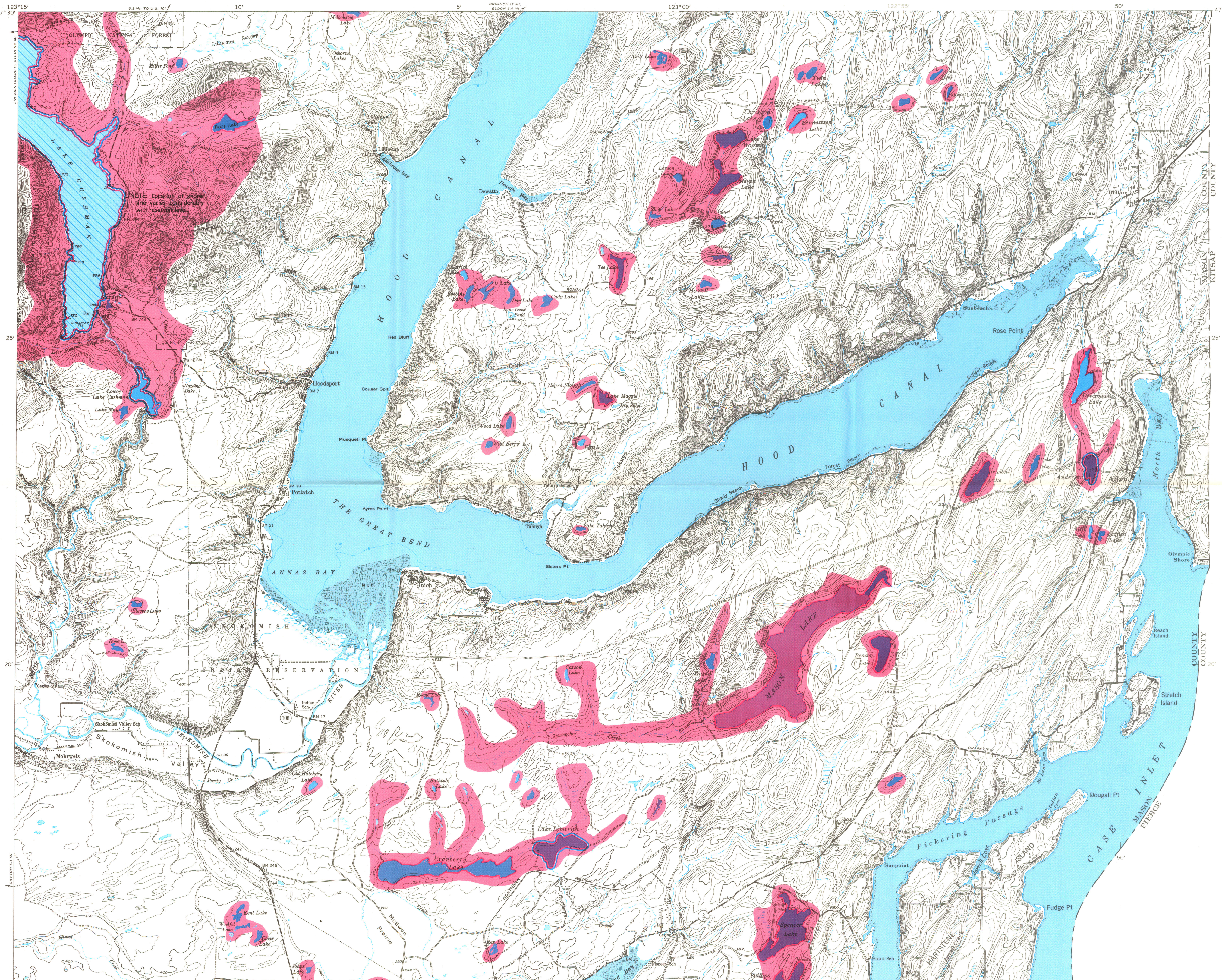


Base from U.S. Geological Survey
Potlatch, 1937-52 and Allyn, 1938

TRUE NORTH
MAGNETIC NORTH
22°
APPROXIMATE MEAN DECLINATION, 1974

SCALE 1:62 500

1 ½ 0 1 2 3 4 5 MILES

1 .5 0 1 2 3 4 5 6 7 KILOMETERS

CONTOUR INTERVAL 40 FEET IN WESTERN HALF OF MAP
AND 20 FEET IN EASTERN HALF
DATUM IS MEAN SEA LEVEL
DEPTH CURVES IN FEET—DATUM IS MEAN LOWER LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE AVERAGE RANGE OF TIDE IS APPROXIMATELY 8 FEET

