Title: **Subdivision Impacts on Groundwater Quality**

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Background/Need: Concern over the impact of subdivisions on groundwater quality has been growing due to increased incidence of high nitrate in private wells, concern over wellhead protection, and an awareness of groundwater protection. In Portage County, increasing lot sizes to protect groundwater from septic systems has resulted in more expensive housing and other problems. Historical data indicates groundwater quality problems or the potential for groundwater quality problems for the Jordan Acres and Village Green subdivisions selected for this study.

Objectives: To determine homeowner practices that impact groundwater quality, attitudes about groundwater quality and protection, and the relationship between beliefs about groundwater contamination and chemical use practices. To determine areas of greatest educational need. To determine nitrate loading to groundwater from septic systems and lawns and evaluate the use of the BURBS nitrogen mass balance model for predicting nitrogen impact. To determine the impact of individual septic systems on nitrate and phosphorus concentrations in groundwater. To determine if volatile organic compounds (VOCs) are reaching groundwater from subdivision activities. To evaluate monitoring systems for use in determining subdivision impacts on groundwater. To evaluate Electrical Resistivity (ER) and Ground Penetrating Radar (GPR) for locating septic system effluent plumes.

Methods: A survey was conducted of subdivision households to collect information regarding chemical usage, waste disposal patterns and fertilizer/pesticide usage. 139 of 184 property owners participated in the survey. Frequencies were calculated for pesticide use and household chemical use. Significant relationships between and among questionnaire parameters were searched for. For the BURBS model, demographic-type variables were defined using subdivision averages and areal-type variables were based on land use in specific areas. Hydraulic gradient and groundwater flow direction were determined. Multiport monitoring wells were installed along transects established parallel to groundwater flow. One up and one downgradient well at each subdivision had additional sampling ports. Five septic systems and one lawn from each subdivision were further monitored by one upgradient and at least one downgradient well. Several additional monitoring wells were installed after the study began where additional water quality information was needed. Field pH and conductivity were measured. Samples were collected for nitrate, chloride, reactive phosphorus, sodium, alkalinity, total hardness, relative fluorescence, VOCs, Polynuclear aromatic hydrocarbons, and semi-volatile organic compounds analyses.

Results: Household cleaning product use in the two subdivisions was similar. Chlorine bleach and other products hazardous to septic systems and groundwater were frequently used. The method of waste disposal of household maintenance products is a significant concern. Lawn care practices were similar between the two subdivisions but overall fertilizer use rates were lower in Jordan Acres. Lawn fertilization frequency was related to mowing frequency, watering frequency, and tendency to remove lawn clippings. Wells are generally driven points with an average depth of 9 meters. Homeowners generally reported following proper sewage disposal system maintenance. Most participants believed groundwater contamination was a serious problem in their county and were knowledgeable about groundwater contamination issues, but some lacked understanding of how their own actions may affect groundwater quality. In general there is not a good relationship between household chemical use practices and attitudes about groundwater contamination. The BURBS model estimated fertilizer leaching for Village Green to be lower than those for Jordan Acres

primarily due to the higher percentage of turf at Jordan Acres. Septic systems contributed larger amounts of nitrate to groundwater than do lawns. Average reduction in nitrogen concentration from septic tank to groundwater adjacent to drainfields was approximately two-fold. Phosphorus concentrations ranging from 1 to 11 mg/l were found downgradient of four septic systems. A limited number of samples were found to contain relatively low concentrations of VOCs. ER was limited by space requirements and electrical interferences. GPR results were inconclusive.

Conclusions: Lawns and septic systems contribute nitrate to groundwater, with septic systems having a greater impact than lawns. The BURBS model adequately estimates subdivision water and nitrogen mass balances as long as the variables are well defined. Using an average groundwater recharge of 24.6 cm/yr and three people/household, housing densities of less than 1.1 to 1.7 dwellings per hectare were needed to model nitrate concentrations below 10 mg/l. Mixing of subdivision-originated groundwater with that from upgradient sources is minimal. Due to the runoff water from roads and roofs, groundwater recharge from within a subdivision on sandy soils is considerably greater than from adjacent fields and woods. This results in greater dilution of septic system contaminants. The opposite would be true in areas where most road and roof runoff goes to surface runoff rather than to groundwater recharge. The amount of fluorescence in groundwater samples was generally a good indicator of septic effluent and was useful in identifying water originating from within the subdivision. The ratio of sodium to chloride was useful in determining groundwater sources. Plumes from single or even a row of septic systems show minimal horizontal or vertical mixing with groundwater from other sources. Phosphorus concentrations indicate that sandy soil can become saturated with phosphorus within less than 20 years, resulting in significant leaching of even this relatively immobile chemical. Current levels of use and disposal of VOCs were low enough to prevent any high concentrations from reaching groundwater. ER and GPR are of limited value for locating septic plumes in the subdivision environment.

Implications/Recommendations: Well locations for monitoring subdivision impacts need to be carefully chosen to avoid overestimating or underestimating specific impacts. Well placement and depth need to be carefully considered relative to drainfield location and groundwater flow direction to prevent unwanted recycling of wastewater.

Related Publications: Mechenich, C. and B.H. Shaw. Chemical use practice and opinion about groundwater contamination in two unsewered subdivisions. J. Env. Health. 58:6. pp. 17-23.

Key Words: subdivision, septic systems, nitrate

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Final Report: A final report containing more detailed information on this project is available for loan from Wisconsin's Water Library, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706 (608) 262-3069.