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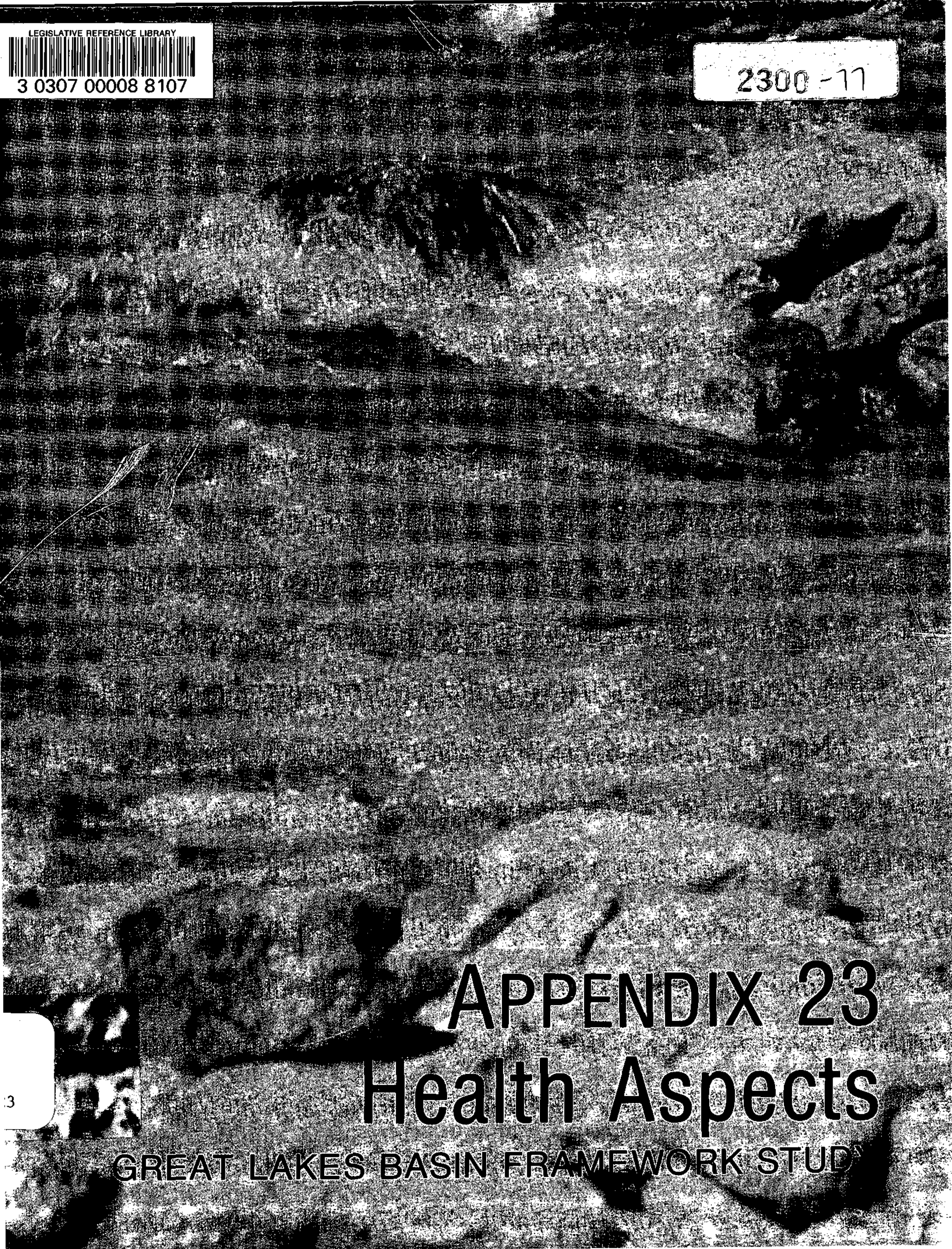

APPENDIX 23
Health Aspects

GREAT LAKES BASIN FRAMEWORK STUDY

Great Lakes Basin Framework Study

APPENDIX 23

HEALTH ASPECTS

GREAT LAKES BASIN COMMISSION

Prepared by Health Aspects Work Group

Sponsored by Water Supply Section, Air and Water Division

U.S. Environmental Protection Agency, Region V

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This appendix to the *Report* of the *Great Lakes Basin Framework Study* was prepared at field level under the auspices of the Great Lakes Basin Commission to provide data for use in the conduct of the Study and preparation of the *Report*. The conclusions and recommendations herein are those of the group preparing the appendix and not necessarily those of the Basin Commission. The recommendations of the Great Lakes Basin Commission are included in the *Report*.

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Great Lakes

SYNOPSIS

Water resource planning and development can greatly affect the health of the people living or visiting in the area concerned. Conversely, public health factors can influence the degree of success of such planning and development. Appendix 23 considers the health aspects of water resource planning. It includes a review of disease vector control (the control of disease carriers), public water supply, recreation, air pollution, solid waste management, radiological health, and individual water supply.

Vector control activity in the Great Lakes Basin is quite limited. Legislation should be enacted to create vector abatement districts, and State and local vector control programs should be developed. Vector control costs and benefits should be considered in all water resource planning.

The Community Water Supply Study of 1969 demonstrated that deficiencies in public water supplies were apparent in the study areas chosen, especially in the smaller systems. These deficiencies included objectionable quality, inadequate facilities, inadequate State and local surveillance, lack of cross connection control, and lack of operator training. These problems occur to varying degrees in the Great Lakes States. It is recommended that each State establish new programs and continue to improve existing programs to better train current operators and new operators. Increased attention to cross connection control programs, adequate funding for effective surveillance, and State provision for laboratory services for chemical analyses are additional measures that would help to insure the delivery of safe drinking water to the people of the Great Lakes Basin. Flouridation should be provided as an important health benefit wherever feasible.

Because immersion in polluted water can cause illness, State and local surveillance is necessary to assure safe water at beaches. Public recreation developments near populated areas are needed to meet the growing demand for recreation areas. State surveillance should be provided for these areas to assure safe water supply and proper sanitation.

Air pollution control and solid waste management are important planning aspects affecting water resource development projects in and near urban areas. Planners should be familiar with the health aspects of these developments and should maintain liaison with environmental health agencies to minimize any effects that may be detrimental to health. Because individual water supplies are susceptible to contamination, local health agencies should provide technical assistance to individual water supply owners to help them obtain safe water supplies.

Also included in this appendix are radiological health aspects of nuclear power projects, irrigation with sewage treatment plant effluent, and solid waste management. Health guidelines for public water supply systems, irrigation with sewage treatment plant effluent, recreation area development, vector control, and solid waste management were developed to point out areas that require special attention by planning authorities.

FOREWORD

Material for Appendix 23 was furnished by the various State departments of health and environmental control, by the Bureau of Community Environmental Management, Department of Health, Education, and Welfare, and the Environmental Protection Agency.

The appendix was prepared by the Health Aspects Work Group, appointed by the Great Lakes Basin Commission. Work was initiated in July 1969 and completed in May 1974.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

This appendix examines water-related health problems in relation to present and future water usage. It defines in general terms the actions needed to protect man's health and welfare in water resource development and related land use management. The appendix deals primarily with the areas of environmental health that are most directly affected by water resource development and most directly affect it. These areas are vector control, recreation sanitation, and public water supply. The appendix also reviews air pollution control, solid waste management, and radiological health areas that are less directly affected by water resource development and have lesser effects on it. In addition, emphasis is placed on aspects of water resource development and planning that are most affected by Federal activities.

The Great Lakes Basin includes those portions of the States of Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York from which surface water flows into the Great Lakes. For most of these States, the portions within the Basin are restricted to relatively narrow strips along the shoreline of one or more of the Great Lakes. Exceptions include Michigan, which is almost totally within the Basin and borders all of the Lakes except Ontario, and Ohio, the northern third of which is included in the Basin. Although the Basin is narrow for the most part, it exceeds 400 miles in maximum width and 900 miles in length.

Because much of the information available is compiled on a county basis, the Great Lakes Region has been bounded along county lines to simulate as closely as practicable the hydrologic boundaries of the Great Lakes Basin. In this appendix the terms Great Lakes Region and Great Lakes Basin are used somewhat interchangeably, and always refer to the Great Lakes Region, which has political boundaries rather than hydrological boundaries.

Human population is concentrated mainly in industrialized areas along the Lakes. Large portions of the Basin, including northern Wisconsin, northern Minnesota, and the Upper Peninsula of Michigan, are sparsely populated. Continued rapid growth is projected for the area along the lakeshore and the disparity in population will probably increase. If the present trend continues, the area around the Great Lakes will become several strip cities extending from Milwaukee to beyond Chicago, from Detroit through Toledo, and from Cleveland and Erie to Buffalo. Projections indicate this may constitute one of five large urban complexes in which 70 to 80 percent of all Americans will live by the year 2000.

The Basin is characterized by a diversity in climate, topography, soil type, flora, and fauna. The diversity is generally more pronounced across its narrow north-to-south dimension than along its east-to-west dimension. The Basin portions of Minnesota, northern Wisconsin, and the Upper Peninsula of Michigan have a somewhat vigorous climate. Lumber production from coniferous forests in these areas is a major industry. The southern portion of Wisconsin within the Basin produces lumber from deciduous forests, dairy products, grain, and other crops. Nonindustrialized Basin areas in Illinois, Indiana, and Ohio produce livestock, grain, and other crops. Winter weather in these areas is not as severe as in the forested northern portions of the Basin.

The Basin is rich in minerals and fertile soil, and has good land and water transportation. The diversity of natural resources is reflected in the diversity of developed enterprises. These factors suggest additional growth and development.

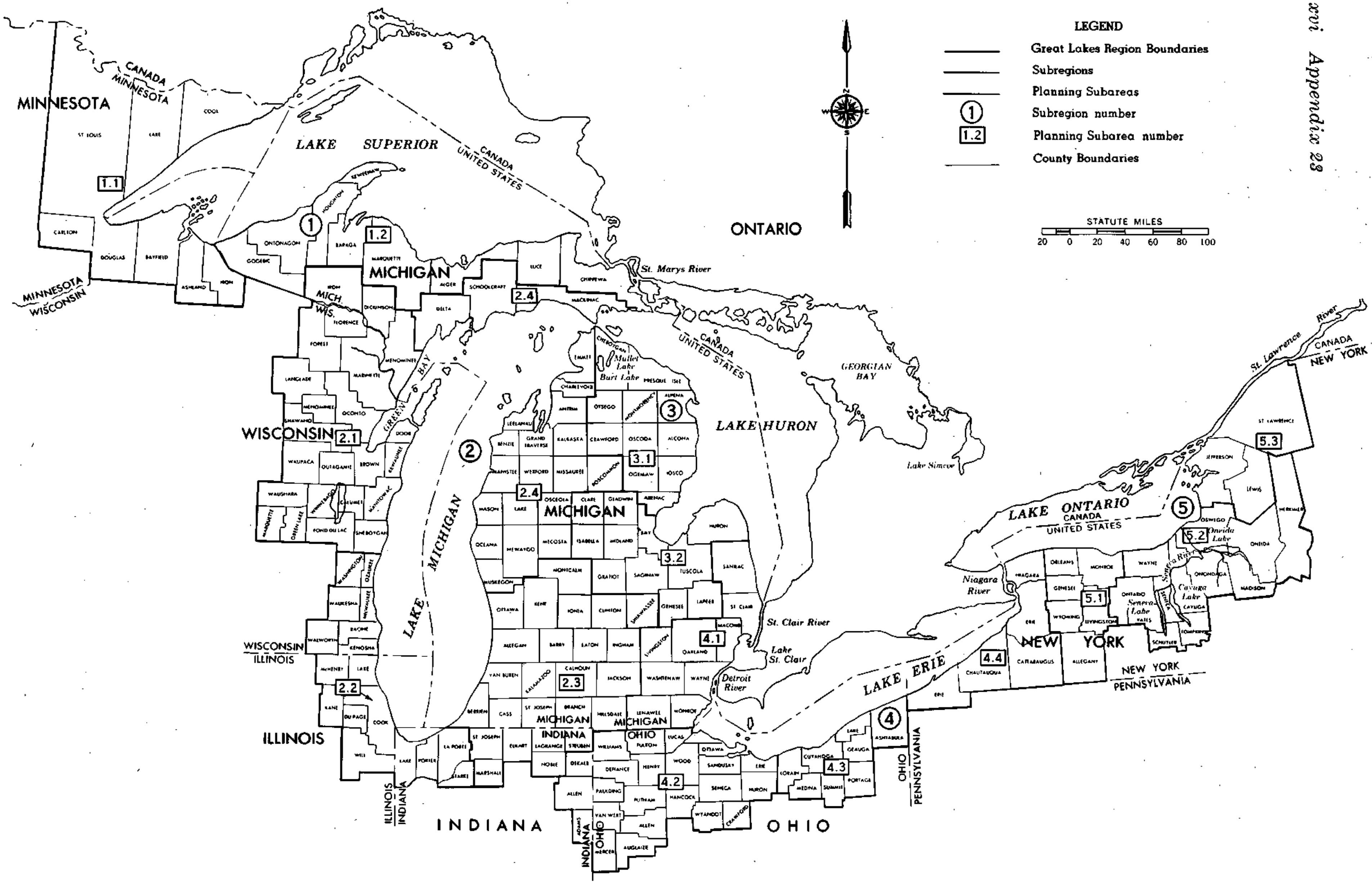


FIGURE 23-1 Great Lakes Region Planning Subareas

Section 1

DISEASE VECTOR CONTROL ASPECTS

This section reviews disease vector control as of July 1970. It examines the status of disease vector control programs and the need for new programs. It also reviews vector-borne diseases and other vector problems in the Great Lakes Basin.

