HYDROGEOLOGIC ANALYSIS OF ON-SITE SEPTIC SYSTEM LOT SIZE

Dennis McQuillan, Tom Brandt, and Gary Beatty
New Mexico Environment Department, Field Operations Division
525 Camino de los Marquez, Suite 1, Santa Fe, NM 87505

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Introduction

Ground-water quality impacts caused by on-site septic systems are discussed by McQuillan (2004). This paper discusses the effect that lot size has on the magnitude of those impacts. Lot size determines the rate of mass loading per area, and is a critical factor in the degree to which natural attenuation occurs between the location where septic effluents enter the aquifer, and the nearest down-gradient point of ground-water withdrawal. A number of field studies and modeling simulations have addressed the effect of lot size on ground-water quality (Woodward et al., 1961; Konikow and Bredehoeft, 1978; Ford et al., 1980; Perkins, 1984; Yates, 1985; Earp and Koschal, 1986; Geohydrology Associates, Inc. 1989; McQuillan et al., 1989; Lowe et al., 2000; Thomson et al., 2004).

New Mexico regulations define Lot Size (LS acres) as the acreage of the lot itself excluding roadways and easements. Assuming that roads comprise 15% of the area in a residential community, the lot density would be LS * 1.15. For an area developed with on-site systems, the Mass Loading Rate (MLR) in lbs/acre/yr can be calculated as follows:

$$\text{MLR}, \frac{\text{lbs}}{\text{ac yr}} = Q\,\frac{\text{gal}}{\text{day}} * \frac{365\ \text{day}}{\text{yr}} * \frac{3.78\ \text{L}}{\text{gal}} * \frac{C\ \text{mg}}{\text{L}} * \frac{2.2\ \text{lbs}}{10^6\ \text{mg}} * \frac{1}{A\ \text{ac}} \quad \text{where}$$

A = lot density = LS * 1.15, ac
C = contaminant concentration, mg/L
Q = wastewater flow rate, gal/day

The MLR for 375 gpd wastewater, with 60 mg/L total nitrogen, on a 0.75 acre lot would be

$375 * 365 * 3.78 * 60 * 2.2\text{x}10^{-6} / (0.75 * 1.15) = 79$ lbs N/ac/yr

In New Mexico, residential developments with average lot densities up to 0.84 acre have caused ground-water contamination in excess of allowable standards (Table 1). In the Albuquerque South Valley, the highest concentrations of ground-water manganese (greater than 1 mg/L) are associated with areas having the highest densities of on-site septic systems (Table1; Gallaher et al., 1987; Geohydrology Associates, Inc., 1989), and there appears to be a similar association with ground-water iron (Anderholm, 1987). The Utah Geological Survey calculated lot densities, ranging from 3 to 54 acres, that would increase background nitrate-N in ground water by 1 mg/L (Table 1). Relationships between mass loading rates and impacts to ground water quality, for both field studies and modeling simulations, are shown in Figure 1.

Discussion and Conclusions

Septic system effluents are migrating to, and chemically impacting, aquifers deeper than 100 feet. There is mounting evidence that the minimum New Mexico lot size of 0.75 acre (lot density of 0.86 acre) may not be adequate to protect ground water in all hydrogeologic environments.

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Table 1. Quantitative Studies on the Effect of Septic System Lot Size on Ground-Water Quality.

Location	Average Lot Density (acres)	Depth to Ground Water (feet)	Mass Loading Rate lbsN/acre-year)	Ground-Water Impact (max above background)	Reference
Albuquerque, Sandia Heights	1	200-400	68	2.5 mg/L NO_3-N	Thomson et al., 2004
Albuquerque, Western Barcelona Road area	0.43	30-60	159	22 mg/L NO_3-N	McQuillan et al., 1989
Bernalillo County, Inner Rio Grande Valley	 2 1.5 1 0.75 0.5 0.25	< 30	 34 46 68 91 137 273	mg/L NO_3-N 12 14 18 21 24 30	Geohydrology Associates, Inc. 1989
Bernalillo County, Inner Rio Grande Valley	 13.9 2.5 1.03 0.78	< 30		mg/L Mn, average 0.2 0.6 1.0 1.0	Geohydrology Associates, Inc. 1989
Ruidoso Downs, Palo Verde Slopes	0.82	60-200 126 average	83	12 mg/L NO_3-N	unpublished NMED data
Utah, Castle Valley, Grand County	5 to 15		14 to 5	1 mg/L NO_3-N	Lowe et al., 2004
Utah, Cedar Valley, Grand County, Hamiltons Fort	5.6	18-176 < 100 average	12	1 mg/L NO_3 –N	Lowe et al., 2000
Utah, Cedar Valley, Grand County, Bauers Knoll	54	15-210 40 average	1	1 mg/L NO_3-N	Lowe et al., 2000
Utah, Ogden Valley, Weber County	3		23	1 mg/L NO_3-N	Wallace and Lowe, 1998a
Utah, Tooele Valley, Tooele County	53		1	1 mg/L NO_3-N	Wallace and Lowe, 1998b

Figure 1. Mass Loading and Maximum Ground Water Contamination with Nitrate from On-Site Septic Systems.
The health standard for nitrate in ground water and drinking water is 10 mg/L as N (red dashed line). The mass loading rate for the design flow for a three bedroom house on 0.75 acre lot is 79 lbsN/acre-year (purple dashed line).