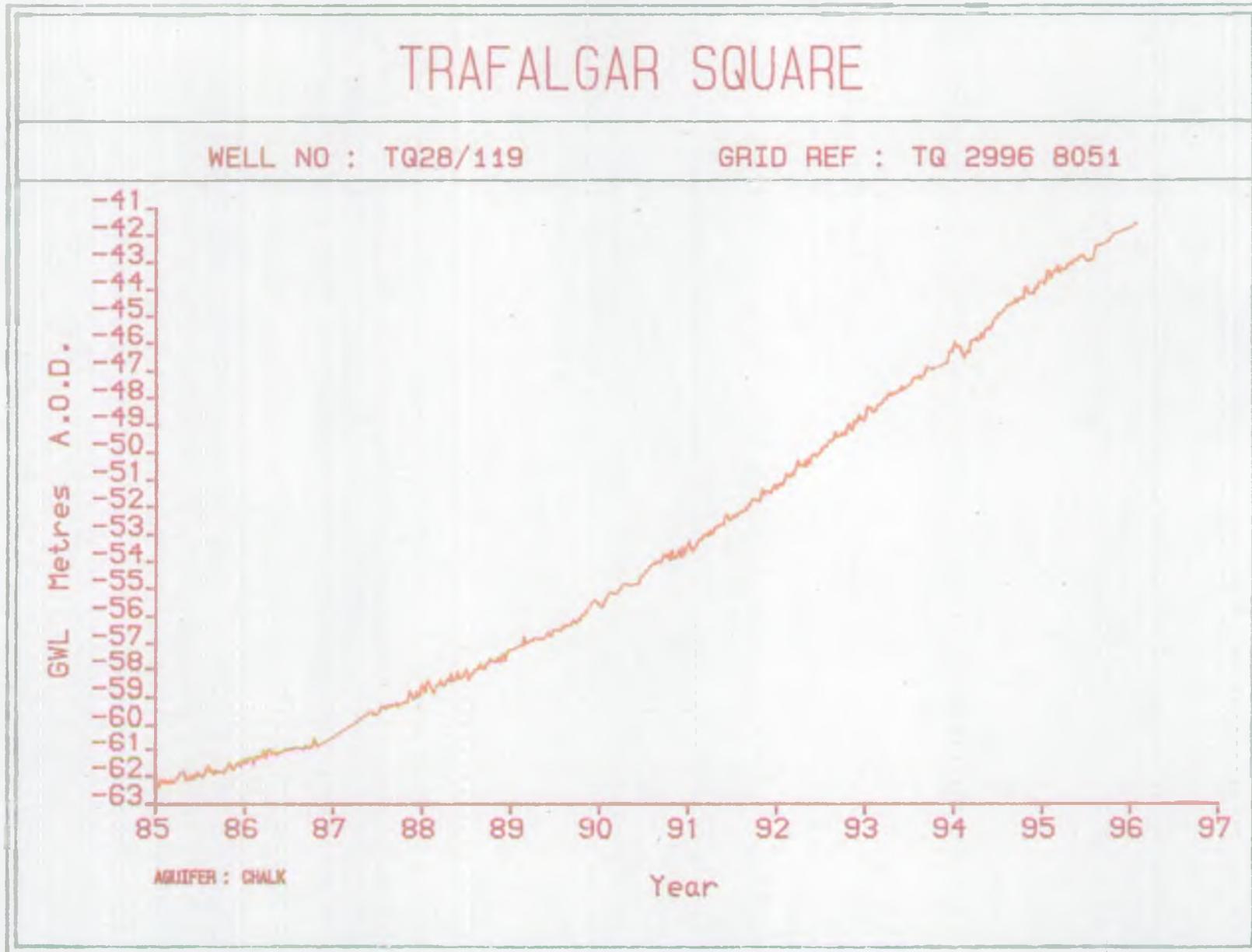


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Figure 4.