1.1 Status and Needs

1.1.1 July 1970 Status

Arthropod- and rodent-borne diseases cause a significant problem in the States bordering the Great Lakes. The most important vector-related diseases in the Basin are mosquito-borne encephalitis; Rocky Mountain spotted fever, transmitted by ticks; leptospirosis, caused by contact with water contaminated by rats and other infected animals; and tularemia, which may be transmitted indirectly by ticks and certain biting flies and directly by infected rabbits and other animals. In addition people in many areas suffer severely from the bites of mosquitoes, black flies, ticks, deer flies, horseflies and stable flies. Several species of mosquitoes in the genus *Aedes*, commonly called the woodland mosquitoes, are severe biters as well as possible vectors of encephalitis. These make life especially miserable for campers, hunters, and fishermen. The saltmarsh mosquito *Aedes sollicitans* is found in the Basin where man has contaminated the surface environment with brine. At the peak of their season viciously biting black flies may be a greater problem in some parts of the Basin than anywhere else in the United States. Found in Minnesota, Michigan, and New York, black flies are often more severe pests than mosquitoes in forest country with rapidly flowing streams where their larvae develop. The black widow, northern widow, and brown recluse spiders, several important species of ticks, and numerous other stinging and biting arthropods abound in the Basin. Houseflies cause serious concern due to their likely involvement in transmission of enteric diseases. Authorities of the resort area of Mackinac Island, Michigan, have vainly struggled with the problem of controlling houseflies for years. These houseflies are a consequence of the island's large population of horses and mules used exclusively for transportation on the island.

Another insect problem, which occasionally becomes severe in local areas, relates more to safety than direct irritation of humans. In the spring May flies may emerge from lakes and streams in prodigious numbers. Frequently attracted to lights along bridges and roads, May flies hamper visibility, and their body juices cause slippery roadway surfaces.

1.1.2 Needs

Little vector control activity exists in the Great Lakes Basin. The States of Minnesota, Wisconsin, Michigan, Indiana, and Ohio have no comprehensive vector control programs. Numerous urban areas have limited abatement activities or none at all. There are several reasons for increasing vector control activities in the Basin:

(1) rapid population growth

(2) the development of suburbs near areas of vector production

(3) the continuing development of resistance to insecticides by numerous species of mosquitoes and other vectors

(4) the decreasing use of insecticides to minimize environmental contamination

(5) man's exposure to insects and other arthropods of public health importance in expanding outdoor recreational activities, especially those associated with water and related land resources

(6) man's decreasing tolerance for mosquitoes and other arthropods that are harmful to man

(7) man's increasing mobility, which broadens the chance of introducing aberrant diseases and vectors

Increased local vector control activity depends on improved State enabling legislation and technical assistance including surveillance services.

Because sufficient and dependable financing is needed to develop and operate vector control programs, State enabling legislation should be created to establish mosquito abatement districts in Wisconsin, Michigan, and Indiana. Enabling legislation in New York should be revised to permit the operation of mosquito abatement districts anywhere in the State. The name "mosquito abatement district" is generally applied to comprehensive local programs, and only the most shortsighted of the State enabling acts restrict the activities to mosquito control. In most cases any arthropod of public health importance may be the target of control operations.

Federal and State public health services should provide basic information and technical assistance to local groups concerned with vector control and to the various agencies involved in water resources development. Assistance should include consultation on appropriate control methods following surveys of problem areas and training of personnel who will perform control operations. The type and magnitude of vector problems vary in different areas throughout the Basin. Continuing surveillance is required to evaluate vector populations and determine major sources of production; to define factors responsible for vector problems; to establish the most appropriate control methods; and to determine the need for emergency control measures when outbreaks of vector-borne disease threaten.

1.2 Vectors and Vector-Borne Diseases

1.2.1 Mosquito-Borne Diseases and Problems

The viral encephalitides are the most important mosquito-borne diseases in the Basin. The occurrence of encephalitis varies from area to area and year to year. Western encephalitis (WE), St. Louis encephalitis (SLE), and California encephalitis (CE) have occurred repeatedly in the past, and eastern encephalitis (EE) has occurred in isolated cases. Although encephalitis has a low incidence, it is a serious disease because it has high epidemic potential, it may cause permanent brain damage or death, no specific treatment is known, and most cases occur among children.

Present knowledge about the natural history of the encephalitis viruses indicates that there are two basic groups determined by the reservoirs or animals in which viruses live. These two groups are the bird reservoir, which includes EE, WE, and SLE, and the rodent-rabbit reservoir, which contains CE. Normally, the infection chain is limited to birds, small mammals and mosquitoes. Under certain conditions, the virus is transmitted to humans and horses. Although subject to severe illness or death, humans and horses do not develop a sufficiently high level of viruses in the peripheral circulatory system to infect mosquito vectors. Thus humans and horses are dead-end hosts. Data are shown in Table 23–1.

The California encephalitis virus was first isolated in 1943 when it was found in naturally infected mosquitoes, *Aedes dorsalis* and *Culex tarsalis*, in the San Joaquin Valley of California. Clinical cases were reported first in Kern County, California in 1945, followed by the reporting of one case from Dunedin, Florida, in 1963. Beginning the following year significant numbers of cases have been reported regularly in Ohio, Indiana, Wisconsin, Minnesota, and Iowa, with occasional cases from other States. Ohio leads the nation in the reported occurrence of CE. The focal point of CE activity extends from Ohio into Indiana and Wisconsin. Cases also have occurred in Illinois and New York.

California encephalitis appears to represent a complex disease with several strains. Most human cases now apparently result not from the original California strain, but from a strain first isolated in LaCrosse, Wisconsin, the LaCrosse strain. In Ohio the disease has shown an epidemic curve running from the last week in June through early October. The age group principally affected is the 15-year-old and younger group with a peak at the four-year-old level. California encephalitis in the Midwest is a suburban and rural disease, probably because of the distribution of both the reservoirs and vectors. Since it was recognized as a separate disease entity in Ohio, an average of 31 cases per year have been reported. Most cases were laboratory confirmed (Table 23–1). The figure of 25 cases in 1969 would have been much greater except for emergency insecticidal operations conducted following floods caused by nearly 15 inches of rain that fell July 4 and 5, 1969. More than three million acres in north-central Ohio were sprayed once with an ultra-low-volume application of malathion. In the treated area a

TABLE 23-1 Human Cases of Arboviral Encephalitis by State and Year

State	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	Total
Minnesota											
C	--	--	--	--	1	13	9	7	16	16	
W	--	--	--	3	2	2	2	1	3	--	
S	--	--	--	--	--	3	--	1	--	--	
Total	1	15	15	3	3	18	11	9	19	16	110
Wisconsin											
C	--	--	--	4	14	4	3	5	20	26	
W	--	--	--	--	1	--	--	--	--	--	
S	--	--	--	--	--	--	--	--	--	--	
Total	1	6	2	4	15	4	3	5	20	26	86
Illinois											
C	--	--	--	--	--	1	--	--	--	--	
W	--	--	--	2	--	--	--	--	--	--	
S	--	--	--	44	1	--	--	23	--	--	
Total	--	48	148	46	1	1	--	23	--	--	267
Indiana											
C	--	--	--	12	7	2	2	1	--	--	
W	--	--	--	--	1	--	--	--	--	--	
S	--	--	--	18	--	--	--	--	1	1	
Total	--	56	58	30	8	2	2	1	1	1	159
Michigan											
C	--	--	--	--	--	--	--	--	--	1	
W	--	--	--	1	--	--	--	--	--	--	
S	--	--	--	--	1	--	--	--	--	--	
Total	--	45	57	1	1	--	--	--	--	1	105
Ohio											
C	--	--	--	25	28	37	26	43	25	36	
W	--	--	--	--	--	--	--	--	--	--	
S	--	--	--	1	1	--	--	--	--	--	
Total	--	139	108	26	29	37	26	43	25	36	469
Pennsylvania											
C	--	--	--	--	--	--	--	--	--	3	
W	--	--	--	--	--	--	--	--	--	--	
S	--	--	--	21	1	--	--	--	--	--	
Total	--	118	127	21	1	--	--	1	--	3	271
New York											
C	--	--	--	--	--	--	--	--	2	2	
W	--	--	--	--	--	--	--	--	--	--	
S	--	--	--	--	--	--	--	--	--	--	
Total	--	255	194	--	--	--	--	--	2	2	453
TOTAL	2	682	709	131	58	62	42	82	60	85	1,920

C--California encephalitis
W--Western encephalitis
S--St. Louis encephalitis

Note: All data are for entire State.
Data for 1961, 1962, and 1963 include post-infectious and reported arthropod-borne encephalitis.
Specific breakdown by type of encephalitis is not available for 1961, 1962, and 1963.

Source: Epidemiology Program, Center for Disease Control, U.S. Public Health Service.

number of cases of CE developed between 1964 and 1968. Of the 22 Ohio cases that occurred following the spraying, none was within the spray area (Figure 23-2).

St. Louis encephalitis occurred in epidemic proportions in Indiana in 1964 and in Illinois in 1964 and 1968. Repeated occurrences may be expected in Ohio, Indiana, and Illinois. Isolated cases may be expected in Wisconsin. The vector of SLE *Culex p. pipiens* is a mosquito distributed throughout the Basin. It is especially abundant in urban areas. With in-

FIGURE 23-2 California Encephalitis Occurring in Ohio Following Emergency Spraying, Done from August 13 to 26, 1969

creased urbanization throughout the area, this species probably will become an even greater problem. Evidence indicates that the mosquito *Culex tarsalis*, the vector of SLE and WE in the western portion of the United States, is now well established in the western portion of the Basin, and may be increasing its range.

Western encephalitis is expected to occur repeatedly from Illinois westward where *Culex tarsalis* is well established and an excellent vector for both man and horses. Isolated cases may be expected in Michigan. *Aedes dorsalis*, formerly considered rare in Indiana, is becoming more common. An increased population of this vector increases the possibility of WE transmission in the area.

Eastern encephalitis has occurred very rarely in the Basin, and not within the last 10 years. This disease has occurred in Michigan and Wisconsin, but the entire Basin is outside the normal range of this very serious disease.

Before 1930 indigenous malaria occurred regularly in the southern portion of the Region. Although some cases are reported in all States of the Basin from time to time, usually in veterans or military personnel who served in malarious areas, local transmission has disappeared. Malaria occurrence increased with U.S. activity in Southeast Asia as shown in Table 23-2. The efficient mosquito vector *Anopheles quadrimaculatus* is widespread in the Region and occasionally becomes abundant in local areas. The 10 documented episodes of local transmission of malaria introduced into the United States since 1944 suggest that such transmission might recur and that surveillance remains important.

