

## Summary

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Regional concentrations of farms raising livestock and poultry in confinement and their potential adverse effects on water quality and public health have prompted Federal regulations and guidelines on animal waste management. The primary emphasis of recent policies is to limit the application of manure to land at rates no greater than those at which crops can extract specified nutrients from the manure. Limiting the rate of manure application will limit potential nutrient runoff to surface water. However, many confined animal operations have insufficient land on the farm to land-apply all the manure produced without exceeding nutrient requirements of the crops grown. Some of the manure, therefore, must be moved off the farm to be spread on other land in the area. In regions with many confined animals, manure-hauling distances (and the resultant costs) are determined largely by the spatial distribution of land area available for manure application relative to the location of animal operations requiring additional land.

### ***What Is the Issue?***

An accurate assessment of the costs of manure hauling and land application argues for a regional perspective that accounts for the acreage needed (in addition to land on the animal farm itself) and that considers spatial interactions across animal operations and agricultural land resources. A regional analysis—in contrast to farm-level or national sector assessments—can be more readily designed to capture the effect of competition for limited land resources under alternative policy settings. As part of a broader ERS assessment of the costs of manure management, a regional modeling framework was developed to evaluate the effect of Federal guidelines for farmland application of manure on hauling and spreading costs. Results from an initial application of the modeling system are featured in the ERS publication *Manure Management for Water Quality: Costs to Animal Feeding Operations of Applying Manure Nutrients to Land* (AER-824, June 2003).

This report, *Technical Documentation of the Regional Manure Management Model for the Chesapeake Bay Watershed Model*, presents details of the regional modeling system applied to production and disposal of animal manure in the Chesapeake Bay watershed—an environmentally sensitive area with large concentrations of confined animals. The model is used to evaluate the feasibility of land application of manure as a regional manure management strategy and the effect of key policy provisions and manure use assumptions on costs to the animal sector. The report includes an overview of the model's scope and structure, data sources, and modeling assumptions.

### ***How Was the Study Conducted?***

The model is designed to assess regional costs of managing the manure on the farm of origin and transporting and spreading it on area farmland, given the existing structure of the animal industry, manure-storage technologies, and alternative manure disposal options currently in use. The modeling system is centered on a nonlinear mathematical programming model of animal manure-nutrient production and distribution.

The regional model allocates manure nutrients produced within the Chesapeake Bay basin to agricultural land for crop use to minimize hauling and land application costs incurred by the regional animal sector, given land availability and nutrient management policies. The model was defined at a watershed spatial scale that includes portions of six States (Virginia, Maryland, Delaware, Pennsylvania, New York, and West Virginia) to account for the regional distribution of crop and pasture land as well as the animal operations competing for available land resources. A watershed scale is also appropriate for potential modeling extensions designed to assess implications of Federal manure management policies on water quality in the Chesapeake Bay.

A defining feature of the regional modeling system involves the integration within an optimization framework of (1) cropland coverage from a Geographic Information System (GIS) and (2) farm-level data from the 1997 Agricultural Census, aggregated to the county level. Counties within the watershed serve as the primary modeling unit, providing consistency with Census of Agriculture data and other county-level data. County-level specification permits subregional differentiation in animal production, nutrient uptake, waste technologies, and regulatory conditions across county and State boundaries within the watershed. Reliance on national data series for key model parameters (e.g., number of animals) is an important element of the modeling framework, ensuring consistency of data within the watershed while facilitating the potential for model updates and transferability of the model to other U.S. watersheds.

Key decision variables in the model include the quantity of manure transported by system type, the hauling distance of manure moved off the farm, and acres used for manure spreading in receiving counties. The direction and magnitude of manure transfers is determined by the nutrient and moisture content of the source manure, the nutrient uptake capacity of receiving lands, and per-unit costs of manure hauling and land application.

### ***What Did the Study Find?***

The regional modeling framework provides a unique and valuable perspective on the cost of Federal regulations and guidelines for manure land application. The integration of Census and GIS data enables the regional model to capture important spatial interactions between animal concentrations and land available for manure spreading.

With a large proportion of animal producers dependent on land off the farm for manure spreading, competition for available land resources is an important consideration in the costs of managing manure. Competition for land and the resultant hauling requirements and costs of manure management will depend, in turn, on the (policy-determined) manure application rate, quantities of manure that can be used for industrial purposes, and landowners' willingness to accept manure on farmland.

During the initial application of the model, a number of potential model improvements and extensions were identified. Several priority extensions of the model are under development for future model applications, as outlined

in the conclusion of this report. For a review and analysis of findings from the initial application of the model, see *Manure Management for Water Quality: Costs to Animal Feeding Operations of Applying Manure Nutrients to Land* (AER-824, June 2003).