ESTIMATION OF EVAPORATION FROM OPEN WATER

Estimates of evaporation from open water are increasingly required for several Environment Agency functions, particularly Water Resources and Ecology. Current methods of estimation vary between and, in some cases, within Regions; there is no generally adopted best method. Consequently, there is a need to review the Agency's requirements for estimating open water evaporation in relation to the methods and data available. The aims of this project are to:

- evaluate current methods of estimating open water evaporation;
- recommend the best available practicable methodologies for producing robust estimates;
- assess the associated uncertainty of these methodologies.

The project consisted of two Phases. Phase 1 dealt with the first two objectives and made recommendations for the quantified assessments of uncertainty carried out under Phase 2.

A survey of Agency staff in 1999 established that the Agency currently requires estimates of open water evaporation for 3 purposes: abstraction licensing, water balance studies and wetlands management. Empirical factors applied to estimates of potential evaporation (PE) are used to produce these estimates in all Areas and Regions. However, the values of the factors and data sets of potential evaporation employed vary between Regions and may vary between Areas. Thus, although there is consensus on the method, there is little on how it is operated.

The review identified seven methods of estimating open water evaporation. A ranking of these methods against nine criteria established that the equilibrium temperature approach would best serve the Agency's purposes. The use of empirical factors and the combination models were ranked equal second.

The spatial variability of the meteorological variables that drive evaporation is strongly influenced by proximity to the coast. Inland, the spatial variability of wind speed and air temperature is low whilst incoming solar radiation and relative humidity show significantly more spatial variability. Topography has a strong effect on the driving variables, either in terms of the lapse rates of air temperature and vapour pressure, or indirectly through the formation of clouds affecting the amount of incoming solar radiation.

Correcting for the effect of altitude on the driving variables can be achieved except for the effect of cloudiness on incoming solar radiation. Empirical corrections to evaporation estimates for altitude have also been found, and although this is not as physically rigorous as correcting the driving variables, the analysis indicated that the latter performed better.

The size of the water body affects evaporation rates in two ways. Firstly, there is evidence that, for water surfaces greater than 10 m in diameter, the rate of evaporation over water is enhanced due to increased wind speed resulting from the smoother surface. However, no means of taking these effects into account has been found. Secondly, the size of the water body in England and Wales affects the development of thermal stratification. The maximum depth of the warmer surface layer is a function of the surface area of the water body. This can have a significant effect on open water evaporation.

The methods recommended for use by Agency staff (equilibrium temperature and empirical factors) have been tested against measurements of evaporation made at Kempton Park. The results show that the estimates of open water evaporation made by the equilibrium temperature model are in excellent agreement with the measured values. Using the empirical

factors of Penman (1948) with MORECS grass PE, reasonable agreement was achieved. Other methods performed poorly.

The sensitivity of the estimates of open water evaporation made using the equilibrium temperature method to the parameters required was investigated and values for these parameters have been recommended.

New empirical factors, for use with MORECS grass PE, PENSE and PETCALC, have been calculated from the measured values at Kempton Park. The effect of different climate types in England and Wales on the accuracy of estimates of open water evaporation made using these factors has been investigated.

The accuracy of corrections for differences in altitude, between the meteorological station and the site for which an estimate of open water evaporation is to be made, have been tested.

The potential implementation of the equilibrium temperature method in the longer term is being considered, along with other options, by the Agency. In the medium term, the Agency should make use of the empirical factors developed by this project to be applied to MORECS grass PE, PENSE and PETCALC. Practical guidance in the use of these methods by Agency staff has been provided in a handbook "Estimating open water evaporation – guidance for Environment Agency practitioners" produced as part of the output from this R&D project. The recommended methods are to be reviewed by the Agency National Hydrology Group and may then go on to become Agency 'best practice' and part of the Environment Agency National Hydrology Handbook.

This R & D Technical Summary relates to information from Project W6-043 contained in the following outputs:

R&D Technical Report W6–043/TR: Estmation of Open Water Evaporation, A Review of Methods ISBN: 1 85705604 3

R&D Handbook W6-043/HB: Estimating Open Water Evaporation – Guidance for Environment Agency Practicioners ISBN: 1 85705603 5

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Copies of the Technical Report are available from each Regional Information Centre (Library) or the National Information Centre in Bristol, and externally from the Environment Agency R&D Dissemination Centre, c/o WRc plc, Frankland Road, Blagrove, Swindon, Wiltshire SN5 8YF, Tel: 01793 865138, Fax 01793 514562

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