Vector control specialists are reluctant to categorize each species of mosquito as either a vector, which transmits communicable disease, or as a pest, which annoys man without causing health hazards. Because medical entomology is progressing so rapidly, mosquitoes that were recently considered to be pests only are now recognized as major transmitters of human diseases. An example is *Culex p. quinquefasciatus*, which transmits St. Louis encelphalitis. Even now, new disease strains are being identified, and previously identified strains are being found in new locations. Therefore, it is unrealistic to assume that a species now considered only a pest does not transmit disease simply because of lack of evidence.

Although some mosquitoes may not transmit disease, they can be hazardous because they can cause serious allergic, traumatic, and infectious reactions and can interfere with food production and essential sanitation activities. These problems have increased because human activity has multiplied the breeding areas of mosquitoes and other pests. This is probably true for numerous species of mosquitoes indigenous to the Great Lakes Basin.

1.2.2 Mosquito Vectors and Pests

Distribution of recorded mosquito species in the Great Lakes Basin States is shown in Table 23-3. Some species found in a State may not be present in the portion of the State that lies within the Basin. Where records are available the mosquito species occurring within the Basin are indicated in the table by (x). Certain extrapolations were made, based on similarity of habitat and other ecologic factors. Records are fairly complete for species

TABLE 23-2 Human Cases of Malaria by State and Year

State	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	Total
Minnesota	--	3	2	3	--	6	12	17	42	64	149
Wisconsin	--	--	--	2	--	--	--	--	--	13	15
Illinois	1	5	3	3	1	16	38	64	124	68	323
Indiana	--	1	--	--	--	5	17	20	33	25	101
Michigan	1	1	--	--	--	14	17	50	68	90	241
Ohio	--	--	2	--	2	6	16	11	34	30	101
Pennsylvania	4	1	5	11	30	138	157	190	70	77	683
New York	5	5	6	16	11	27	49	73	93	160	445
Total	11	16	18	35	44	212	306	425	464	527	2058

Note: All data are for entire State

Source: Epidemiology Program, Center for Disease Control, U.S. Public Health Service that are presently known to be disease vectors and species that are important for other public health reasons, but records of other species are sketchy.

Aedes dorsalis is the mosquito from which the virus of a California encephalitis was initially isolated. This mosquito is also a severe and very persistent biter, attacking anytime, day or night, especially during calm and cloudy weather. Although *Aedes dorsalis* is usually considered a western species because of its abundance in the western portions of the United States and Canada, it also occurs in all Great Lakes Basin States. For the present this species must be considered as a vector of CE, especially in the western portion of the Basin. *Aedes dorsalis* is usually regarded as a meadow-breeding species, but its range in habitat is very broad. Larvae can develop in water with a salt content as great as 12 percent (along the margins of the Great Salt Lake) and in fresh water areas (marshes, irrigated pastures, and attendant irrigation appurtenances and seepage). The species seems to prefer alkaline water in grassy areas exposed to direct sunlight. It is associated with industrial waste lagoons in Wisconsin and Indiana. The species is capable of dispersal and migratory flights longer than 20 miles, and its season of activity is long.

Several species of woodland *Aedes*, associated with CE by virus isolation, are considered to be the most likely vectors in the Basin. These include *Aedes triseriatus*, *Aedes canadensis canadensis*, and *Aedes trivittatus*. These species breed mostly in woodlands, usually are persistent biters, and may be present throughout summer. *Aedes triseriastus*, *Ae. c. canadensis*, and *Ae. trivittatus* are found in all Basin States. Larvae of the woodland *Aedes* develop mostly in temporary or semipermanent shaded pools following rains. The *Ae. triseriatus* larvae, however, develop in tree holes rather than ground pools. In the southern portion of its range the species is commonly found within urban areas, where it develops in such artificial containers as discarded automobile tires, buckets, and even beer cans and soft drink bottles. Breeding in automobile tires has been observed in Ohio.

Another of the woodland *Aedes*, *Aedes stricticus*, is single-brooded in some areas, multibrooded in others, and causes great discomfort to man, domestic animals, and wildlife. The species has been recorded in most of the United States, including all Basin States, and Alaska. To date, neither the viruses of the encephalitides nor other known etiological agents have been recovered from wild-caught specimens, but mechanical transmission of various agents is a definite possibility. The larvae of *Ae. sticticus* occur mostly in floodwater pools in river valleys both in woodlands and open country. They also may be found in rain-filled pools containing fallen leaves and other vegetative material. The eggs may remain viable, in the absence of flooding, for at least three years. Normally the adults are serious pests in the Basin during May, June, and July. Broods may develop later in the season following flooding of the breeding sites.

Aedes stimulans is present throughout the Basin and is one of the most abundant and annoying woodland mosquitoes, frequently invading villages and parks near woodlands. Its bite is extremely painful. The larvae are among the first to appear in the spring in temporary pools formed by overflow from streams, snow melt, and early spring rains. Adults may be present in April, May, or June depending on temperature and location. Some adults may live until September and are known to fly more than two miles from breeding sources.

Breeding in flood water and temporary rain pools, *Aedes vexans* is a mosquito of paramount importance throughout the Basin. Although the natural history of eastern encephalitis is uncertain, this species is a likely vector in the bird-to-man cycle. The virus of California encephalitis has been isolated in *Ae. vexans* by the Ohio Department of Health. Although this species is not generally considered an efficient vector of these arboviruses, an inefficient vector with aggressive biting habits may transmit viral agents when viremia within the reservoir is sufficiently high. *Aedes vexans* is considered the most important mosquito in many areas of the Basin, both because of its abundance and painful bite and its potential as a vector of the encephalitides. *Aedes vexans* adults are common from May until October. Winter is passed in the egg stage. All eggs do not hatch with a single flooding, but larvae appear periodically following alternative flooding and drying of the eggs during the season. Opinions vary as to whether the species produces a single generation per year (with delayed hatching accounting for a more or less continuous supply of adults) or whether there are several generations each year. Both ideas may be accurate for certain ecotypes in specific locations.

Historically the principal malaria vector east of the Rocky Mountains, *Anopheles quadrimaculatus* occurs in all States of the Basin. The species may become very abundant under

TABLE 23-3 Mosquitoes of the Great Lakes Basin States

	Minn.	Wis.	Ill.	Ind.	Mich.	Ohio	Pa.	N.Y.
AEDES								
abserratus	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
aegypti	---	---	x	x	---	---	---	---
atlanticus	---	---	x	x	---	---	---	x
atropalpus	(x)	(x)	---	---	---	---	x	(x)
aurifer	(x)	(x)	x	x	(x)	(x)	(x)	x
barri	x	---	---	---	(x)	---	---	---
campestris	x	x	---	---	x	---	---	---
canadensis	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
cantator	---	---	---	---	---	(x)	x	x
cinereus	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
communis	(x)	---	---	---	(x)	---	(x)	(x)
decticus	(x)	---	---	---	(x)	---	(x)	(x)
diantaeus	(x)	(x)	---	---	(x)	---	(x)	(x)
dorsalis	x	x	(x)	x	(x)	(x)	x	x
dupreei	---	---	(x)	x	---	(x)	---	---
excrucians	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
fitchii	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
flavescens	(x)	(x)	(x)	x	(x)	---	---	x
fulvus pallens	---	---	x	---	---	---	---	---
grossbecki	---	x	x	x	---	(x)	x	---
hendersoni	---	---	(x)	(x)	---	(x)	---	---
impiger	---	---	---	---	---	(x)	---	x
implicatus	(x)	(x)	---	---	(x)	x	---	x
infirmatus	---	---	x	---	---	---	---	---
intrudens	(x)	(x)	---	---	(x)	(x)	(x)	(x)
mitchellae	---	---	x	---	---	(x)	x	x
nigromaculis	x	---	x	---	---	(x)	---	---
pionips	(x)	---	---	---	x	---	---	---
pullatus			(Doubtful x Record)					
punctor	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
riparius	x	x	---	---	x	(x)	---	x
sollicitans	---	---	(x)	x	---	(x)	(x)	x
spencerii	x	x	x	---	x	(x)	---	x
sticticus	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
stimulans	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
taeniorhynchus	---	---	---	---	---	---	(x)	x
thibaulti	---	---	x	x	---	(x)	---	---
tormentor	---	---	x	---	---	x	---	---
trichurus	(x)	(x)	---	---	(x)	---	---	x
triseriatus	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
trivittatus	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
vexans	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
ANOPHELES								
barberi	x	---	(x)	x	---	(x)	x	x
bradleyi	---	---	---	---	---	---	---	x
crucians	---	---	x	x	---	(x)	x	x
earlie	(x)	(x)	---	---	(x)	---	---	(x)

x Species known to occur in State

(x) Species known or presumed to occur within Basin portion of State

TABLE 23–3(continued) Mosquitoes of the Great Lakes Basin States

	Minn.	Wis.	Ill.	Ind.	Mich.	Ohio	Pa.	N.Y.
ANOPHELES								
perplexens	(x)	(x)	---	---	(x)	---	---	(x)
punctipennis	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
quandrimaculatus	x	(x)	(x)	(x)	(x)	(x)	(x)	x
walkeri	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
COQUILLETTIDIA								
perturbans	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
CULEX								
erraticus	x	---	(x)	x	x	(x)	---	---
peccator	---	---	x	---	---	---	---	---
pipiens pipiens	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
pipiens quinquesfasciatus	---	---	x	x	---	x	---	---
restuans	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
salinarius	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
tarsalis	(x)	(x)	(x)	(x)	(x)	(x)	---	---
territans	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
CULISETA								
impatiens	---	(x)	---	---	(x)	---	---	x
incidens	---	---	---	---	x	(x)	---	---
inornata	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
melanura	x	(x)	x	x	(x)	(x)	x	x
silvestris minnesotae	(x)	(x)	(x)	x	x	(x)	---	---
morsitans	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
parodites	---	x	---	---	---	---	---	---
ORTHOPODOMYLA								
alba	---	---	x	x	---	(x)	x	x
signifera	x	---	(x)	x	x	(x)	(x)	x
PSOROPHORA								
ciliata	x	x	(x)	x	x	(x)	(x)	x
confinnis	x	---	(x)	x	---	(x)	(x)	---
cyanescens	---	---	x	x	---	(x)	---	---
discolor	---	---	x	x	---	(x)	---	---
ferox	x	x	(x)	x	x	(x)	(x)	x
horrida	x	---	x	x	---	(x)	x	---
howardii	---	---	x	x	---	(x)	---	---
varipes	---	x	x	x	---	(x)	---	x
TOXORYNCHITES								
rutilus septentrionalis	---	---	x	x	---	(x)	(x)	---
URANOTAENIA								
sapphirina	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
WYEOMYIA								
smithii	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)

x Species known to occur in State
(x) Species known or presumed to occur within Basin portion of State

favorable conditions such as those which occurred in Ohio following the floods of 1969. The larvae occur in permanent and semipermanent fresh water in lakes, slow-moving streams, and ponds containing floating debris or vegetation. The larvae are seldom found in temporary pools. During summer the rather short larval period lasts about 12 to 20 days. The pupal period requires another two to six days. It is estimated that from six to eight generations per year occur in the Basin.

Culex pipiens pipiens, the northern house mosquito, is a major vector of St. Louis encephalitis. The virus of western encephalitis has been isolated from wild-caught specimens. It also transmits the organisms causing heartworm in dogs, bird malaria, and fowl pox. The species has been recorded in all States in the Basin. The southern house mosquito, *C. p. quinquefasciatus* (generally accepted as a subspecies), has been reported in Illinois, Indiana, and Ohio. This subspecies probably is restricted to the southern portions of these States. These two subspecies interbreed readily, and intergrades probably occur along the transition areas of the subspecies' ranges. The southern house mosquito is associated with major urban epidemics of SLE during recent years, mostly in the Southwest. The *C. pipiens* complex is a foul-water mosquito and very domesticated. It breeds in roadside ditches, catch basins, sewage oxidation ponds, septic tank and sewage effluent, water contaminated with wastes from vegetable and meat processing plants, and in man-made containers. The adults easily enter houses and bite at night. This mosquito reaches its greatest abundance in late summer and fall. Paradoxically the greatest numbers are often encountered during prolonged dry spells when pollution is concentrated by water evaporation. This is, however, by no means always true. The epidemic of St. Louis encephalitis that occurred in Dallas, Texas, in 1966, was preceeded by a great increase in populations of the southern house mosquito breeding in sewage-polluted floodwaters. The *C. pipiens* complex presents a threat under both drought and flood conditions.