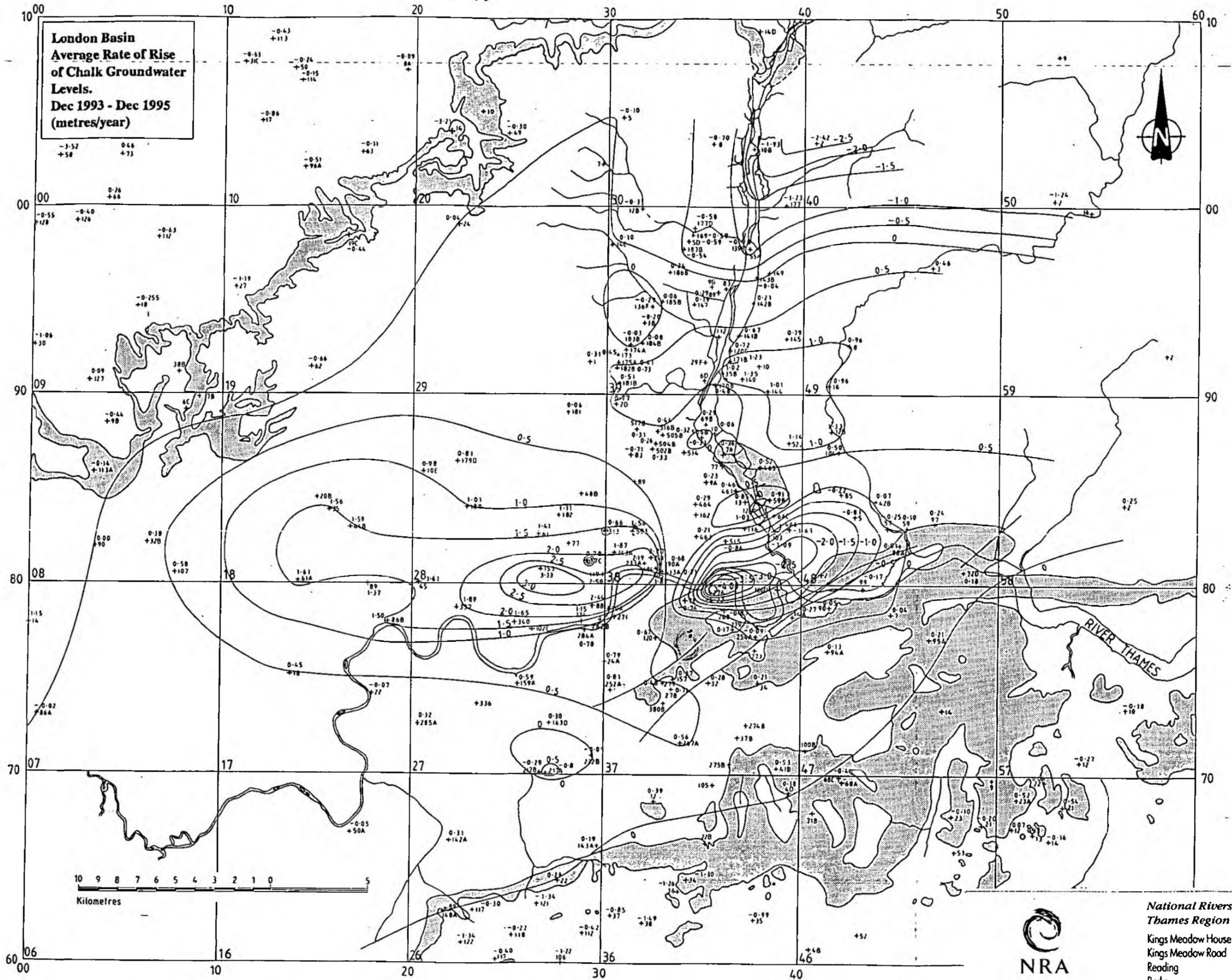
Hydrograph at Trafalgar Square, TQ28/119.