EXPLANATION

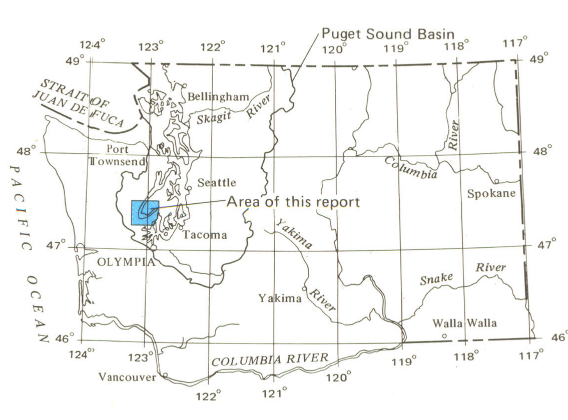
Lakeshore environs (200 ft wide) subject to management under Washington State Shoreline Management Act

Artificially created shoreline (by utility or private development)

General areas where major disposal of wastes are likely to affect lake water detrimentally

Relative susceptibility to water-quality degradation

Lakes for which significant management opportunities are available (shorelands largely undeveloped)		Lakes for which nearshore management opportunities are limited
	Minimum	None
	Moderate	
	High	



INDEX MAP OF WASHINGTON

INTRODUCTION

The scenic southern Hood Canal area provides exceptional recreational opportunities and many desirable sites for second homes. The lakeshores, in particular, are attracting increasing recreational development. Use of the land for this purpose, however, is especially conducive to temporary, often inadequate waste-disposal practices. Degradation of lake-water quality is often an inevitable consequence of lake-basin development unless environmental controls are wisely selected and used.

Reliable prediction of the effects that man's activities will have on a lake requires detailed data gathered over a considerable period of time. Because such data are not available for most of the lakes of this area, there is a pressing need for some preliminary evaluation to guide land-use planning and lake-basin development until more detailed information about the lakes is gathered and interpreted. For this purpose, special techniques were devised to allow a rapid assessment of conditions pertaining to the lakes in the southern Hood Canal area. The available data, although incomplete and from a variety of sources, proved to be meaningful when combined and carefully analyzed. The results of that assessment are summarized on the accompanying map.

The main objective of this study was to evaluate lakes in the area as to their relative susceptibility to water-quality degradation from natural and man-related causes. In addition, available data also allow (1) differentiation of the lakes into two categories according to the opportunities that remain for management and use of their nearshore areas, and (2) delineation of areas where major disposal of wastes is expected to be especially detrimental to lake quality. (See map explanation.)

This map is one of a series being prepared in cooperation with several agencies to present basic information and interpretations of an environmental nature to assist land-use planning, resource development, and environmental protection in the southern Hood Canal area and other parts of the Puget Sound basin.

THE LAKES AND THEIR SETTING

This part of Mason County has more than 100 lakes with a total surface area of roughly 7,400 acres (Wolcott, 1965). The largest, Lake Cushman, is an artificial reservoir with a surface area of about 4,000 acres; Mason Lake, which is the largest natural lake, has an area of 996 acres.

This study was limited to the 63 lakes in the area that have surface areas of 5 acres or more. Most of the lakes are fairly shallow; more than one-half of the lakes studied have a mean depth of less than 13 feet. Even some lakes with a large surface area are shallow; Price, Tee, and Melbourne Lakes have mean depths of less than 10 feet. Mason Lake, the deepest natural lake, has a mean depth of 48 feet and a maximum depth of 90 feet. The deepest lake is Lower Lake Cushman, which has a maximum depth of about 160 feet, but the depth varies with the stage of the reservoir.

Most of the lakes in the southern Hood Canal area occupy depressions in the land surface formed largely by ice-age glaciers. These depressions are mainly in rolling upland plains that commonly reach altitudes of 400-600 feet above Hood Canal. Under natural conditions the lakes were surrounded by conifer forests; most are still bordered by woodlands, some of which are in a period of regrowth after timber harvesting. All the lakes studied that have a surface area greater than 20 acres (except Maggie), and about one-half the smaller lakes, have surface-water outlets, at least during periods of high water.

EVALUATING THE LAKES

Previous studies of 60 Washington lakes showed that the buildup of nutrients in the lakes (eutrophication) is roughly indicated by some natural characteristics of the lake and its drainage basin and by certain activities of man (Bortleson and others, 1974). Data available for the southern Hood Canal area were not adequate to use all the indicators developed from the previous lake studies. However, much useful information was obtained from previous studies (see "Selected References"), interpretation of the most recent aerial photographs, and bathymetric maps (available for 27 lakes); the value of this information was greatly increased by observations made during rapid field and aerial reconnaissance.

PHYSICAL FACTORS

Physical factors, largely interrelated aspects of the natural setting and natural processes, shape the native lake conditions which man's activities tend to alter.