Culex tarsalis is the most important vector of western encephalitis, particularly west of the Mississippi River. It is also a major vector of St. Louis encephalitis, and the virus of California encephalitis has been isolated from this mosquito. Additionally, the females are painful and persistent biters, attacking at dusk and after dark. The species is recorded in all States of the Basin except Pennsylvania and New York. Ohio records indicate the *C. tarsalis* is becoming more prevalent in that State. The larvae are found in clear water in a variety of habitats including irrigation systems with their tail water and seepage, ditches, ground pools, pools in stream beds, and marshes. In foul water *C. tarsalis* is found in association with corrals and slaughter houses, in sewage oxidation ponds, and in septic tank and sewage effluent. Throughout most of its range *C. tarsalis* produces larvae continuously from late spring until early autumn. Several generations are produced, and the maximum adult population usually occurs during August or September.

Culiseta melanura is probably the most important vector in the enzootic and epizootic (bird to bird) cycles of eastern encephalitis. Because this species bites man only rarely, other mosquitoes probably serve as vectors from the bird reservoirs to man and horses. Two species of mosquitoes that may play this role in the Basin, *Aedes vexans* and *Coquillettidia perturbans*, are discussed later. *Culiseta melanura* is recorded in all Basin States. *Culiseta melanura* larvae are most often found in small permanent bodies of water, particularly in swamps. The species has been found to be naturally infected with EE, although it rarely bites man.

Coquillettidia perturbans is a troublesome species. Although it bites mostly at night, it occasionally bites during daylight in the shade and mainly near its breeding sites. The virus of eastern encephalitis has been recovered from *C. perturbans*, which occurs in all Basin States. Species of the genus *Coquillettidia* have a unique morphological adaptation, a sharpened structure on the breathing protuberances of larvae and pupae. This enables them to penetrate the roots and stems of emergent plants, to attach there, and to secure oxygen from plant tissues. These species thus pass the aquatic stages while entirely submerged. Detection of breeding sites is very difficult because the larvae quickly detach themselves from host plants whenever they are disturbed. Carefully executed procedures are required to capture the immature stage of *Coquillettidia*.

1.2.3 Other Vector-Borne Diseases and Problems

The occurrence of Rocky Mountain spotted fever, tularemia, and leptospirosis in the States bordering the Great Lakes is shown in

Tables 23-4, 23-5, and 23-6. These records apply to the entire States and in some cases may not directly reflect the situation within the Basin.

Rocky Mountain spotted fever is considered to be slightly endemic to Illinois, Indiana, and Ohio, the southernmost States of the Basin. It occurs infrequently in Michigan, Wisconsin, Minnesota, and those areas of Pennsylvania and New York that lie within the Basin. It is usually transmitted in the Basin by the American dog tick *Dermacentor variabilis*. From records of the Ohio Department of Health it appears that the disease began in the southwest portions of the State in Clermont County and then moved in a generally northeast direction. It has occurred throughout most of the southern half of the State, and sporadic cases have occurred in the northern part of the Basin. If the present rate of spread continues the disease will be generally endemic to Ohio by 2020. The occurrence of the prime vector *D. variabilis* is recorded only for the south-central portion of Ohio, but the records are sparse. This vector probably occurs throughout the State and is the most abundant species of ticks.

Tularemia is a highly infectious, plague-like bacterial disease which can be transmitted by various arthropods by their bites, feces, or body juices, and by exposure to the body fluids of infected rodents, rabbits, or hares. The disease organism *Francisella tularensis* can penetrate unbroken skin. During recent years more cases have been recorded in Illinois and Indiana than in other Basin States. In Michigan recent cases have occurred among muskrat trappers. In earlier cases rabbit hunters suffered the highest incidence.

Leptospirosis (Weil's disease) is a group of acute infections transmitted by contact with water contaminated with the urine of infected rats and other animals. Outbreaks occur among swimmers and occupational groups such as sewer workers, farmers, veterinarians, slaughterhouse workers, and military groups. The disease occurs in sporadic outbreaks throughout the Region. Rat control in urbanized and recreation areas is a major preventive measure.

1.2.4 Other Important Vectors and Pests

The relationship of water resources to fly production is not as apparent as that to mosquito production. Development of water and related land resources allows expansion of urban areas, agriculture, and industries that generate wastes that support flies. Contact between humans and flies frequently increases as a result of water resources development. Domestic flies have considerable impact on man's welfare. They may seriously affect the health of man, domestic animals, and wildlife. Because of the omnivorous and promiscuous feeding habits of many species (notably the housefly, *Musca domestica*), they are potential vectors of a number of human diseases. Feeding first upon filth such as excrement or sewage, flies may then infect food intended for human use. They may be significant causes of outbreaks of intestinal diseases such as typhoid or the dysenteries. Maintaining animals such as chickens over pits where manure accumulates may result in tremendous production of several species of muscoid flies, including *M. domestica* and *Ophyra spp*. Some animal farms are located near enough to cities to permit infiltration of flies and spread of enteric disease to concentrations of human population. Several species of domestic flies may also cause myiasis in man. Myiasis is the presence of a disturbance caused by fly larvae living as parasites on the tissues of man and other animals. The larvae of some species, including the primary screwworm fly *Cochliomyia hominovorax*, are obligate parasites that initiate wounds and thus can infest areas of unbroken skin as well as existing lesions. *Wohlfahrtia vigil* is a specific myiasis producer recently reported in Indiana. The larvae of other species, such as the green bottle fly *Phaenicia sericata*, cause semispecific myiasis. Although these larvae do not cause lesions, pregnant females may be attracted to existing wounds where they deposit eggs. The larvae live in such lesions and extend them. Myiasis also, may occur within men's intestines and his body openings. The stable fly *Stomoxys calcitrans* is a biting fly often associated with houseflies, which it superficially resembles. It is found in and around man's dwellings and in windrows of wet, decaying vegetation along lakeshores. Both males and females are vicious biters, particularly during warm, humid weather.

Certain species of black flies in the northern woods (*Prosimulium hirtipes* complex and *Simulium venustum* complex) regularly become locally abundant and very troublesome to man. The bites of black flies are extremely annoying. These flies commonly appear in swarms and attack viciously. In a susceptible individual, the bite may result in hemorrhagic spots, followed from three to 24 hours later by

TABLE 23-4 Human Cases of Rocky Mountain Spotted Fever by State and Year

State	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	Total
Minnesota	2	--	--	--	--	--	4	--	--	--	6
Wisconsin	--	--	--	--	--	--	--	--	--	--	--
Illinois	4	4	7	7	9	11	12	8	8	6	76
Indiana	6	7	9	18	--	8	11	--	11	--	70
Michigan	--	--	--	--	3	--	--	--	--	--	3
Ohio	4	6	8	12	10	9	11	14	11	20	105
Pennsylvania	6	2	6	15	27	20	8	10	25	10	129
New York	7	11	2	2	9	14	9	5	7	6	72
Total	29	30	32	54	58	62	55	37	62	42	461

Note: All data are for entire State

Source: Epidemiology Program, Center for Disease Control, U.S. Public Health Service

TABLE 23-5 Human Cases of Tularemia by State and Year

State	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	Total
Minnesota	1	--	2	2	1	1	--	--	--	1	8
Wisconsin	2	8	4	3	1	1	--	--	5	1	25
Illinois	39	19	24	21	14	21	18	15	10	10	191
Indiana	15	16	5	2	9	15	2	--	3	13	80
Michigan	--	1	1	1	2	--	--	1	--	--	6
Ohio	2	3	2	4	--	3	--	1	2	4	21
Pennsylvania	3	2	1	1	--	--	--	7	--	1	15
New York	3	1	1	--	1	--	1	7	4	2	20
Total	65	50	40	34	28	41	21	31	24	32	366

Note: All data are for entire State

Source: Epidemiology Program, Center for Disease Control, U.S. Public Health Service

TABLE 23-6 Human Cases of Leptospirosis by State and Year

State	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	Total
Minnesota	1	1	2	1	--	--	--	--	--	--	5
Wisconsin	--	--	--	--	--	--	--	--	--	--	--
Illinois	--	--	2	--	5	1	--	1	3	1	13
Indiana	--	--	5	--	--	--	--	1	1	2	9
Michigan	--	--	1	1	2	--	2	--	--	1	7
Ohio	2	1	3	--	7	--	--	2	8	1	24
Pennsylvania	1	2	1	3	--	--	--	--	3	1	11
New York	4	2	1	6	4	1	1	1	1	3	24
Total	8	6	15	11	18	2	3	5	16	9	93

Note: All data are for entire State

Source: Epidemiology Program, Center for Disease Control, U.S. Public Health Service a pustular lesion, and later by a vesicular lesion, which may last from a few days to several weeks. Lesions from nearby bites may become confluent, causing a large slow-healing lesion. Secondary infection is a frequent complication. The larval stages of black flies are found in running water. Larvae are found attached to rocks, floating grasses, or other pendulous plants. One or more generations develop each year, depending on the species. Adult black flies are annoying during the spring and summer.

Horseflies and deer flies, because of their persistent and painful bites, cause great annoyance to humans, livestock, and wildlife. Most species encountered are in the genera *Tabanus* (horseflies) and *Chrysops* (deer flies). Deer flies, particularly when interrupted while feeding and consequently visiting several hosts, may transmit the bacterial agents of tularemia. Both groups can inflict painful puncture wounds, which may continue to bleed after the fly has left the host. Such wounds may attract other types of flies that can cause myiasis. These wounds may also become infected by bacteria. The breeding grounds for horseflies and deer flies include both freshwater and saltwater marshes and margins of ponds, lakes, and streams. Adults frequently leave the breeding sites and move to uplands, especially to wooded areas, where they cause a severe daytime annoyance. It is apparent that the problems associated with these insects can be increased by the development and use of water and related land resources.

Biting midges, commonly called "punkies" or "no-see-ums" (sand flies in coastal areas) are blood-sucking flies which become serious pests in woodlands, communities, and recreational areas. The dominant species in the Adirondacks and other wooded areas of the eastern Great Lakes Basin is the vicious biter *Culicoides sanguisuga*. The species *Culicoides obsoletus* is perhaps the most widely distributed North American *Culicoides crepuscularis*, originally found in Illinois. *C. stellifer*, *C. haematopotus*, and *C. variipennis* are all well represented within the Region, but they are not considered common biters attacking man.

The larvae of *Culicoides* are found in mud, sand, and debris at margins of lakes, ponds, springs, and creeks, and in tree holes. Near breeding sites the adults are usually abundant during most of the warmer months. The adult *Culicoides* are small flies that can pass through ordinary 16-mesh screens. They dislike wind and are seldom bothersome except during calm periods. For many people the lesions produced by *Culicoides* bites last longer and are more painful than most mosquito bites.

Although short-lived and nonbiting, the chironomid midges have become a significant problem in some areas. Water containing a heavy load of organic material favors midge production. The larvae, frequently called bloodworms, are produced in the bottom debris of shallow lakes, ponds, sewage oxidation lagoons, and slow-moving streams. During periods of peak emergence, adult midges can produce great annoyance by their great numbers. The midge *Chironomous plumosus* frequently reaches great numbers in shallow lake areas, notably in the Lake Winnebago area in east-central Wisconsin. When the chironomid midges are present with mosquitoes, which they resemble, people often become unduly alarmed, believing that the numerous insects on the wing can all inflict painful bites. In the Toledo, Ohio, area this situation has occurred repeatedly, causing considerable consternation to persons responsible for controlling mosquitoes.

