

Comparison of several EPA-recommended US and German well-head protection area delineation methods in agricultural settings

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Abstract

Preventive measures for protecting water supplies from contamination necessitates the delineation of well-head protection areas (WHPAs), in which potentially groundwater-endangering activities are strictly regulated and monitored. In the case of private well operators in agricultural settings, there generally exists greater control of restricting and regulating particular land uses in the proximity of a well-head, than in municipal settings. However, due to typically limited and strained financial resources of farm operators, alternative and affordable WHPA delineation methods would be of great advantage. Consequently, relatively simple and inexpensive well-established German WHPA delineation models were evaluated to several typically more cost-intensive United States Environmental Protection Agency (EPA)-recommended WHPA delimitation methods in three agricultural settings, located in south-eastern Pennsylvania. The delineation results revealed that several of the German approaches compared fairly well with the more advanced numerical module, which is recommended by the EPA. Hence, German WHPA delineation methods may provide a viable alternative for WHPA delineation in agricultural settings.

Keywords: well-head protection area, private water supply, delineation method

Introduction

The contamination of groundwater by harmful substances has many natural and anthropogenic causes. A significant portion of groundwater contamination is associated with agricultural land uses. In fact, the contamination of groundwater in agricultural settings has increased with the intensification, specialisation, and mechanisation of agricultural production. Intensive agricultural and horticultural land utilisation calls for the optimal combination of inputs to achieve high yields and, therefore, maximise profits. In regions with intensive livestock farming, manure has become a troublesome waste product and can directly impact surface and groundwater quality. The impact on drinking water supplies from agricultural operations is of particular concern in intensive processing regions and where high value specialty crops are grown. Because the quantity and quality of drinking water demands are increasing, there is greater demand for groundwater protection.

Well-head protection ultimately decreases the risk of water supply contamination. In the long run, well-head protection is designed to prevent expensive groundwater clean-up operations or well-field relocation. The main feature in well-head protection is the delineation of the well-head protection area (WHPA), which is the mapping of the area under the WHPA. This area typically can range from less than a hundred metres to several kilometres from a well (Lennox, 1993). Moreover, the delineation of a WHPA involves investigating the water-bearing zone

for its soil cover type, thickness, quality, productivity, depth to groundwater, present land uses, as well as potential threats originating from the surface above the water-bearing zone. Generally speaking, it is the land surface surrounding a well, well-field, or spring into which contaminants are likely to enter (Cleary and Cleary, 1991; EPA, 1987). Therefore, outlining a protection area around wells and springs is the basis for developing a contamination control system. Within this protection area, activities are managed to prevent further sources of contamination. It is important to define a sufficient protection area so that contaminants from beyond the boundary can be treated or diverted before reaching the water supply.

Due to the higher threat of contamination of non-public wells in agricultural settings, cost-effective, but reliable, delineation methods are urgently needed. As noted by Doscher (1992), particularly private well operators in agricultural regions are often financially constrained, however; normally have greater control in regulating and restricting land uses in the recharge areas of their water supply. Strobl and Robillard (2005) provided a brief overview of EPA (1987)-recommended WHPA delineation methods (Blandford and Huyakorn, 1991; 1993) as well as in-depth examinations of some well-established German WHPA delineation approaches. It should be noted that these delineation methods were derived exclusively for porous aquifers and are not suitable for use in fractured rock environments. Strobl and Robillard (2005) concluded that in order to evaluate the applicability and validity between the methods when employed in private water supplies in agricultural settings, specific case studies need to be performed. In this paper, WHPA delineation case studies will be used to compare different delineation methods. A comparison of the outer boundaries of the respective WHPAs is made and the probable amount of under-protection or overprotection estimated. Furthermore, the effects of

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