The Use of GIS in Modeling Ground-Water Vulnerability to Nitrate in the High Plains aquifer

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GIS is often used as an important tool in developing ground-water vulnerability models and corresponding maps, which are valuable for ground-water resource management and planning. In this study, which is an expansion of a pilot study, ArcGIS Desktop and Workstation were used to extract geospatial data from various large data sets for input to a logistic regression model of ground-water vulnerability and to produce a corresponding vulnerability map. The map illustrates the predicted probability of recently recharged (defined as less than 50 years) ground water of the High Plains aquifer to non-point source nitrate contamination. Spatial data from 31 individual vector and raster layers were extracted for each of 6,946 well locations throughout the study area. These layers included information about saturated thickness, depth to water, precipitation, percent irrigated/nonirrigated/agricultural land, nitrogen applications, soil characteristics, lithology of unsaturated zone, playa lakes, and water use. Extractions for categorical data and certain continuous data sets were performed using a series of identity overlays, directly from the layer at the location of each well. Ninety-degree sectors of varying radii, which was determined by hydraulic conductivity, were created upgradient from each well for extraction of data where information needed to be related to a well location. These variables were inventoried for the 90-degree sector areas using both vector-union techniques and raster map-algebra techniques. The extracted data were used as input for logistic regression analyses to determine which of the variables (layers) or combination of variables were significantly correlated with observed water-quality conditions and would be used in a model of the probability of predicting nitrate concentrations greater than 4 milligrams per liter (as N) in ground water. Five variables were considered significant (depth to water, organic content of soils, amount of irrigated/nonirrigated land, and the amount of clay in the unsaturated zone) in the final two models that were developed to represent different regions of the study area. The appropriate GIS layers were converted to raster data sets in order to use the map algebra capabilities of ArcGIS. The two model equations and the various coefficients for each layer were fed back into ArcGIS and, using map algebra, the probability surface was calculated and then easily visualized across the entire study area with GIS.