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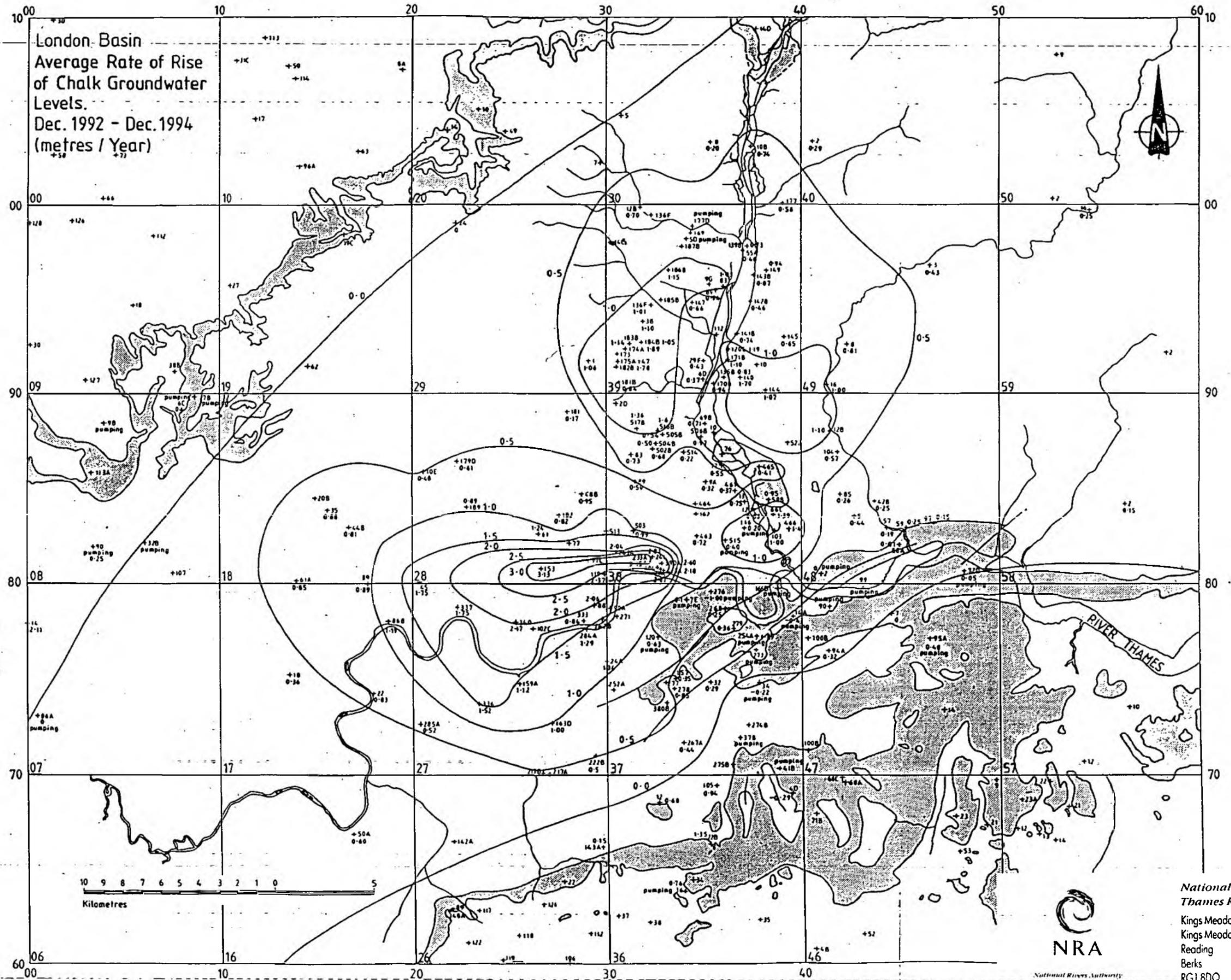
Figure 5. London Basin Average Rate of Rise of Chalk Groundwater Level, Dec 1993 to Dec 1995.



