Effect of land area on average annual suburban water demand

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ABSTRACT

Current guidelines for estimating the average annual residential water demand (AADD) in South Africa are based on residential plot size. This paper presents a novel, robust method for estimating suburban water demand as a function of the suburb area. Seventy suburbs, identified as being predominantly residential, were selected for analysis from the largest urban metropolitan area in South Africa. A linear relationship was noted between the total suburb water demand and two land cover areas, namely, the total suburb area and total residential plot area. The average demand for the 70 suburbs based on suburb area was 6.6 kℓ·d^{-1}·ha^{-1}, with 90% of the values in the range between 4.4 kℓ·d^{-1}·ha^{-1} and 8.7 kℓ·d^{-1}·ha^{-1}. The average demand was 10.4 kℓ·d^{-1}·ha^{-1} for calculation based on the residential area. The results are useful when crude estimates of AADD are required for planning new land developments.

Keywords: urban water demand, suburb area, residential

SYMBOLS

A_{PLOT}	-	Individual residential plot area (m^2)
A_{RES}	-	Total residential plot area in a suburb (ha)
A_{SUB}	-	Total suburb area (ha)
$AADD$	-	Average annual daily water demand (kℓ·d^{-1})
$AADD_{SUB}$	-	Average annual daily water demand of an entire suburb (kℓ·d^{-1})
x	-	Area parameter for linear fit (ha)
α	-	Linear slope
α_{SUB}	-	Linear slope in relation to A_{SUB}
α_{RES}	-	Linear slope in relation to A_{RES}
β	-	Linear intercept

INTRODUCTION

Land development and water demand

Guidelines for residential average annual water demand (AADD) based on plot size were introduced to the South African Civil Engineering fraternity before 1960. The AADD still forms the basis of calculations performed during the design and analysis of water distribution systems. Jacobs (2007) provided a chronological review of South African AADD guidelines used between 1950 and 2007 and noted that only two guidelines were employed for relatively long periods at a time, namely those of the Department of Water Affairs prior to 1965 (DWA, 1975) and various CSIR guidelines thereafter (Van Duuren, 1965; CSIR, 1983).

One of the first steps in planning water services for land development is to obtain an estimate of the water requirement of the potential future land users, both in terms of the expected AADD and peak flows. This research project focused on residential land use and the AADD, which is still applied in South African practice as a basis for estimating residential peak flows.

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Estimating residential water demand in South Africa

Various methods are available for estimating residential AADD in South Africa, but this is the first investigation into demand at a relatively large spatial scale. The most recent methods for estimating residential AADD in South Africa use individual plot size (m^2) as an independent variable to provide an estimate of AADD (in kℓ·d^{-1}) for the particular property (Van Zyl et al., 2008; Jacobs et al., 2004).

Research problem

The problem in applying local guidelines for AADD to new land developments is that the residential plot size remains undetermined at the early stage of urban planning and the planner needs to make crude assumptions in order to apply the available methods. The spatial resolution could be increased with end-use modelling (Buchberger and Wu, 1995), where each property needs to be described in more detail by considering individual water use events. Application of end-use modelling has also been illustrated in South Africa (Jacobs and Haarhoff 2004; Van Zyl et al., 2003). However, end-use modelling poses no solution to the problem of estimating water demand for new land developments, because an increased number of parameters are needed for end-use models.

The approach presented in this paper was to decrease the spatial resolution to investigate the AADD of suburbs as a function of the total land area, a parameter that is easy to obtain at an early stage of urban planning. The entire suburban area would ultimately include the roads, parks and public open spaces in addition to the residential properties, despite much of this not requiring water supply per se.

Objectives

Suburban AADD in terms of the water demand per hectare was reported by Vorster et al. (1995) for what was then called the East Rand region, now known as Ekurhuleni Metropolitan Municipality in Gauteng Province, South Africa. Stephenson and Turner (1996) also reported AADD per hectare for '14 varied areas' in Gauteng Province. These publications

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