Ticks are vectors of Rocky mountain spotted fever and tularemia. The principal species involved is the American dog tick *Dermacentor variabilis*. Although records are incomplete, there are indications that this tick is generally distributed throughout most of the Basin, and is especially prevalent in the southern portion. The dog tick can also cause tick paralysis, probably by introducing neurotoxin from the tick's saliva into nervous tissues of the host, especially at the base of the skull. Death in man and other animals may result if the tick remains attached. Complete recovery, however, is usually remarkably rapid when the tick is removed. Tick paralysis in dogs has been unusually prevalent in Ohio during recent years, and two human cases in the State were recorded in 1970.

The dark woods ticks (genus *Ixodes*) and others are severe pests of wildlife and livestock. Even large animals occasionally die from massive tick infestations.

Most ticks are typically found in wooded and brushy areas, particularly along pathways and animal runs. Campsites, picnic grounds, nature trails, and other outdoor recreation areas constructed in association with water resources developments present unusual opportunities for bringing man and his pets into close contact with ticks.

Spiders are common within the Basin. The vast majority are harmless. The black widow, *Lactrodectus mactans*, and the northern widow, *Lactrodectus variolus*, are widely distributed and considerably feared. Bites are uncommon but serious. Fatality from this systemic neurotoxin, in untreated cases, may reach five percent. The brown recluse or fiddleback spider, *Loxosceles reclusa*, is expanding its range throughout the Midwest. The venom of this spider causes hemoglobin to separate from red blood cells. In severe cases, it can cause ulceration.

Lice seldom have come to public attention since World War II. Outbreaks of head and body lice may occur from time to time, usually when personal cleanliness is neglected. Each year during the opening of schools in rural Indiana it is not uncommon to find several children infested with head lice. Public schools in Rossville, Clinton County, were closed October 5 and 6, 1967, because objects found in the hair of many students and some faculty members closely resembled lice eggs (nits). Upon closer entomologic examination, these objects proved not to be eggs in this case.

1.3 State Vector Control Problems and Programs

An organized vector control program should meet these standards: it operates for the sole or major purpose of abating vectors; it is under the guidance of a vector control specialist, usually an entomologist or engineer; it bases its operations upon entomologic or epidemiologic data rather than complaints; and it practices comprehensive operations rather than limited operations using insecticides only. An organized vector control program is usually a line budget item, and it is frequently supported by a specific tax.

Ideally vector control is performed at the local level by mosquito or vector abatement districts, legally constituted under State enabling legislation, and financed by specific local revenues. At the State level vector control sections usually function within the State health department, and they are frequently combined with solid waste management programs. The State vector control programs usually provide coordinating services; research, and technical consultation; training, and epidemiological and laboratory services through cooperation with other State health department divisions. In several States outside the Basin the State health department provides support on some type of matching basis for local control operations, usually of the permanent source-reduction type.

Enabling legislation for the creation and operation of vector abatement districts has been enacted in Illinois (1927), Ohio (1945), Minnesota (1949), and Pennsylvania (1935). Enabling legislation was passed in New York in 1916 and subsequently amended to allow creation of a mosquito abatement district in Suffolk County. Although enabling legislation merely permits a local area to vote for or against formation of a vector abatement program and to provide for local financing, some States include restrictive phrasing in this legislation.

Most Basin States, particularly in the Midwest, have devoted relatively little attention to vector problems. No specific State-level vector control programs exist in Indiana, Michigan, Minnesota, Ohio, and Wisconsin. This situation is improved somewhat, however, by several organized local vector abatement districts, U.S. Public Health Service grants for rat control in several major metropolitan areas (Table 23–7), and by a U.S. Public Health Service research grant to investigate arthropod-borne encephalitis in Ohio, Wisconsin, and Illinois.

1.3.1 Illinois

Western encephalitis and St. Louis encephalitis have occurred repeatedly in Illinois. The first mosquito annoyance of the season is ordinarily caused by *Aedes stimulans* in April and May, followed by *Aedes vexans* in the summer. Later, *Culex p. pipiens*, *Culex salinarius*, and *Coquillettidia perturbans* may become major pests. A total of 58 species of mosquitoes in 10 genera is recorded in Illinois. Rocky Mountain spotted fever is slightly endemic. Tularemia, leptospirosis, and rat bites are additional public health problems. Both the widow and brown recluse spiders occur within the Basin portion of Illinois.

The State Department of Public Health has a well-staffed vector control program. Of the 20 organized mosquito abatement districts in Illinois, 11 are in the Basin area. The Illinois Mosquito Control Association is composed of persons interested in various aspects of vector control. Under a Public Health Service grant the City of Chicago presently receives funds to help defray the costs of a rat control program.

TABLE 23-7 Rat Control Projects in the Great Lakes Basin

Location	Initial Project Budget (Fiscal Year 1969) PHS Grant	State and Local Funds	Total Budget	Projected Target Area Square Miles	Population
Milwaukee, Wisconsin	$ 413,162	$207,445	$ 620,607	6.3	148,330
Chicago, Illinois	2,100,000	894,157	2,994,157	5.0	256,233
Cleveland, Ohio	373,821	276,380	650,201	20.0	250,000
Buffalo, New York	562,406	322,264	884,670	10.6	140,000
Rochester, New York	317,420	196,549	513,969	5.6	45,000
Syracuse, New York[a]	140,626	108,000	248,626	1.1	37,000
Erie, Pennsylvania	0	90,000	90,000	?	?

[a]Syracuse, New York, data is for Fiscal Year 1971

1.3.2 Indiana

California encephalitis and St. Louis encephalitis have occured in repeated outbreaks in Indiana. Cases of Rocky Mountain spotted fever are reported occasionally. *Aedes stimulans* is troublesome in the northern two-thirds of the State and *Aedes vexans*, as well as *Culex p. pipiens*, are often locally abundant. A total of 51 species of mosquitoes in 10 genera has been recorded in Indiana. A principal mosquito problem area exists in the Calumet area in the northwest part of the State along Lake Michigan. The dunes-type physiography with slow-moving streams and marshes provides excellent mosquito breeding habitat. This is one of the most densely populated sections of the State.

The Indiana State Board of Health does not have an active vector control program, nor is there State enabling legislation for creation and operation of mosquito abatement districts. Several local health departments have environmental improvement programs that include such mosquito control activities as larviciding, fogging, and public information programs directed toward encouraging cleanup of water-containing refuse.

Doctor R. E. Siverly, Professor and Director, Public Health Entomology Laboratory, Ball State University, has conducted a continuing "Study of Indiana Mosquitoes" for several years. Included in the project was the preparation of the monograph entitled "Mosquitoes of Indiana." This investigation and study has been supported in part by a grant from the Indiana State Board of Health.

1.3.3 Michigan

During the years 1968 through 1971, six cases of encephalitis in humans involving the California encephalitis virus occurred in Michigan. Exposure to the California encephalitis virus has been detected in 11 other humans without encephalitis. Cooperative efforts to determine the true incidence of California encephalitis virus in Michigan and the mosquito vectors involved are being conducted by the Michigan Department of Public Health and Michigan State University.

Dirofilaria immitis, dog heartworm, a disease with limited human involvement, occurs in many parts of Michigan. Work is in progress to determine the vectors of this disease in Michigan. Several woodland species of *Aedes* and *Aedes vexans* often are severe pests during June and July. *Culex p. pipiens, Anopheles quadrimaculatus*, and *Coquillettidia perturbans* frequently become locally abundant. The former species breeds in at least half of the sewage lagoons in State parks. Black flies and the woodland *Aedes* mosquitoes are serious pests in the Upper Peninsula. A total of 49 species of mosquitoes in eight genera have been recorded in the State.

One medical entomologist each is now on the staffs of the State Health Department and Michigan State University. As a result State vector control activity has been increased during recent years. The State and local health departments in the major cities provide consultation in vector control to the extent of their resources. In Detroit the health department investigates vector problems.

A bill providing for establishment of mosquito abatement districts in Michigan has been introduced in the Michigan House of Representatives. An organized mosquito control program has been initiated in the Michigan State Park System, with the involvement of the Michigan Department of Public Health, Michigan State University, and the Michigan Department of Natural Resources in each stage of the planning and development of the program. The Huron-Clinton Metropolitan Authority has an organized mosquito control program in operation in each of the eight metro-parks under their control.

In the mid-1950s the former Communicable Disease Center of the U.S. Public Health Service cooperated with the Lansing Health Department in conducting a vector control demonstration project for a limited period. This activity, especially the mosquito control aspects, is an ongoing program in Lansing and surrounding communities with a 1971 budget of $178,000.

The Detroit Department of Public Works operates a rat control program, but cannot carry out a truly effective program with its present resources. The Flint-Genesee County Health Department has received a Federal grant of $149,000 to finance the first year of a comprehensive rat control program in the City of Flint. Rat surveys of a number of Michigan communities have been conducted to establish the need for rat control programs. A rural rat control program involving local health departments and the Cooperative Extension Service has been initiated. A rat control program is also in operation to prevent movement of rats from open dumps to residences when these dumps are closed in compliance with the Michigan Solid Waste Management Law.

1.3.4 Minnesota

The Basin area of Minnesota is restricted to four counties, Cook, Lake, St. Louis, and Carlton, and the principal metropolitan area is Duluth. This is primarily an area of coniferous forests with numerous small lakes and swamps. The woodland *Aedes*, *Aedes vexans*, and black flies are extremely troublesome. A total of 50 species of mosquitoes in nine genera is recorded in the State.

Although State enabling legislation for mosquito abatement districts has existed since 1949, the first district in the State was formed only recently in the St. Paul area which is outside the Basin. No specific vector control program exists in the State Health Department. Leadership in vector control is provided by the State Commissioner of Agriculture, Dairy, and Food, and by the University of Minnesota. Many resort owners in the Basin area conduct mosquito and black fly control operations, usually adulticidal, when the need becomes acute.

1.3.5 New York

Along the shorelines of Lake Erie and Lake Ontario, mosquito problems are associated with *Aedes vexans* and *Culex p. pipiens*. The urban areas, Buffalo, Rochester, and Oswego, have significant rat problems. In the Finger Lakes area and the north-northeast portion of the State, the principal problems are also associated with woodland *Aedes* mosquitoes, biting midges, black flies, deer flies, and ticks. The biting midge *Culicoides sanguisuga* is especially abundant. A total of 55 species of mosquitoes in nine genera are found in New York.

Organized control of medically-important mosquitoes in New York State is conducted primarily on a countywide basis through a 1966 State-funded program cooperatively administered and directed by the Department of Health and the Department of Environmental Conservation. The program provides for State-county cooperation, with State matching funds of 50 percent up to a maximum of $25,000. Approved counties must have a qualified program director and follow State-approved methodology.

Nassau and Suffolk Counties, both outside of the Basin, have two of the largest, oldest, best supported, and largely autonomous mosquito control programs in the United States.

Rodent control programs, operated in most counties in New York State, receive 50 percent funding from the State Health Department. In addition Rochester, Buffalo, and Syracuse receive large U.S. Public Health Service grants for rat control.

More than 1,000 square miles in the Adirondack State Park area of New York State are treated each year for black fly control.

1.3.6 Ohio

California encephalitis and St. Louis encephalitis occur in repeated outbreaks in Ohio, with the State leading the nation in reported cases of California encephalitis. *Aedes vexans*, the most prevalent mosquito, usually reaches maximum abundance in late summer and early fall. *Coquillettidia perturbans* is a major pest in marshes along Lake Erie and Indian Lake. *Aedes sollicitans* occasionally becomes very annoying in salty water near Lake Erie. Its possible involvement in transmitting eastern encephalitis from reservoir birds to man increases its public health importance. *Aedes sticticus* is greatly abudant in northwestern Ohio, and *Aedes stimulans* is an early season pest in wooded areas. *Aedes triseriatus* is widespread, abundant, and a major pest, as well as a potential vector of California encephalitis during the entire summer. The State has recorded 59 species of mosquitoes in 10 genera and most of these occur within the Basin area.

