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Development and Assessment of a Refined Probabilistic Rational Method for Design Flood Estimation in Drainage Regions A, C and U in South Africa

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South Africa currently has no set guidelines for Design Flood Estimation (DFE). However, there are several manuals which provide designers with several recommended methods. Many of these methods were developed in the late 1970s and need to be updated and modernized.

Flood Frequency Analysis (FFA) can be performed at-site or at a regional scale using long records of reliable observed data. However, when the required historical data are unavailable, other approaches are used to estimate design floods. These are based on empirical, deterministic or probabilistic approaches. As a consequence of the possible variability and inherent limitations of deterministic methods, a probabilistic approach is generally recommended.

In South Africa the Standard Design Flood (SDF) method is a probabilistic approach developed for South Africa but, as reported in a number of studies, requires refinement. This paper contains a review of suitable methods for use in the development of a refined probabilistic DFE method for South Africa. It was found that the Rational Method (RM) is the most appropriate method due to its familiarity, widespread use and ease of application. In order to develop a Probabilistic RM (PRM) calibrated coefficients at gauged sites were computed and the 10 % Annual Exceedance Probability (AEP) (C_{10}) flood peaks were used to generate a surface of C_{10}values. The C_{10} values are related to the remaining AEP flood peaks through the use of Frequency Factors (FF_T) that are derived from a regional FFA. Using goodness-of-fit testing and L-moment ratio diagrams, the most suitable regional FFA distributions were the General Pareto (GPA) and Generalised Extreme Value (GEV) distributions.

The pilot study was conducted in Primary Drainage Regions A, C and U. The FFA sites were grouped into hydrologically relatively homogeneous regions using clustering. The homogeneity of the clusters was verified using tests proposed by Hosking and Wallis (1993). The clustering generally resulted in homogeneous clustering of sites when considering only geographical proximity and a ratio between the 50 % and 2 % AEP design rainfall depth, yielding a total of ten homogeneous regions. Using Multiple Linear Regressions (MLR), relationships between the catchment parameters, C_{10} and FF_T were derived.

The C_{10}, FF_T and C_T models were verified using the "One-at-a-time" verification method, whereby each station was "hidden" for a single iteration during the surface generation and regionalization process. The use of performance statistics, as applied by Rahman *et al.* (2012), identified that the revised PRM DFE estimates were within acceptable limits for two of the clusters investigated.

When comparing the performance of DFE estimated using the PRM developed in this study with those estimated using the SDF method it was evident that a higher percentage of the PRM estimates fall within reasonable limits than the SDF method. In addition, the variance of the SDF estimates were up to double that of the PRM estimates.