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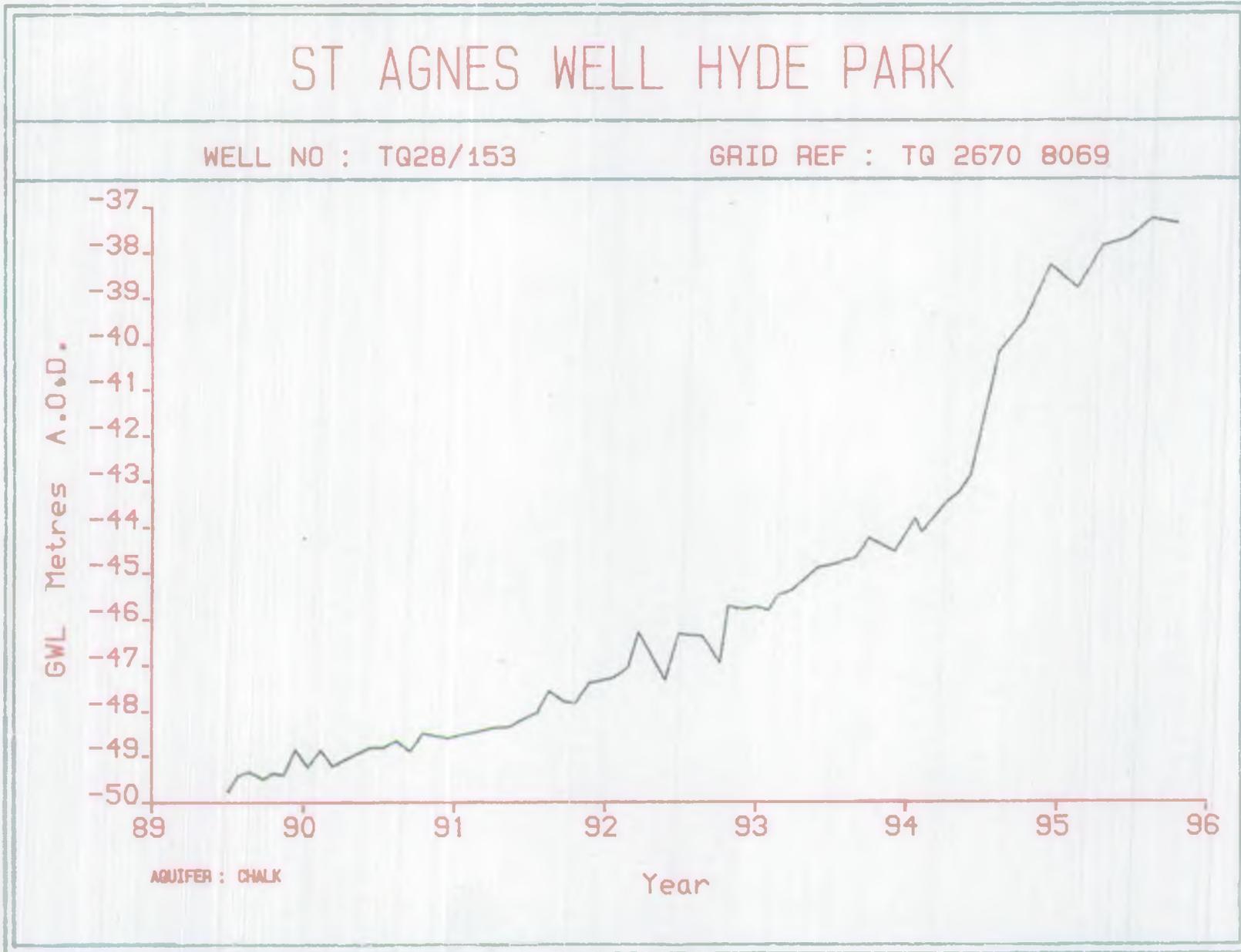
Figure 6. London Basin Average Rate of Rise of Chalk Groundwater Level, Dec 1992 to Dec 1994.



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Figure 7.

Hydrograph at St Agnes Well, Hyde Park, TQ28/153.



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Figure 8.

Hydrograph at Windmill Lane, Southall, TQ18/61A.