The Ohio Department of Health does not have an organized vector control program. Vector control services are usually provided by county sanitarians and by the State agricultural extension entomologist. To a limited extent these services are also provided by the medical entomologist and her staff, part of the State Health Department, funded by a Public Health Service research grant to investigate California encephalitis in Ohio. This group proved to be an invaluable resource in directing epidemic preventive work following the 1969 floods. Because of the high level of California encephalitis virus activity in Ohio, interest in mosquito control increased during the late 1960s. An earlier questionnaire inquiring about local mosquito control programs was sent to all local health departments by the State Department of Health. One-third of the 168 questionnaires were answered. Of these, 11 cities and two counties reported some form of mosquito control. This was usually a fogging or misting operation, directed against adult mosquitoes, and was frequently sponsored by a civic club. Only two areas conducted larval surveys or directed control activities against larvae. These findings, plus subsequent requests for assistance, prompted the State Department of Health to promote establishment of the Ohio Mosquito Control Adivisory Council to provide technical consultation to local agencies interested in pesticide application in Ohio. The Ohio Mosquito Control Association, formed in 1966, is a growing organization of workers in mosquito control and others interested in vector problems. Enabling legislation for creation and operation of sanitary districts, which may function solely for mosquito control, was enacted in 1945. The Toledo Area Sanitary District, in operation for more than 25 years, was the only mosquito abatement district in Ohio until 1969, when the Northeast Salem Sanitary District was organized. The 1969 appropriation for the Toledo Area Sanitary District was more than $353,000. Work by this district is comprehensive, using a number of proven mosquito control methods. The district owns and operates heavy earth-moving equipment in a continuous program of source reduction. Major emphasis is focused on clearing, deepening, and maintaining river and stream banks, and ponding and draining swampy areas.

1.3.7 Pennsylvania

A mosquito control survey of Erie County, Pennsyvania, conducted in 1968, showed that *Aedes vexans* and *Culex p. pipiens* were the most abundant species at that time. As part of its research program on California encephalitis, the State Department of Environmental Resources placed sentinel animals in Presque Isle State Park and South Erie Game Lands in Albion. Serums drawn from animals in South Erie Game Lands in September 1970 showed neutralizing antibodies for CE. These finds and other findings approximately 55 miles south in Mercer County cause the Department to believe that CE is probably endemic to Erie County. During 1970 a large population of a salt-marsh mosquito, *Aedes taeniorhynchus*, existed in Presque Isle State Park. This mosquito, a severe biter, is usually restricted to the Atlantic and Gulf coastal areas. A large percentage of the soils in Erie County are poorly drained, particularly in the southern townships. In wet years swamp-like conditions have prevailed, creating habitat productive of large populations of horseflies (*tabanids*). A total of 40 species of mosquitoes in 10 genera have been recorded in Pennsylvania. Approximately 34 species occur in Erie County.

Although the State of Pennsylvania has legislation permitting creation and operation of mosquito abatement districts, none has been established in Erie County. The State Department of Environmental Resources has a well-staffed vector control program, which provides valuable research and consultative services to local health departments.

1.3.8 Wisconsin

California encephalitis and western encephalitis have occurred repeatedly in Wisconsin. The cold-hardy woodland *Aedes* reach enormous numbers in the early summer. The *Aedes communis* complex usually attains its population peak the first week in June. *Aedes trivittatus* is most abudant in the Basin area of Wisconsin, and *Culex p. pipiens* is widely distributed in both urban and rural areas. *Culex tarsalis* may become abudant at times. The State has recorded 45 species of mosquitoes in eight genera. The midge *Chironomus plumosus* breeds prolifically in the many shallow lakes. Black flies frequently become very troublesome.

Wisconsin lacks enabling legislation for creation and operation of mosquito abatement districts, and the State Department of Health does not have an organized vector control program. Notable research on the natural history of California encephalitis is conducted at the Zoonoses Research Center, University of Wisconsin. The cycle of CE in Wisconsin apparently involves chipmunks or squirrels and *Aedes triseriatus*. The disease is concentrated in the southwestern portion of the State, outside the Basin.

Section 2

PUBLIC WATER SUPPLY ASPECTS

Health protection for the people who are the ultimate users and intended beneficiaries should be an important consideration in any discussion of water supplies. Because municipal water supplies are used for drinking and cooking, health and safety considerations are directly associated with those supplies.

One of the most significant achievements in the past 100 years in the United States has been the provision of safe and potable community water supplies. This achievement was accomplished by the development of treatments to remove turbidity and destroy bacteria, and by water supply surveillance activities. The need for pollution control and the publicity devoted to that subject have caused many States to emphasize the pollution control portion of their surveillance programs to the detriment of their water supply programs. In these States the water supply surveillance program must be reemphasized to meet the ever-growing needs of water supply systems.

The solution to present domestic water supply problems has two aspects. First, data gathering must be improved to better define the scope and danger of present and potential problems. Second, known health hazards in the nation's water supply systems must be reduced or eliminated. Research is needed to determine if chemicals being introduced into the water by modern society are detrimental to health, to establish acceptable limits for their presence, and to determine if present treatment techniques and facilities will reduce such chemicals to acceptable limits if they now exist above those limits.

This section includes a brief review of some of the problems present in the water supply systems chosen for review in the 1969 Community Water Supply Survey.

Section 2 also summarizes potentially water-borne disease, water quality, fluoridation, operator training, cross connection control, and water supply assistance and surveillance programs in the Great Lakes Basin.

2.1 1969 Community Water Supply Study

In 1969 the Division of Water Supply, Environmental Protection Agency (EPA), conducted a Community Water Supply Study of 969 public water supply systems located in nine areas of the nation. These water supply systems delivered water to more than 18 million people. The study was undertaken to answer two questions about the nation's water supplies. First, are well established standards of good practice being applied to assure the quality and dependability of water being delivered to consumers' faucets today? Second, what should be done to assure adequate quantities of safe drinking water in the future throughout the nation? Of the nine areas studied, the Cincinnati metropolitan area in southwest Ohio and northern Kentucky is closest to the Great Lakes Basin.

Following are excerpts from the discussion of the study findings and the problems facing the waterworks industry in the "Significance of National Findings" report:

> Well established standards of good practice, in terms of the full application of existing technology, are not being uniformly practiced today to assure good quality drinking water. While most professionals hold the USPHS Drinking Water Standards in high esteem, the study shows that an unexpectedly high number of supplies, particularly those serving fewer than 100,000 people, exceeded either the mandatory or recommended constituent levels of bacterial or chemical content, and a surprisingly larger number of systems evidence deficiencies in facilities, operation, and surveillance.
>
> The National significance can be placed in perspective by considering the size-distribution of municipal water supply systems that were the subject of comprehensive facilities census conducted during 1963. At that time, 150 million Americans were being served by 19,236 public water supply systems including 73 million people dependent upon 18,837 small systems, each serving communities of less than 100,000 people. When these statistics are compared with the fact that over 40 percent of the small systems investigated during the current study evidenced current quality deficiencies *on the average* and both large and small communities were judged

> to be giving inadequate attention to quality control factors, there can be little doubt that this situation warrants major National concern.
>
> Most of our municipal water supply systems were constructed over 20 years ago. Since they were built, the populations that many of them serve have increased rapidly—thus placing a greater and greater strain on plant and distribution system capacity.
>
> The task in the future for our water treatment plants can be visualized by examining our population trend. By the year 2000—less than 30 years from now—our present population of about 205 million is expected to grow to 300 million. By that time, it is expected that 187 million people (the total U.S. population just eight years ago) will be concentrated in four urban agglomerations—on the Atlantic Coast, the Pacific Coast, the coast of the Gulf of Mexico and the shores of the Great Lakes. Most of the remaining population will be living in cities of 100,000 or more.
>
> Consideration of the findings of this study leaves no doubt that many systems are delivering drinking water of marginal quality on the average, and many are delivering poor quality in one or more of their water distribution systems today. To add to this quality problem, the deficiencies identified with many water systems justifies real concern over the ability of these systems to deliver adequate quantities of safe water in the future.

Because the Community Water Supply Study did not include any of the metropolitan areas of the Great Lakes Basin, it is difficult to determine to what degree the problems defined by the study occur in the Basin. It is known, however, that these problems do occur within the Basin. Obviously, the problems vary from area to area and from State to State.

The trend towards population concentration in large cities and metropolitan areas may mitigate the problems that seem to occur so often in small water supply systems. This will be particularly true if small water supplies are brought together by the regionalization encouraged by planning and surveillance agencies. Problems common to small water supply systems may also improve because of the increased attention water supply surveillance is now receiving in the Great Lakes States. Examples of this increased attention are the levels of water supply surveillance funding in New York and Michigan, mandatory certification laws adopted in the early 1970s in Indiana and Minnesota, rules and regulations on cross connection control adopted in the early 1970s in Ohio and Michigan, and resources applied to operator training in Illinois and Ohio. Past efforts and this recent emphasis on water supply surveillance, however, have not been adequate in many areas to eliminate the problems confronting waterworks officials in the Great Lakes Basin.

The protection and safety of a public water supply system depend on the sanitary environment, the quality and quantity of source waters, the effectiveness and reliability of treatment processes and facilities, the capacity and condition of storage and distribution systems, the quality control surveillance, and the qualifications and effectiveness of the operating personnel. Continued emphasis on water supply surveillance and facility and operator improvement is essential to the provision of safe, adequate water supply for the people of the Great Lakes Basin.

2.2 Major Health Aspects Problems

2.2.1 Potentially Water-Borne Diseases

Bacteria, protozoa, worms, viruses, and fungi are the five categories of parasitic organisms infective to man that are found in water. The most serious bacterial water-borne diseases of the middle latitudes of the world have been cholera and typhoid fever, two highly specific infections which caused much sickness and death in cities during the industrial revolution of the 19th century. By the early 1870s the occurrence of cholera in the United States was stopped through community sanitation and quarantine practices. Today typhoid fever seldom occurs in the United States. Salmonellosis, shigellosis, and hepatitis were the most common water-borne diseases in the United States in the past decade.

Five diseases that may be caused by ingestion of drinking water are reportable on a national basis. These diseases are amebiasis, hepatitis, salmonellosis, shigellosis, and typhoid fever. Most of the reported cases are known to result from person-to-person transmission or food transmission. The occurrence of these diseases, however, serves as a reminder that potentially water-borne disease focuses continue to exist, and that disease outbreaks can occur when protective measures for drinking water production or distribution fail.

The nationally reported data on these five diseases for the Great Lakes States were used to estimate the number of cases occurring in the Great Lakes Basin from 1965 through 1968. Figures on disease incidence for each State in the Basin were taken from reports prepared by the Center for Disease Control. To estimate the number of cases of each disease that occurred within the Basin, these figures were multiplied by the percentage of each State's population that lives within the Basin. Table 23–8 summarizes the estimated number of cases of amebiasis, hepatitis, salmonellosis, shigellosis, and typhoid fever that occurred from 1965 through 1968 in the Basin.

TABLE 23–8 Estimated Number of Reportable Cases of Potentially Water-Borne Diseases in the Great Lakes Region (1965–1968)

Disease	1965	1966	1967	1968	Total
Amebiasis	126	137	86	148	497
Hepatitis	5,566	5,048	4,898	5,759	21,271
Salmonellosis	2,141	2,126	1,644	2,183	8,094
Shigellosis	1,174	1,308	1,650	1,463	5,595
Typhoid Fever	35	32	28	28	123
Totals	9,042	8,651	8,306	9,581	36,580

The actual occurrence of diseases is much greater than the number reported because many cases are not repoted by physicians and many other cases are not severe enough to require attention by a physician. Disease outbreaks that may be water-related should be more thoroughly investigated and analyzed.

Comparing the estimated incidence of the five diseases in the Great Lakes Basin with their incidence throughout the nation reveals no outstanding differences. From 1965 through 1968 the portion of the diseases occurring in the Great Lakes Basin was approximately 12 percent, while the Great Lakes area contained approximately 14 percent of the nation's population.

