OFR 92-107

WATER FACT SHEET

U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

HYDROLOGIC RESEARCH AT THE PRINCETON, MINNESOTA MANAGEMENT SYSTEMS EVALUATION AREA

BACKGROUND

The Management Systems Evaluation Area (MSEA) program is part of a multi-scale, inter-agency initiative to evaluate the effects of agricultural management systems on water quality. The program resulted from the integration of the U.S. Department of Agriculture (USDA) Research Plan for Water Quality and the U.S Geological Survey (USGS) Mid-Continent Herbicide Initiative and is part of the President's Water Quality Initiative. The mid-continental corn belt was selected for study because it is an area where about 60% of the Nation's pesticides and nitrogen fertilizers are used.

The USGS, Agricultural Research Service (ARS), Cooperative State Research Service (CSRS) of the USDA, and U.S. Environmental Protection Agency (EPA) are collaborating on research at scales ranging from laboratory to small (about 20-square-mile) watersheds that have the objectives to: (1) measure the effect of prevailing and modified farming systems on ground-water and surface-water quality; (2) understand the processes and factors affecting the fate of selected agricultural chemicals; (3) assess the effect of selected agricultural chemicals on ecosystems; (4) assess the projected benefits to water quality of implementing modified farming systems; (5) evaluate the socioeconomic effects of using alternative farming management systems; and (6) transfer appropriate technology for use on the land.

Five MSEAs (fig. 1) were selected to represent some of the principal hydrogeologic settings and geographic diversity of prevailing management systems in the region. MSEAs in sand and gravel settings are in Minnesota, Nebraska, and Ohio. Those in loess and till are located in Iowa and Missouri. Research is focused on ground-water processes in all areas, but stream processes also are a major consideration at areas in Iowa and in Missouri.

Figure 1. Location of MSEA (Management Systems Evaluation Area) sites in the Midwest.

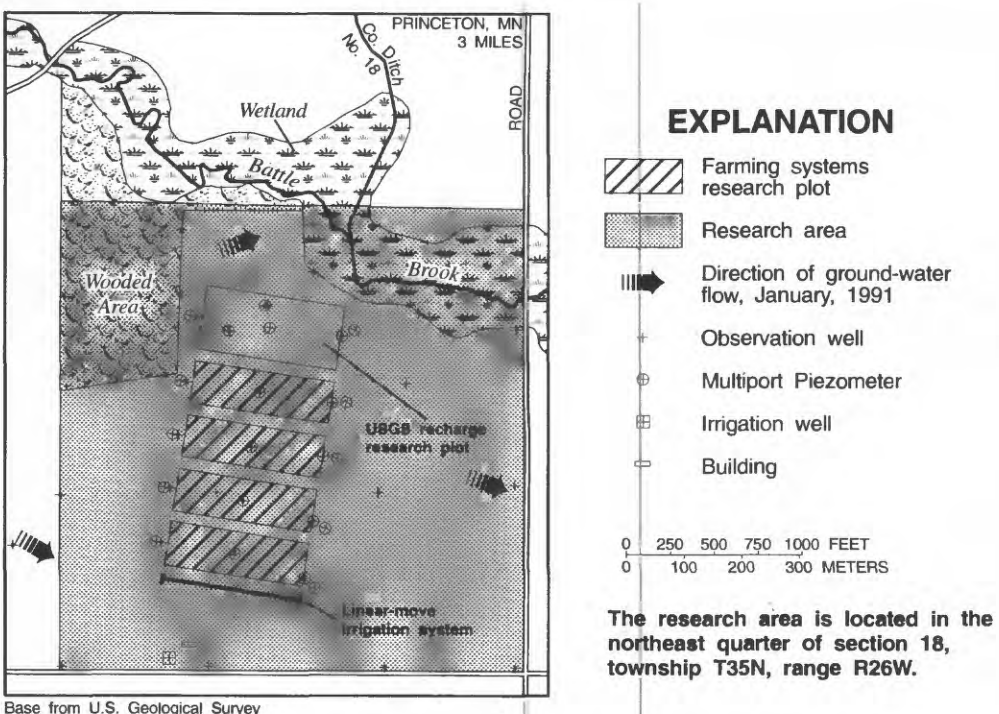
The interagency research objective of the northern cornbelt sand-plain MSEA is to implement modified and prevailing farming systems in a sand-plain setting in Minnesota and at satellite areas in North Dakota, South Dakota, and Wisconsin (fig. 1). The modified farming system involves irrigated ridge-tillage in a corn/soybean rotation and the prevailing farming system in the Anoka Sand Plain involves irrigated conventional tillage in continuous corn. Nitrogen fertilizer and the herbicides atrazine, alachlor, and metribuzin are used. The effects of the modified farming system on ground-water quality will be assessed in four sand plain settings that have slightly different climatic conditions.