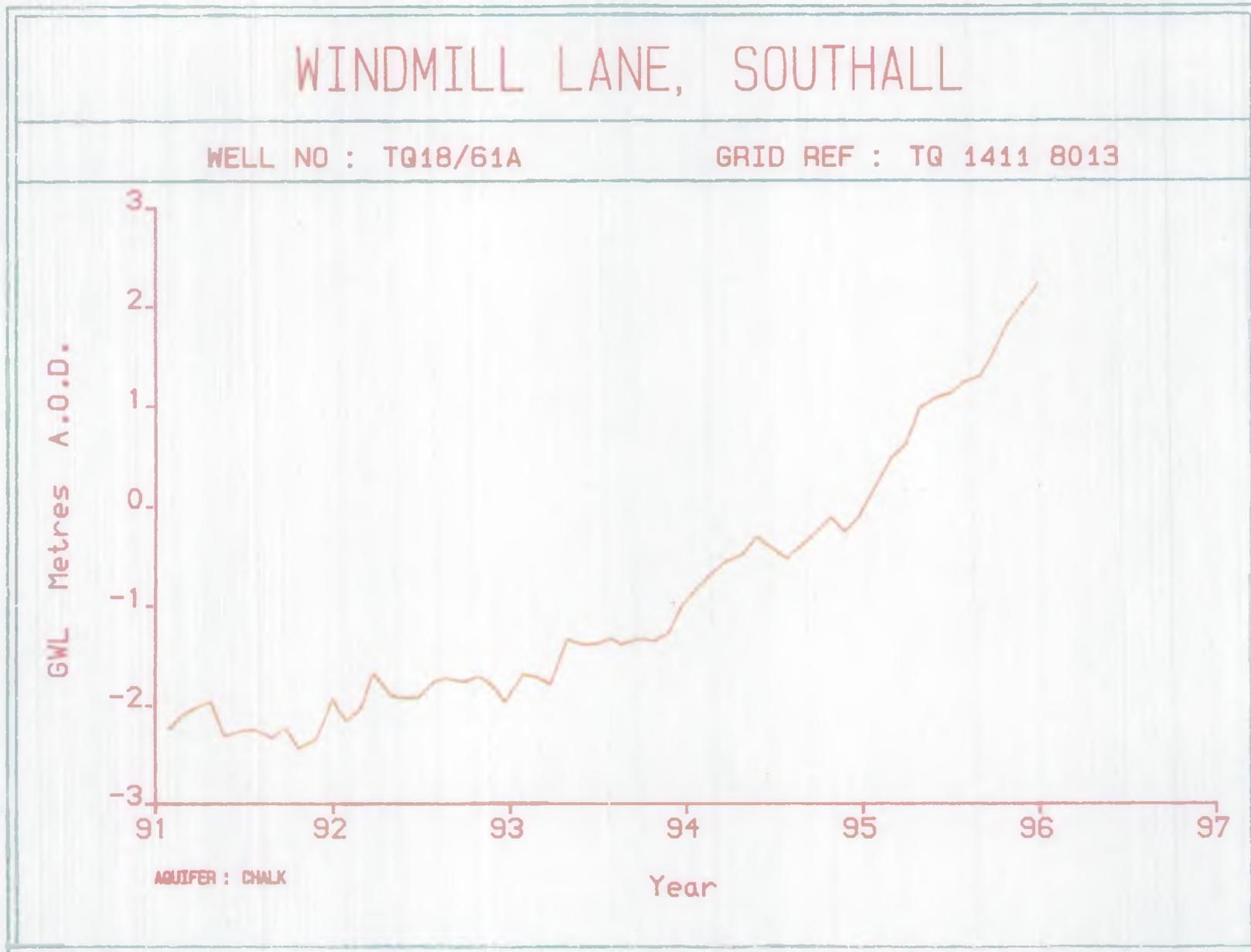
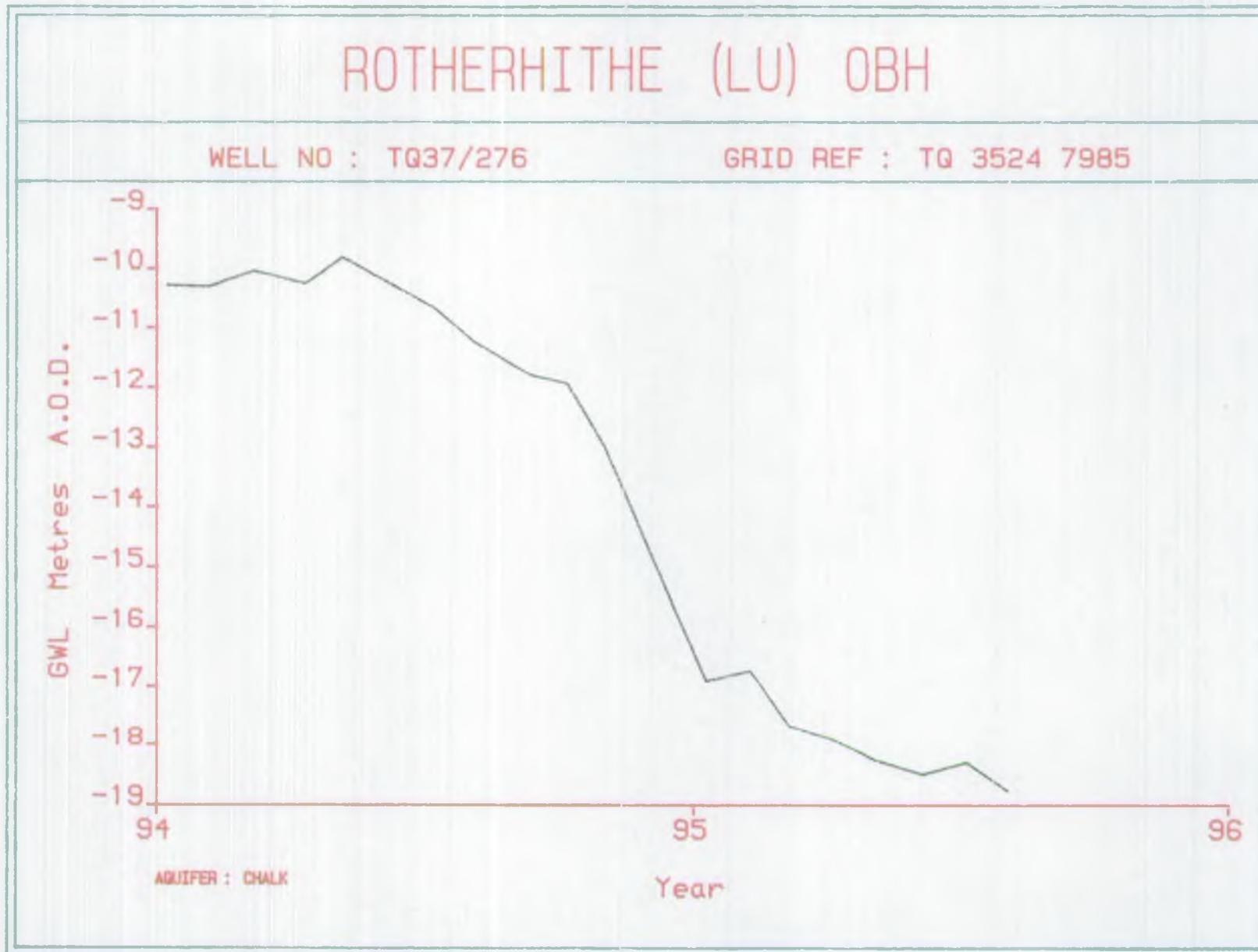