A recent disease outbreak illustrates the potential health problem related to contaminated drinking water. In the early spring of 1968 more than 180 persons served by the Angola, New York, public water system became ill with gastroenteritis. A review of conditions at the time of the episode indicates that highly polluted raw water and inadequate chlorination facilities combined to allow contamination to pass through the water treatment plant and into the distribution system. New cases of the disease abated after an order to boil water was issued. Steps taken by health and water hygiene authorities should prevent recurrance of this situation.

Water, particularly drinking water, causes other possible effects on the health of man. Under certain circumstances, excessive nitrates in drinking water can cause methemoglobinemia in infants. Trace metals such as mercury can poison the human system. The long-term effects of other substances such as pesticides, radioactive materials, and carcinogenic chemicals are not fully known and require greater research and surveillance. Excess sodium in drinking water can be harmful to heart disease patients, and epidemiologists are investigating a potential inverse relationship between hardness in water and heart disease. More attention should be given to the acute and chronic relationships of water to the health of people in the Basin.

In 1973 amphibole asbestos fibers were found in water supplies from Duluth to Silver Bay, Minnesota. Because of the health risk associated with these fibers, this finding caused considerable concern. Massive pollution of Lake Superior waters from a taconite milling plant caused the contamination. As a result the Duluth water supply could not be used as an interstate water supply, and increased emphasis was placed on special filtration for the affected water supplies.

In part of Illinois outside the Basin barium and radiological levels were found to exceed the maximum levels in the 1962 Public Health Service Drinking Water Standards in a significant number of ground-water supplies. Excessive levels of barium also have been found in several water supplies in Ohio and Wisconsin.

2.2.2 Drinking Water Quality

The Public Health Service Drinking Water Standards,[27] initially adopted in 1914 and last revised in 1962, widely influenced drinking water supply standards and practices in the nation. Indiana and Pennsylvania have officially adopted these Drinking Water Standards and the other five Basin States use the standards as guidelines. The standards include bacteriological, chemical, radiochemical, and physical components important to the potability of a water supply, but they do not include limits for many of the pesticides, organic materials, and other new substances that are appearing in water supplies. Federal legislation that would authorize the inclusion of such limits and make the standards applicable nationally has been pending since 1971. Increased research is needed to provide basic information on which realistic standards can be set for the new substances found in water.

To meet modern quality requirements, water supplies must be wholesome and palatable, two closely related attributes. To be wholesome, water must be free from pathogenic organisms, toxic subtances, and excessive amounts of mineral and organic matter. Palatable water must be of moderate temperature, and significantly free from color, turbidity, offensive chemicals, taste, and odor. If water is not attractive to the consumer's senses of sight, taste, and smell, people will either drink insufficient amounts of water or resort to drinking water that may be pleasant to their senses, but possibly hazardous to their health.

People of the United States expect to be provided with high quality drinking water. Although the occurrence of certain enteric disorders, notably typhoid fever and cholera, has been greatly reduced, massive outbreaks of diarrheal disease conveyed through drinking water still occur.

Until quite recently concern for water quality has centered principally on the danger of bacteriological contamination from inadequately treated sewage discharged into rivers and streams. Today chemical pollution of source waters poses problems that are possibly even more difficult to solve. Even the most effective treatment of municipal and industrial wastes cannot remove all threats of water contamination. The need for research to define the limits of chemical pollutants acceptable in drinking water and the capability of present treatment methods to remove such pollutants is obvious. Of equal importance is the need for monitoring chemical pollutants to determine whether such pollutants are present in significant concentrations in drinking water supplies.

The current Drinking Water Standards, established in 1962, do little more than mention viruses, neglect numerous inorganic chemicals that are toxic to man, and identify carbon chloroform extract as the only index for the entire family of organic chemical compounds. Established in 1914, the first standards include bacteriological quality in accordance with Federal authority over communicable diseases. Revisions in 1925 and 1946 include inorganic chemicals that are potential toxicants, such as lead and copper, and elements that are esthetically undesirable, such as iron and manganese. In the 1962 standards organic chemicals are also included. The Water Supply Program of the Environmental Protection Agency is currently preparing a revision of the 1962 edition of the Drinking Water Standards that would include standards for organophosphate and chlorinated hydrocarbon pesticides, sodium, and mercury. The most recent proposed revision of the standards, dated December 1973, is summarized in Table 23–26.

A nationwide reconnaissance of the trace elements arsenic, cadmium, chromium, cobalt, lead, zinc, and mercury in surface water of the 50 States was conducted by the U.S. Geological Survey (USGS) in late 1970.[51] The report presents data from the analysis for these trace elements in grab samples taken from surface waters that serve as municipal water supply sources for the nation's metropolitan areas. Samples were filtered (0.45 micron) to provide information on sediment-free water similar to that supplied to the domestic consumer after treatment. Table 23–9 shows data for samples taken from water supply intakes in the Great Lakes Basin as recorded in the reconnaissance report. Except for mercury, the limits recommended by the 1962 Drinking Water Standards are shown under the elemental name for quick comparison to the data reported by USGS. For mercury the proposed 1973 Drinking Water Standards level is used. The concentrations of the chemical constituents shown did not approach or exceed the maximum concentrations prescribed by the 1962 Drinking Water Standards, except for arsenic in Michigan, New York, and Wisconsin. These arsenic levels, however, are well below the proposed 1973 Drinking Water Standards, which call for a revision of the maximum allowable level of arsenic from 10 micrograms per liter to 100 micrograms per liter. This revision was proposed because of new information demonstrating that arsenic is not carcinogenic. Although data from the report are inadequate to define water quality for any of the surface waters sampled, they can indicate possible problems and provide limited information where almost no data for these constituents in raw or finished water supplies existed prior to 1970.

Waste products from the nation's highly urbanized and technological society pollute our land, air, and water. These wastes, many of them not even identified, persist in the environment and react with one another in complex and little understood ways to affect the life cycles of plants, animals, and man. This indicates a need for research to define what happens to these waste products after their release into the environment and to define the health effects of these waste products in drinking water. This problem is vividly illustrated by the finding in 1973 that the filings of a taconite processing plant located on the shore of Lake Superior contained massive amounts of amphibole asbestos fibers which were being carried in high concentrations to

TABLE 23-9 Reconnaissance of Selected Minor Elements, Surface Waters of the United States, October 1970, Great Lakes Basin Data (Micrograms per Liter)

Location	Element (Standard µg/l)					
	As(10)[a]	Cd(10)	Cr(50)	Pb(50)	Zn(5000)	Hg(2)[b]
Illinois						
Lake Michigan at Evanston	x	3	x	16	30	x
Lake Michigan at Chicago	x	x	1	3	130	x
Indiana						
Lake Michigan at Whiting	x	x	x	1	60	x
Lake Michigan at Gary	x	x	1	1	x	0.8
St. Joseph River at Fort Wayne	x	x	x	3	90	x
Michigan						
St. Marys River at Sault Ste. Marie	10	1	x	5	110	x
Lake Michigan near Agnew	10	x	x	7	70	0.7
St. Clair River at Port Huron	x	x	x	5	160	x
Detroit River at Detroit	x	x	x	4	10	x
Lake Erie near Point Aux Peaux	x	1	x	3	110	0.1
Minnesota						
Lake Superior at Duluth	x	1	x	x	80	x
New York						
Hinckley Reservoir near Utica	x	1	2	7	20	x
Lake Erie at Woodlawn	x	3	x	1	20	0.5
Lake Erie at Buffalo	20	3	x	3	30	0.5
Niagara River at Niagara Falls	x	2	x	1	x	x
Lake Ontario at Rochester	x	1	x	1	x	x
Skaneateles Lake at Skaneateles	x	1	1	x	30	x
Otisco Lake at Marietta	20	1	x	x	x	x
East Branch Fish River at Tabert	10	1	x	x	x	x
Ohio						
Lake Erie at Toledo	x	x	2	x	10	x
Lake Erie at Cleveland	x	x	2	x	130	x
Cuyahoga River near Kent	x	1	2	1	x	x
Pennsylvania						
Lake Erie at Erie	x	x	2	7	10	x
Wisconsin						
Lake Superior at Ashland	x	x	1	14	90	x
Lake Winnebago at Neenah	10	x	1	10	20	x
Milwaukee River at Milwaukee	x	x	1	2	30	x

Note: x indicates an amount less than lower limit of detection as follows:
As=10; Zn=10; Cd=1; Cr=1; Pb=1; Hg=0.5

[a]Proposed 1973 Drinking Water Standards show a revision of arsenic to 100 µg per liter.

[b]Proposed 1973 Drinking Water Standards show a level of 2 µg per liter for mercury.

drinking water supplies located as far as 60 miles away. These fibers are known to be carcinogenic in the lung, but little is known about their effect in the gastrointestinal tract.

More perhaps than any other resource, water resources illustrate the the interaction of all parts of the environment and the recycling process that characterizes every resource of the biosphere. Everything that man injects into his environment, chemical, biological, or physical, can ultimately find its way into the earth's water. These contaminants must be removed, by nature or man, before the water is again potable.

Data such as those reported by USGS have prompted increased attention to the trace metals and other constituents listed in the 1962 PHS Drinking Water Standards. Before 1970 very little trace metal analysis on either finished or raw water was done in the Great Lakes States. By the end of 1971 most State water supply surveillance laboratories had begun sampling and analysis for the majority of the constituents listed in the 1962 PHS Drinking Water Standards. This increased surveillance has detected several apparently longstanding problems for a large number of water supplies shown to exceed the radiological standards in Illinois and for a limited number of supplies shown to exceed the barium standard in Illinois, Ohio, and Wisconsin. These problems, occurring in groundwater supplies, are probably natural in origin.

As shown by Tables 23–10 and 23–11, the frequency of sampling, sample location, and number of analyses routinely done varies considerably from State to State. The frequency referred to in Table 23–11 means that frequency established by State policy. The actual frequency will vary from year to year depending upon State resources. For example Ohio in 1971 achieved a sampling frequency of every 16 months for ground-water source supplies, while Indiana achieved a sampling frequency of every four years in 1971. Ohio places the greatest emphasis on chemical analysis with more frequent determination on more parameters than the other States. (In July 1972 Wisconsin determined more parameters per sample for surface water samples.) Ohio is rapidly moving to inclusion of all the parameters of the Drinking Water Standards (with the exceptions of odor, carbon-chloroform extract, and phenols) and to meeting its frequency policy.

As a group the water utilities conduct very limited analysis on a routine basis, primarily to assure operational control of the major problems for which the utilities were designed to control. A number of utilities occasionally obtain trace metal analyses by sending samples to private laboratories for analysis. A few very large water utilities, including the Chicago water utility, periodically conduct comprehensive sampling and analysis for trace metals, using in-house capability.

2.2.3 Fluoridation

Fluoridation is the adjustment of the fluoride content of public water supplies to an appropriate concentration range to reduce tooth decay. Approximately 10 million people in the United States have a naturally fluoridated water supply, and in the past 25 years more than 4,000 communities have adjusted the fluoride content of their water. Leaders in community water supply fluoridation include Grand Rapids, Michigan, in 1945; Sheboygan, Wisconsin, in 1946; and Evanston, Illinois, in 1947.

Tooth decay attacks 95 percent of the U.S. population, and results in more than four million days of restricted activity per year. The 90,000 active non-Federal dentists devote more than half their time to treatment of dental caries at a cost of more than two billion dollars annually. The current backlog of needs for dental treatment overwhelms the present and foreseeable supply of dentists and auxiliaries.

Prevention of dental caries through water supply fluoridation is the most direct way of attacking this growing problem. Twenty-five years of experience show fluoridation to be safe and capable of reducing the incidence of dental caries as much as 65 percent. This has been demonstrated by a number of studies including the comparison of Grand Rapids, Michigan, to Muskegon, Michigan, (see references 46 and 57), and Newburgh, New York, to Kingston, New York, (see references 47 and 48). It is the most effective action available to decrease the occurrence of dental caries because its effectiveness in preventing caries does not depend on the individual's economic means, knowledge, or motivation, or on the availability of dentists.

Every national health organization in the United States that speaks with authority on the benefits and safety of fluoridation has adopted policies favoring it. Study after study in the United States and abroad has demonstrated the effectiveness of fluoridation beyond question in the scientific community.