DESCRIPTION OF THE PRINCETON, MINNESOTA MSEA

The modified farming system research area is located near the town of Princeton, Minnesota, about 60 miles northwest of the Twin Cities of Minneapolis and St. Paul (fig. 1). Material in the unsaturated and saturated zones generally consists of fine-to-medium sand and medium-to-coarse sand, respectively. A 0.2- to 1.1- foot (ft) thick silty layer is present locally within the unsaturated zone, primarily around the perimeter of the 0.25 square-mile site. Clay-rich till of smaller permeability underlies the surficial aquifer.

Ground water generally discharges to Battle Brook, which flows along the northern edge and east of the Princeton MSEA (fig. 2). Ground-water flow generally is from west to east through the area from November through April (fig. 2). The flow of ground water shifted to a more northerly direction from May through October of 1991, however, because of increased recharge during spring. Consequently, ground-water-flow gradients vary seasonally between 0.001 and 0.002 ft per ft throughout the area. The average depth to the water table is about 12 ft below land surface and the saturated thickness ranges from 16 to 40 ft. Based primarily on analyses of slug-test data, saturated hydraulic conductivities are about 100 ft per day.

Surface and ground waters at the Princeton MSEA are predominately calcium bicarbonate type. Water samples from 14 wells collected during April 1991, before application of agricultural chemicals, had mean concentrations of: calcium 38.1 milligrams per liter (mg/L), magnesium 8.4 mg/L, sodium 3.0 mg/L, potassium 0.9 mg/L, and silica 7.6 mg/L. The median concentration of nitrate-nitrogen was 7.03 mg/L, with maximum concentration of 19.92 mg/L. Atrazine was detected in one well at a concentration of 0.17 micrograms per liter (μg/L) and was detected below the reporting limit of 0.08 μg/L in another well. The atrazine metabolite de-ethylatrazine was the most frequently detected herbicide in ground water, being detected in 9 of the 14 wells. The median concentration of de-ethylatrazine was 0.12 μg/L with a maximum concentration of 2.30 μg/L. The median concentration of atrazine metabolite de-isopropylatrazine was below the reporting limit of 0.08 μg/L with a maximum concentration of 0.98 μg/L. Concentrations of metribuzin, alachlor, and alachlor metabolites chloroalachlor and metalachlor were below the reporting limit in samples collected during April 1991.



Base from U.S. Geological Survey
Princeton 1:24,000 quadrangle, 1982

Figure 2.--Plot layout at the Princeton, Management Systems Evaluation Area

HYDROLOGIC RESEARCH AT THE PRINCETON MSEA

The specific objectives of research by the Minnesota District of USGS at the Princeton MSEA are to determine (1) the relation of spatial and temporal distribution of agricultural chemicals to transient recharge, topography, and subsurface heterogeneities, and (2) the effect of the ridge-tillage farming system on ground-water quality.

To assess the effects of recharge on the movement of agricultural chemicals through the unsaturated zone, controlled recharge experiments are being conducted in upland and lowland sites of the recharge research plot (fig. 2). The recharge experiments will consist of controlled application of water, nitrogen fertilizer, atrazine, and conservative tracers. The following monitoring equipment are being installed at each site and connected to a datalogger: (1) time-domain reflectometry probes and neutron-access tubes to measure soil moisture, (2) tensiometers to measure soil-moisture tension, (3) thermocouples to tract the movement of wetting-fronts, (4) a shaft encoder to measure water-level fluctuations, and (5) a precipitation gage to measure rainfall and irrigation water inputs. Samplers are also being installed in the unsaturated and saturated zones to collect ground water and determine concentrations of agricultural-chemicals.

The effect of the ridge-tillage farming system on ground-water quality is being determined by analyzing water samples collected from multiport piezometers installed upgradient, within, and immediately downgradient of the farming system (fig. 2). Six sampling ports are included in each sampling unit at 1.6 ft intervals in the saturated zone to determine the three dimensional distribution of agricultural-chemicals. Water samples are being collected from the multiport piezometers, ground-water observation wells, precipitation, and from Battle Brook both up- and down-stream of the MSEA (fig. 2). Samples also are being collected from observation wells located offsite to determine the concentrations of agricultural chemicals in these adjacent areas. Each point will be sampled at least four times per year to quantify the concentrations of agricultural chemicals after they are applied to the plots and after recharge.

In addition to the above described research, other objectives include evaluating the (1) influence of spatial variation in soil properties in controlling water and solute flux through the unsaturated zone; (2) influence of macropores on the flow and transport of agricultural chemicals; (3) effects of evaptranspiration on pesticide distributions and transport in the unsaturated zone; (4) effects of agricultural chemicals on wetlands; (5) biodegradation of agricultural chemicals in the unsaturated and saturated zones; (6) interactions of natural organic matter with agricultural chemicals; (7) nitrogen cycling; and (8) isotope fractionation.

SELECTED REFERENCES

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