Figure 9.

Hydrograph at Rotherhithe (London Underground) OBH, TQ37/276.



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APPENDIX 1

CONCLUDING REMARKS FROM 1995 LONDON BASIN REPORT

THE CURRENT SITUATION

In the central London cone of depression groundwater levels are currently around -44 mOD, having risen from a low of -90 mOD in 1967. The current rate of rise has accelerated slightly to 3m/year in some places.

The drilling and test pumping by TWUL have demonstrated the great variability in yield and quality of groundwater at sites throughout the area. Not surprisingly in the west London Basin area where the Chalk is very deeply buried, yields are poor but rising levels do not pose a problem anyway. In the Central London Basin area substantial yields of up to 4Ml/d at individual sites have been obtained whilst other sites have had a very poor yield or the water quality has been very poor. The current situation is that TWUL has investigated about 20 sites of which 7 have indicated yields of sufficient quantity and treatable quality to be used for public water supply.

The work with LUL has demonstrated the feasibility of controlling groundwater rise in the vicinity of tube tunnels.

In conclusion, sufficient OBH's now exist and sufficient aquifer modelling, on site testing and hydrogeological research have been carried out to understand the rising groundwater problem to the extent that technical decisions can be made on controlling it.

THE CURRENT WATER RESOURCES STRATEGY FOR CENTRAL LONDON

During 1994 a number of factors became clear.

- a) The relaxation of restrictions on abstraction licensing in London has produced almost no new abstractions and the long term decline in abstraction from the Chalk aquifer under London continues. The NRA has concluded that it is unlikely that sufficient control of rising levels will be achieved through licensable non-public water supply abstractions.
- b) TWUL have reviewed their demand deficit in the London area in the light of:-
 - i. improved leakage control
 - ii. the success of the North London recharge/abstraction scheme (currently 36 groundwater abstraction sites)
 - iii. the major enhancement of the distribution of strategic resources by the completion of the London Tunnel Ring Main System
 - iv. the findings of preliminary investigations in the South London groundwater resources project
 - v. the results of yield and quality tests in central London
 - vi. improvements and rationalisations of the New River Aqueduct, Lee

Reservoirs, Coppermills Treatment Works infrastructure system.

