

# The Hydrologic Cycle: How Water Movement Affects Water Quality

John M. Jemison, Jr., Extension water quality and soil specialist

## Introduction

To understand how contamination of groundwater and surface water occurs, it is necessary to understand the hydrologic cycle—the endless circulation of water from the ocean, atmosphere and land. Then you can understand how contaminants move with it.

The hydrologic cycle begins with precipitation in the form of rain, snow, sleet or hail falling on the surface of the earth. As precipitation falls, some of it may evaporate directly into the atmosphere from bodies of water and land surfaces and a portion may be intercepted by vegetation. The remainder reaches the ground, where it can enter the soil by a process called infiltration.

Some of the infiltrating water remains near the soil surface and evaporates into the atmosphere. Another portion is extracted by plant roots and transported to leaves where it is lost to the atmosphere as a vapor. This process is called transpiration.

When the precipitation rate exceeds the infiltration rate, excess water builds up on the soil surface and moves by overland flow called surface runoff. If surface runoff is excessive or concentrated, erosion can occur.

Still another portion of water that enters the soil can move vertically or laterally out of the plant root zone. Significant lateral movement of water through the

soil is called throughflow or interflow. Downward movement of water through the soil is referred to as percolation.

Percolating water eventually makes its way to a saturated zone, where all spaces between rock and soil particles are filled with water. The water filling the spaces between soil particles and rock in the saturated zone is called groundwater.

## Groundwater flow

Recharge is the process in which water percolating through the soil replenishes groundwater. Because the amount of precipitation and evaporation varies seasonally, the rate at which groundwater is recharged will vary seasonally as well. In turn, the depth to the water table will vary. The water table is the upper boundary or top of the groundwater. Water moves within the saturated zone under the influence of gravity from areas where the water table elevation is high toward areas where the water table elevation is lower. As it does, groundwater may flow into surface water, such as a lake or river. In fact, this process, known as baseflow, accounts for rivers and lakes.

One common misconception, however, is that groundwater moves somewhat rapidly. In reality, groundwater moves much more slowly than water in a river or stream. This is because groundwater must overcome friction to move through the small spaces between soil particles and rocks. While water in a stream may move several inches or feet per second,

groundwater generally moves several inches or feet per month. Because groundwater flows slowly, most wells draw on the groundwater that lies close to the point where it is withdrawn. This is why activities taking place on the land surface closest to the well have the greatest impact on water quality.

### **Aquifers and Aquitards**

An aquifer is defined as permeable, geologic material through which significant quantities of water can move. Geologic materials that serve as aquifers include unconsolidated material, such as sand and gravel, including tills; permeable sedimentary bedrock, such as sandstone, limestone and dolomite; and fractured crystalline bedrock.

Geologic material through which significant quantities of water cannot move is referred to as an aquitard or aquiclude. Clays, shales, dense crystalline and sedimentary bedrock, and other very slowly permeable materials are common aquitards.

Aquifers and aquitards vary in their occurrence, thickness, continuity and depth. A confined aquifer is bounded on the top and bottom by aquitards. In contrast, unconfined aquifers are overlaid by permeable layers and are generally found close to the land surface.

### **Groundwater Contamination**

Groundwater becomes contaminated as substances are leached downward by percolating water. Some groundwater contamination occurs naturally, but contamination usually is the result of human activities on the land surface.

An aquifer overlaid by an aquitard is less susceptible to contamination than one that is not because contaminated water has difficulty percolating through

the aquitard. In addition, deep aquifers are relatively less susceptible to contamination than shallow aquifers because of the distance the contaminant must move in the soil before reaching a deep aquifer. However, these relative differences, and differences in percolation rates due to different geological structures, have little practical effect in Maine. Most groundwaters are vulnerable to contamination.

### **Point and Nonpoint Source Pollution**

Point sources of contamination are identified by a well-defined point of entry where pollutants reach a body of water, such as municipal and industrial treatment facilities, where treated wastewater is discharged into rivers or streams.

Nonpoint sources of contamination have no easily identified point of entry where pollutants reach a body of water.

Contaminants originate from a wide variety of sources over a wide area, and they enter surface water and groundwater at many locations, by many processes. Pesticides and fertilizers applied to cropland, effluent from septic systems, leaching of highway de-icing salts, landfill leachate and products from leaking underground storage tanks are commonly identified as nonpoint sources of pollution. It is important to consider the cumulative effects of the nonpoint source problem.

### **What's Beneath Your Land?**

After becoming familiar with these concepts, the next step is to determine the source of your well water. Is it a sand and gravel or a bedrock aquifer and is the aquifer confined or unconfined. What is the potential for contamination?

If the company that drilled the well is not known, general information may be obtained from the Maine Geological Survey, Ray Building, Hospital St., Augusta, ME 04333, (207) 287-2801.

### **Protecting Your Water Supply**

You should pay particularly strict attention to the handling and disposal of potential contaminants, such as pesticides, fertilizers, cleaning solvents and motor oil. Mix and handle chemicals as far from the well as possible.

In addition, if large amounts of pesticides are mixed and handled, consider installing a concrete pad and rinsate collection system, far from the

well. Chemicals can be mixed and handled there safely. Rinsate should be reapplied in the field or garden. Follow state rules for triple-rinsing and disposal of pesticide containers. Prepare a management plan for application of waste products so that you don't apply too much. Follow application directions strictly. The University of Maine Cooperative Extension has a notebook available for agricultural producers on best management practices. For a copy, contact your county Extension office. Homeowners should also adopt practices that limit potential groundwater contamination, such as pumping their septic system regularly and disposing of household toxic wastes properly.

Reprinted and adapted from Land and Water Fact Sheet #13, published by University of Illinois at Urbana - Champaign, College of Agriculture, Cooperative Extension, September 1988. Reviewed by Steve Pinnate and Paul Dutrum, Maine DEP.

This material is based on work supported by the U.S. Department of Agriculture, Extension Service, under special project number 92-EWQI-I-9231.

---

For our most current publications, see our online catalog at [www.umext.maine.edu](http://www.umext.maine.edu)

*A Member of the University of Maine System*

Published and distributed in furtherance of Acts of Congress of May 8 and June 30, 1914, by the University of Maine Cooperative Extension, the Land Grant University of the state of Maine and the U.S. Department of Agriculture cooperating. Cooperative Extension and other agencies of the U.S.D.A. provide equal opportunities in programs and employment. 02/02