

Groundwater Pollution, Aquifer Recharge and Vulnerability

Geological Society Special Publications
Series Editor A. J. FLEET

It is recommended that reference to all or part of this book should be made in one of the following ways:

ROBINS, N. S. (ed.) 1998. *Groundwater Pollution, Aquifer Recharge and Vulnerability*. Geological Society, London, Special Publications, **130**.

ADAMS, B. & MACDONALD, A. M. 1998. Aquifer susceptibility to side-effects of groundwater exploitation. *In*: ROBINS, N. S. (ed.) *Groundwater Pollution, Aquifer Recharge and Vulnerability*. Geological Society, London, Special Publications, **130**, 71–76.

GEOLOGICAL SOCIETY SPECIAL PUBLICATION NO. 130

Groundwater Pollution, Aquifer Recharge and Vulnerability

EDITED BY

N. S. ROBINS

British Geological Survey
Wallingford
UK

1998

Published by
The Geological Society
London

THE GEOLOGICAL SOCIETY

The Society was founded in 1807 as The Geological Society of London and is the oldest geological society in the world. It received its Royal Charter in 1825 for the purpose of 'investigating the mineral structure of the Earth'. The Society is Britain's national society for geology with a membership of around 8000. It has countrywide coverage and approximately 1000 members reside overseas. The Society is responsible for all aspects of the geological sciences including professional matters. The Society has its own publishing house, which produces the Society's international journals, books and maps, and which acts as the European distributor for publications of the American Association of Petroleum Geologists, SEPM and the Geological Society of America.

Fellowship is open to those holding a recognized honours degree in geology or cognate subject and who have at least two years' relevant postgraduate experience, or who have not less than six years' relevant experience in geology or a cognate subject. A Fellow who has not less than five years' relevant postgraduate experience in the practice of geology may apply for validation and, subject to approval, may be able to use the designatory letters C Geol (Chartered Geologist).

Further information about the Society is available from the Membership Manager, The Geological Society, Burlington House, Piccadilly, London W1V 0JU, UK. The Society is a Registered Charity, No. 210161.

Published by The Geological Society from:
The Geological Society Publishing House
Unit 7, Brassmill Enterprise Centre
Brassmill Lane
Bath BA1 3JN
UK
(Orders: Tel. 01225 445046
Fax 01225 442836)

First published 1998, reprinted 1999

The publishers make no representation, express or implied, with regard to the accuracy of the information contained in this book and cannot accept any legal responsibility for any errors or omissions that may be made.

© The Geological Society 1998. All rights reserved. No reproduction, copy or transmission of this publication may be made without written permission. No paragraph of this publication may be reproduced, copied or transmitted save with the provisions of the Copyright Licensing Agency, 90 Tottenham Court Road, London W1P 9HE. Users registered with the Copyright Clearance Center, 27 Congress Street, Salem, MA 01970, USA: the item-fee code for this publication is 0305-8719/98/\$10.00.

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library.

ISBN 1-897799-98-5
ISSN 0305-8719

Typeset by The Alden Press, Osney Mead, Oxford, UK.

Printed by The Alden Press, Osney Mead, Oxford, UK.

Distributors

USA

AAPG Bookstore
PO Box 979
Tulsa
OK 74101-0979
USA

(Orders: Tel. (918) 584-2555
Fax (918) 560-2652)

Australia

Australian Mineral Foundation
63 Conyngham Street
Glenside
South Australia 5065
Australia

(Orders: Tel. (08) 379-0444
Fax (08) 379-4634)

India

Affiliated East-West Press PVT Ltd
G-1/16 Ansari Road
New Delhi 110 002
India

(Orders: Tel. (11) 327-9113
Fax (11) 326-0538)

Japan

Kanda Book Trading Co.
Tanikawa Building
3-2 Kanda Surugadai
Chiyoda-Ku
Tokyo 101
Japan

(Orders: Tel. (03) 3255-3497
Fax (03) 3255-3495)