TWUL have concluded that developing new groundwater resources in central London is generally not a commercially viable option in the short to medium term at least.

- c) The slightly accelerated pace of groundwater rise and the problems now occurring to the LUL tunnels has meant that some action to alleviate problems of rising groundwater has already been started by that body.

FUTURE CONTROL

In the short to medium term, and probably in the long term also, the balance of view must now be that rising groundwater will not be controlled sufficiently as an incidental benefit of increased water supply abstraction, public or private. Instead there will need to be deliberate abstraction solely for the purpose of protecting deep tunnels and foundations. For tunnels this need is starting now; for deep foundations it is still generally some 20-30 years in the future.

As institutional and legislative arrangements stand at present it is the responsibility of the owners of the assets involved to take their own action to protect their assets. This action will normally take the form of groundwater pumping to hold levels below a critical threshold (although occasionally pumping out of invading water may be practicable).

Under Section 30 of the Water Resources Act 1991, groundwater abstraction "to prevent interference with the carrying out or operation of any underground works" is exempt from licensing. However, anyone proposing to construct boreholes etc. for this purpose must give notice to the NRA. In return, the NRA may issue a 'Conservation Notice' specifying "reasonable measures for conserving water". Through such notices the NRA would seek to secure the proper use of water resources and protect the groundwater resource by imposing as appropriate conditions to:

- agree threshold control levels
- dispose of abstracted water
- monitor levels and abstracted quantities
- protect existing rights to abstract.

Action by the owners of assets, or their agents, will result in control on a piecemeal basis. To a great extent, control will be self-limiting as no-one is likely to pump more water than necessary to control their own problem. It is not envisaged therefore that conditions that the NRA would seek to impose through Section 30 would generally be in conflict with the interests of the owners of assets.

Controlling conditions at one site may have incidental benefits for the owners of adjacent sites. This is perhaps more likely to arise in relation to tunnels for which it may be necessary to protect significant lengths by pumping at several locations. The requirement for incidental beneficiaries to reimburse those actually incurring costs will need to be considered.

THE RISING GROUNDWATER LEVEL WORKING GROUP

This has been functioning for nearly two years and is now chaired by TWUL. At present representatives of the NRA, Loss Prevention Council, Association of British Insurers and the British Property Federation attend meetings of this group. Whilst there is a rapidly growing momentum of co-operation between TWUL and LUL, the main objectives of the group are to greatly widen the discussion on rising levels and to continue to bring to the attention of property owners and government the possible consequences of the relentless rise in levels. TWUL see their potential activities and current expertise as the mechanism through which levels can be controlled. Any organisation is welcome to join the working group on a permanent or ad hoc basis. The contact point is Mr R Sage, TWUL, Nugent House, Vastern Road, Reading RG1 8DB.

It should be made very clear that the co-operation between TWUL and LUL will only maintain the integrity of certain vulnerable length of tube tunnel. Large areas of the capital still remain vulnerable to rising groundwater levels. The engineering implications of this were spelled out in the CIRIA (2) report of 1989. Most structures, of course, are unlikely to be affected by the problem. A very specific set of conditions were required to be present to endanger a structure. A civil engineering assessment of each structure is required to determine this. Very few organisations and property owners have taken any action in this direction. The Rising Groundwater Level Working Group can provide further insight and advice.

CONCLUSIONS

- (i) Groundwater levels in the Chalk-Basal Sands aquifer under Central London are still rising; the rate of rise appears to be accelerating slightly.
- (ii) The network of observation boreholes for monitoring groundwater levels is now adequate. Sufficient aquifer modelling, on site testing and hydrogeological research have been carried out to understand the problem of rising groundwater and make technical decisions on controlling it.
- (iii) Rising groundwater represents a water resource but the likely interest in using it for public or private water supply, in the short to medium term and probably also in the long term, will be insufficient to achieve incidental control of the rise to protect subsurface structures threatened by it.
- (iv) Deliberate pumping will be needed to protect subsurface structures. Under the present institutional and legislative arrangements this will be the responsibility of the owners of the assets.
- (v) Where necessary the NRA will seek to protect the water resource, and those with rights to abstraction from it, through Conservation Notices under Section 30 of the Water Resources Act 1991.