From the time of their origin, lakes begin a natural aging process, which man's activities tend to accelerate. Beginning with formation of the lakes as the ice-age glaciers disappeared, growth and decay of plants, erosion of surrounding lands, and deposition of sediment have slowly started to fill the lakes, and in time would turn them into marshes and, finally, bog forests. Depending upon their original physical condition and the rate at which these natural processes are operating, each of the lakes of this area may be at a different stage in the aging process.

Undisturbed forest stands, as most of the lands in this area were originally, have been found to contribute little to eutrophication of natural waters (Cooper, 1969). Man has accelerated the natural lake aging principally through increased sedimentation, resulting from logging and construction in the lake's drainage area, and enrichment of the water with nutrient substances, such as compounds of nitrogen and phosphorous. Even under undisturbed conditions, lakes and ponds may receive enough nutrients from soil, vegetation, and rainfall to support abundant aquatic life; man's activities in the surrounding lake basin characteristically introduce additional nutrients, as well as other contaminants. Nutrient-rich (eutrophic) waters often sustain excessive growth of algae and other aquatic plants in the lakes. Not only does the excessive growth speed the aging process, but may interfere with the use of water, detract from natural beauty, and reduce property values near the lakes.

Some of the major physical factors that were considered, along with the potential for contamination and lakeshore management, in evaluating the lakes are outlined below:

1. *Soil and rock materials* in the lake drainage basin are a major control on the chemical character of lake water under natural (undeveloped) conditions. In the mapped area, soils in most of the lake basins consist largely of gravelly sandy loam developed on glacial till and outwash plains (Ness and Fowler, 1951). These soils have low fertility, and the surface runoff is relatively slight because of high permeability of soils above the till. Waters draining such soils generally contribute small amounts of dissolved minerals to the receiving lakes. Poorly drained peat and muck deposits occur locally in about one-third of the lake basins. Streams draining such deposits generally contribute the brownish water seen in a few lakes.
2. *Lake depth* is the most significant physical feature affecting the ability of a lake to produce and assimilate nutrients. In shallow lakes like many in the southern Hood Canal area, nutrient-rich bottom water can readily mix with water at the surface, thereby providing more nutrients for the aquatic vegetation.
3. *Water volume*, relative to size of the drainage basin (or to number of nearshore homes), largely determines the ability of the lake water to dilute incoming nutrients.
4. *Bottom slope*, which determines the extent of shallow water, is an important determinant to the growth of aquatic plants, especially near the lakeshore.
5. *Shoreline configuration*, which influences the circulation and (along with lake depth and bottom slope) the extent of shallow water, is an indirect indicator of plant-growth capacity.
6. *Inflowing and outflowing streams* largely control the circulation of the lake water and the transport of nutrients through the lake.

CONTAMINATION POTENTIAL

One of the major considerations in this evaluation is the contamination potential in the drainage basin, including identification of contamination sources that could affect streams (perennial or intermittent) that drain to the lakes. Waste-disposal methods, the location and density of waste-disposal sites, and the kinds of waste products are of critical importance in governing the character, concentration, and dispersal of contaminants in a lake basin and, eventually, in the lake. Because virtually all domestic wastes in the map area are dispersed through septic-tank systems, ground water contaminated with septic-tank effluent has become a principal source of nutrients for lakes with populated shorelands (fig. 1). Leachate from garbage dumps can enter the ground water and reach the lakes in the same way. Also, some lakes with inflowing streams receive contaminants with the stream water. Airborne contaminants, as from industrial plants, can settle in a lake or its drainage basin, but they probably are not significant in this area. Conditions that are most likely to lead to enrichment of lake waters by contaminated ground water are those where bedrock or glacial till is shallow, slopes are steep, ground-water gradients are high, and disposal systems are near the shore and densely spaced. Distant sources of waterborne nutrients are more likely to be diluted and assimilated by plants.

As shown in figure 1, time is an important factor in the impact on lake-water quality of contaminants from the nearshore homes. Because movement of the ground water is comparatively slow, nutrients from this source may require years to reach a lake (fig. 1B); conversely, they can continue draining into the lake for years after this type of waste disposal is stopped.

The map pattern surrounding the lakes and some inflowing streams identifies areas where major disposal of wastes can be expected to affect lake water detrimentally. This pattern represents only the zones of greatest contamination potential, and its extent is based mainly on available data regarding the types and general permeability of the soil and rock materials, inflowing streams, and local ground-water conditions. Because a lake is a natural receiving basin, virtually its entire drainage area may be a source of contaminants. Consequently, management efforts to preserve lakes may need to take a basinwide approach.

LAKESHORE MANAGEMENT

An indirect, but important, factor in the susceptibility of lakes to degradation of water quality is the effectiveness of land-use and environmental management of the shoreline and nearshore areas. Lakes for which significant management opportunities are available are separated on the map from lakes for which management opportunities are limited. Options for shoreline management and use depend largely on existing development and landownership patterns; obviously, management opportunities are greatest in the less-developed lake basins.