Contents

ROBINS, N. S.: Recharge: the key to groundwater pollution and aquifer vulnerability	1
FOSTER, S. S. D.: Groundwater recharge and pollution vulnerability of British aquifers: a critical overview	7
GREEN, A. R., FEAST, N. A., HISCOCK, K. M. & DENNIS, P. F.: Identification of the source and fate of nitrate contamination of the Jersey bedrock aquifer using stable nitrogen isotopes	23
SEARS, R.: The British Nuclear Fuels Drigg low-level waste site characterization programme	37
MÜHLHERR, I. H., HISCOCK, K. M., FEAST N. A. & DENNIS, P. F.: Changes in groundwater chemistry due to rising groundwater levels in the London Basin between 1963 and 1994	47
GABRIEL, W. J., MASON, J. M. & GOTTLER, P. F.: Groundwater resource development and protection considerations for the Ogallala Formation in Ogallala, Nebraska	63
ADAMS, B. & MACDONALD, A. M.: Aquifer susceptibility to side-effects of groundwater exploitation	71
MCDONALD, R. J., RUSSELL, N. R. W., MILIORIZOSIS, M. & THOMAS, J. W.: A geophysical investigation of saline intrusion and geological structure beneath areas of tidal coastal wetland at Langstone Harbour, Hampshire, UK	77
MACDONALD, A. M., BREWERTON, L. J. & ALLEN, D. J.: Evidence for rapid groundwater flow and karst-type behaviour in the Chalk of southern England	95
SIMMERS, I.: Groundwater recharge: an overview of estimation 'problems' and recent developments	107
JONES, H. K. & COOPER, J. D.: Water transport through the unsaturated zone of the Middle Chalk: a case study from Fleam Dyke lysimeter	117
SOLEY, R. W. N. & HEATHCOTE, J. A.: Recharge through the drift: a study of contrasting Chalk catchments near Redgrave Fen, UK	129
BLACKIE, J. R., HOUGHTON-CARR, H. A., MCCARTNEY, M. P. & MOORES, J. R.: Estimation of groundwater recharge on Jersey	143
CHILTON, P. J., STUART, M. E., ESCOLERO, O., MARKS, R. J., GONZÁLES, A. & MILNE, C. J.: Groundwater recharge and pollution transport beneath wastewater irrigation: the case of Leon, Mexico	153
ALDERWISH, A. M. & DOTTRIDGE, J.: Recharge components in a semi-arid area: the Sana'a Basin, Yemen	169
DALY, D. & WARREN, W. P.: Mapping groundwater vulnerability: the Irish perspective	179
PALMER, R. C. & LEWIS, M. A.: Assessment of groundwater vulnerability in England and Wales	191
BURGESS, D. B. & FLETCHER, S. W.: Methods used to delineate groundwater source protection zones in England and Wales	199
MATHER, J. D., HALLIDAY, D. & JOSEPH, J. B.: Is all groundwater worth protecting? The example of the Kellaways Sand	211
Index	219

Referees

The Editor is grateful to the following people for their assistance with the reviewing of papers submitted to this Special Publication.

Dr P. J. Aldous	Thames Water Utilities, Reading
Mr D. J. Allen	British Geological Survey, Wallingford
Dr T. C. Atkinson	School of Environmental Sciences, University of East Anglia
Dr W. Back	US Geological Survey, Reston, VA., USA
Mr D. Banks	Norges Geologiske Undersokelse, Trondheim, Norway
Professor J. A. Barker	Department of Geological Sciences, University College London
Mr J. R. P. Bennett	Hydrogeological & Environmental Services, Belfast
Dr W. G. Burgess	Department of Geological Sciences, University College London
Mr D. Burgess	Environment Agency, Anglian Region, Peterborough
Mr K. Cullen	K T Cullen & Co, Dublin, Republic of Ireland
Mr I. R. Davey	Environment Agency, Thames Region, Reading
Dr R. A. Downing	Twyford, Reading
Mr J. Ferry	Geraghty & Miller, Cambridge
Dr A. J. Fleet	Department of Mineralogy, The Natural History Museum
Mr S. W. Fletcher	Environment Agency, Midlands Region, Solihull
Dr T. S. Haines	Entec Ltd, Shrewsbury
Dr J. Heathcote	Entec UK, Shrewsbury
Dr T. H. E. Heaton	NIGL, Keyworth
Dr K. M. Hiscock	School of Environmental Sciences, University of East Anglia
Dr D. G. Kinniburgh	British Geological Survey, Wallingford
Professor D. Lerner	Department of Civil Engineering, University of Bradford
Dr A. Lilly	The Macaulay Land Use and Research Institute, Aberdeen
Mr B. D. R. Misstear	Trinity College, Dublin, Republic of Ireland
Mr M. J. Morrey	Aspinwall & Co, Shrewsbury
Mr B. L. Morris	British Geological Survey, Wallingford
Professor R. N. Mortimore	Department of Civil Engineering, University of Brighton
Professor J. Mulready	Department of Civil Engineering, University of Leeds
Ms H. Nash	Wardell Armstrong, Newcastle-under-Lyme
Dr M. Owen	Environment Agency, Thames Region, Reading
Mr R. J. Peart	British Geological Survey, Keyworth
Mr M. Price	PRIS, University of Reading
Dr M. Robinson	Institute of Hydrology, Wallingford
Dr J. C. Rodda	Brightwell-cum-Sotwell, Oxon
Professor K. R. Rushton	School of Civil Engineering, University of Birmingham
Dr A. C. Skinner	Environment Agency, Midlands Region, Solihull
Dr P. L. Smedley	British Geological Survey, Wallingford
Mr D. C. Watkins	Camborne School of Mines, Redruth
Mr G. M. Williams	British Geological Survey, Keyworth
Dr E. P. Wright	Aston Tirrold, Oxon
Dr P. L. Younger	Department of Civil Engineering, University of Newcastle