Under the Washington State Shoreline Management Act of 1971, shorelands of lakes larger than 20 acres are managed by local governments (see map explanation). The plans and regulations for management of the shorelines of those lakes are set forth by local authorities in accordance with local needs and conditions; however, the plans are subject to review and approval by the Washington Department of Ecology to ensure that statewide policies are followed. Construction of most owner-occupied, single-family dwellings is not controlled by the Shoreline Management Act. Lakes with less than 20 acres in surface area (49 of the 63 in the map area) are generally not under any specified regulatory authority other than county health requirements and restrictions on minimum lot size.

Ownership of a lake's shorelands by a single or a few owners, especially by public agencies, generally affords more opportunity for controlling development than does ownership by many individuals. Fortunately, the margins of several lakes are owned largely by public agencies or service organizations such as churches, the Boy Scouts, and Girl Scouts. Dense development of shoreland for residential and recreational use by many individual owners probably imposes the greatest limitations on management of the lake resource. Dense development also has the greatest impact on the lake ecosystem by the addition of contaminants through the ground water or surface runoff.

The fact that lakeshore lands are already dedicated to a particular use, however, does not assure that serious degradation of the lake water is inevitable, or that future water-quality problems cannot be reduced. The wise application of regulatory tools such as zoning, subdivision controls, sanitary codes, and watershed-management regulations, guided by the best obtainable scientific information about the lake and its drainage basin, can do much to reduce, or even reverse, the rate of eutrophication. For some lakes already undergoing development, the reduction of nutrient inflow by diversion or treatment of household sewage, replacement of unsuitable lake water with high-quality stream water, or the direct treatment of lake water (Boyter and Wanielista, 1973) ultimately may be needed to enhance water quality.

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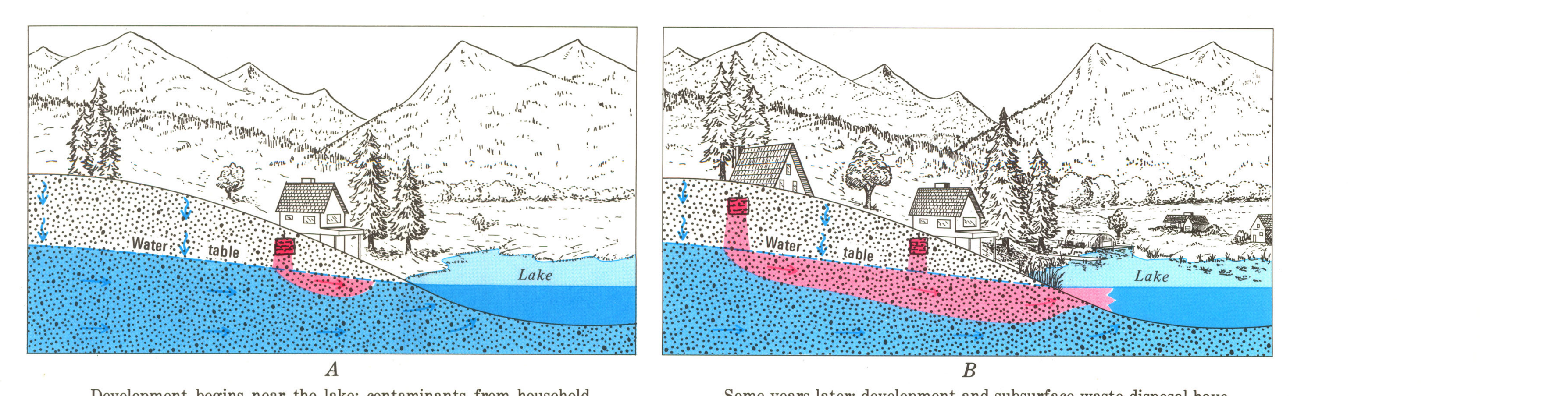

A

Development begins near the lake; contaminants from household wastes percolate downward to the water table and move in the direction of ground-water flow. Contaminants have not yet reached the lake water.

B

Some years later; development and subsurface waste disposal have increased. Contaminants have reached the lake from considerable distances, stimulating growth of water plants and algae.

FIGURE 1.—Contamination of a lake by ground water carrying effluent from household cesspools and septic-tank drain-fields. Colors show character of water: red, contaminated; blue, uncontaminated. Arrows show general water movement.

RELATIVE SUSCEPTIBILITY OF LAKES TO WATER-QUALITY DEGRADATION IN THE SOUTHERN HOOD CANAL AREA, WASHINGTON

By
G. C. Bortleson and B. L. Foxworthy

1974

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