TABLE 23–10 1962 Drinking Water Standards, Analyses Done by State Laboratories, July 1971

Constituent	Ill.	Ind.	Mich.	Minn.	Ohio	Wis.[a]	N.Y.	Pa.
Turbidity	S	R	R	S[b]	R	S	R	R
Color	S	R	R	S[b]	R	S	R	R
Odor	S	S	R	S	N	N	R	R
Methylene-blue Active Substances	S	S	S	R	S	S	S	S
Arsenic	R	S	S	S	S	S	S	S
Barium	R	N	S	S	R	S	S	S
Cadmium	R	S	S	S	R	S	S	S
Chloride	R	R	R	R	R	R	R	R
Chromium	R	S	S	S	R	S	S	S
Copper	R	S	S	S	R	S	S	S
Carbon Chloroform Extract	N[c]	S	S	S	N	N	N	N
Cyanide	S	S	S	S	S	S	S	S
Fluoride	R	R	R	R	R	R	R	S
Iron	R	R	R	R	R	R	R	R
Lead	R	S	S	S	R	S	S	S
Manganese	R	R	R	R	R	R	R	S
Nitrate	R	R	R	R	R	R	R	R
Phenol	S	S	S	S	S	S	S	S
Selenium	R	S	S	S	S	S	S	S
Silver	R	S	S	S	R	S	S	S
Sulfate	R	R	R	R	R	R	S	S
Total dissolved solids	R	S	R	R	R	R	S	S
Zinc	R	S	S	S	R	S	S	S

R -- routinely done
S -- done on special request
N -- not done

[a] In this column S indicates analysis done annually on surface water supplies beginning in 1971.
[b] Color and turbidity analyses are required for surface supplies.
[c] Special arrangements for analyses made with National Environmental Research Center in Cincinnati.

2.2.3.1 Cost-Benefit Relationship

In 1955 the New York State Department of Health compared the time and cost factors involved in providing regular, periodic dental care to five- and six-year-old children in two cities, Newburgh and Kingston. Newburgh, with a population of 30,000, had fluoridated since 1945. Kingston, with a population of 29,000, had not been fluoridated. The children were selected on the basis of residence in the poorest socio-economic areas of each city. In fluoridated Newburgh the group was further limited to children who had resided in the city continuously from birth. During the first year treatment of the backlog of accumulated dental neglect was completed in both cities.

Newburgh children on the average required less than half as many dental services as did the Kingston children. Further, more than twice as many children in the fluoridated city, Newburgh, needed no dental treatment at all. Children in Kingston, the nonfluoridated city, needed many more two-surface fillings and

TABLE 23–11 1962 Drinking Water Standards, Routine Analyses by State Laboratories, July 1971

		Number of Constituents Tested	
	Frequency	DWS Analyses[a]	Other Analyses[b]
Illinois[c]			
Surface source			
Raw	3 yrs.	16	10
Plant	---	--	--
Distribution	3 yrs.	16	10
Ground source			
Raw	3 yrs.	16	10
Plant	---	--	--
Distribution	3 yrs.	16	10
Indiana			
Surface source			
Raw	2 yrs.	8	8
Plant	2 yrs.	8	8
Distribution	2 yrs.	8	8
Ground source			
Raw	2 yrs.	8	7
Plant	2 yrs.	8	7
Distribution	2 yrs.	8	7
Michigan			
Surface source			
Raw	---	--	--
Plant	3 yrs.	10	10
Distribution	---	--	--
Ground source			
Raw	5 yrs.	10	10
Plant	5 yrs.	10	10
Distribution	---	--	--
Minnesota			
Surface source			
Raw	1 yr.	10	8
Plant	1 yr.	10	8
Distribution	1 yr.	10	8
Minnesota (continued)			
Ground source			
Raw	5 yrs.	8	8
Plant	5 yrs.	8	8
Distribution	5 yrs.	8	8
New York			
Surface source			
Raw	6 mos.	11	16
Plant	---	--	--
Distribution	6 mos.	11	16
Ground source			
Raw	1 yr.	11	16
Plant	---	--	--
Distribution	6 mos.	11	16
Ohio			
Surface source			
Raw	---	--	--
Plant	3 mos.	16	12
Distribution	---	--	--
Ground source			
Raw	---	--	--
Plant	1 yr.	16	12
Distribution	---	--	--
Pennsylvania	1.1 yr.[d]	22[d]	7[d]
Wisconsin			
Surface source			
Raw	1 yr.	21	9
Plant	1 yr.	21	9
Distribution	---	--	--
Ground source			
Raw	5 yrs.	7	7
Plant	5 yrs.	--[e]	--[e]
Distribution	---	--	--

[a]Number of analyses conducted for constituents included in U.S. Public Health Service Drinking Water Standards.

[b]Number of analyses conducted for constituents not included in U.S. Public Health Service Drinking Water Standards.

[c]Routine fluoride analyses are conducted monthly for all water supplies. Routine nitrate analyses are conducted monthly for all surface supplies. Routine iron analyses are conducted monthly for all supplies requiring iron removal.

[d]Only total figures are available.

[e]Analyses are conducted only for constituents that do not meet State standards.

many more extractions than children in the fluoridated city. As a result, there was a savings in the fluoridated city of one-third the time needed to provide dental care.

Cost differences were dramatic. Data from the study indicate that the cost of providing incremental dental care for five-year-old children in Kingston for a five-year period was \$101.22 per child, while in Newburgh it was \$48.50. The cost of fluoridation in Newburgh for this five-year period was approximately \$30,000, but the savings in dental care cost for just the five-year-old children was more than \$35,000. Thus, the savings for just this one age group was greater than the cost of providing the benefits of fluoridation to the total community.

National savings that would accrue from fluoridation cannot be estimated with precision. However, a conservative estimate of the relative return on each dollar expended for fluoridation can be made by generalizing from data on national dental caries experience, costs of treatment services, benefits known to be derived from fluoridation, and per capita costs of fluoridation. The estimate assumes that the average child by age 15 has 12 decayed teeth in an unfluoridated community; that the cost of restorative services at $12 per tooth equals $144; that because fluoridation reduces caries by 60 percent, treatment for dental caries would cost only $58 over 15 years, or a savings of $86 per child; and that the cost of fluoridation per capita for 15 years, based on a cost of 16 cents per capita per year is $2.40.

Based on these assumptions, the estimated savings in children's treatment costs for dental caries would be $36 for every $1 expended, a ratio of 36 to one.

2.2.3.2 Current Status in the States of the Great Lakes Basin

The Great Lakes Basin States include many of the communities that lead in fluoridation of public water supplies. Table 23–12 gives appropriate information and statistics on fluoridation. Ohio, Illinois, Michigan, and Minnesota have State laws that require, under varying conditions and timetables, the fluoridation of public water supplies. The percentage of the population served by fluoridated public water supplies in each Basin State varied from 52.4 percent for Pennsylvania to 98.1 percent for Illinois in 1971. All States show some room for improvement, with Pennsylvania and Ohio needing the most. Compared to the nation, the Great Lakes Basin States have been quite progressive. The average national rank for Basin States for proportion of population served is 15 in 52.[26]

In spite of advances made in extending fluoridation, many problems remain. In a recent survey State dental directors indicated that, although the cost of fluoridation is minimal, cost is a significant impediment to the adoption of fluoridation, particularly in small communities. In addition to this, small public water supplies are far more numerous than large public water supplies and represent more difficulty in surveillance and control for the responsible State agency. Consequently laws and regulations in several States have a population cutoff point beneath which fluoridation is not required.

Studies conducted in 1970 and 1971 on the status of fluoridation in Wisconsin, Illinois, and Ohio demonstrated that the operation and maintenance of fluoridation installations, particularly for smaller supplies, is frequently deficient (see references 52 and 53). New means to assist small communities should be devised and tested. Millions of people living in outlying suburban and rural areas are not served by public water supplies. Unless these people fluoridate their own water supplies, they miss the benefits of fluoridation. The spread of public water systems to outlying metropolitan areas and the institution of new public water systems to serve rural and small town areas can help extend fluoridation to more people.

2.2.4 Operator Training

The water utility industry, with a capital

TABLE 23–12 Population Served by Fluoridated Water in the Great Lakes Basin

State	Population Served	Percent of Population Served by Public Water Supplies[a]	Percent of Total State Population	National Rank	Effective Date of Fluoridation Law
New York	12,232,608	75.8	66.3	19	None
Pennsylvania	5,006,568	52.4	42.0	34	None
Ohio	4,546,416	53.5	42.0	32	Jan. 1972[b]
Indiana	3,109,057	88.9	58.6	14	None
Illinois	9,475,367	98.1	84.4	2	July 1968[c]
Michigan	5,752,118	90.7	63.6	9	July 1973[c]
Wisconsin	2,760,477	94.8	61.4	6	None
Minnesota	2,857,117	98.0	73.0	4	Jan. 1970[c]
Total	45,739,728	76.9	60.8	15	---

[a]As of December 1971.
[b]Community water supplies serving 5,000 or more people required to fluoridate.
[c]All municipal water supplies required to fluoridate.

worth of more than $50 billion and an income of more than $3 billion per year, requires the technical, managerial, and operational skills in a variety of disciplines. Nationally it is estimated that the need for managers, engineers, technicians, plant operators, laboratory staff, administrative persons, and others will run to more than 160,000 persons by the year 2000. In 1969 the National Community Water Supply Study[5] revealed that for nine study areas, 77 percent of plant operators were inadequately trained in microbiology and 46 percent were deficient in chemistry. Recruitment, training, and certification programs must be improved to meet the need for personnel with desired levels of skills and expertise.

All Basin States now require certification of water treatment plant operators. Certification programs for Indiana and Minnesota, authorized in 1971, are being developed. Mandatory certification was established for Michigan in 1941, Ohio in 1937, Illinois in 1963, Wisconsin in 1969, Pennsylvania in 1969, and New York in 1938. Most certification laws include "grandfather" clauses which issue certificates to operators employed at the time the law went into effect. Such certificates are often limited to the water supply employing the operator. Several certification laws require that only the person responsible for the supply be certified. In many cases this person may not be the operator of the treatment plant. This is particularly true when more than one work shift operates the plant.

The capability for conducting operator training courses varies from State to State. Such courses vary from seminars lasting one or two days to formal training courses lasting a semester that are offered by universities or technical schools. Table 23–13 shows the training courses offered in each State in fiscal year 1972, broken down according to the length of the course. For this table training was defined to include courses and seminars offered by schools, government agencies, or operator organizations, and technical sessions of operator district meetings. This table shows that the amount of training offered and the attendance vary greatly in the Basin States, with Illinois, Michigan, Ohio, and Pennsylvania having the greatest number of operators enrolled.

Coordination and sponsorship of training efforts in most States is done on a part-time basis by training committees organized by the State American Water Works Association (AWWA) sections and the State surveillance agencies. In Ohio the Operator's Training Committee is a private corporation with a permanent staff who direct training programs for wastewater and water supply operators throughout the State.

In 1973 Federal assistance to water supply operator training was limited to pilot course development in Illinois and Indiana. Courses from two days to two weeks long are offered by the National AWWA and the Environmental Protection Agency. The shorter term courses are often offered in the field, and the longer term courses are most often held in Cincinnati, Ohio.

TABLE 23–13 Operator Training Provided in Fiscal Year 1972

	Ill.	Ind.	Mich.	Minn.	Ohio	Wis.	N.Y.	Pa.
Courses Less Than 9 Hours	17	5	8	7	3	6	--	--
Total Participants	2,090	600	764	350	324	243	--	--
Total Hours of Instruction	5,774	1,600	6,112	2,268	2,268	850	--	--
Courses 9 to 24 Hours	2	--	3	1	1	1	--	4
Total Participants	650	--	289	335	116	30	--	96
Total Hours of Instruction	5,200	--	5,032	6,700	2,088	330	--	1,104
Courses 25 to 40 Hours	3	--	1	--	2	3	14	72
Total Participants	125	--	226	--	118	125	307	1,399
Total Hours of Instruction	7,500	--	8,136	--	4,235	5,000	9,210	40,990
Courses More Than 40 Hours	1	--	--	--	3	5	10	19
Total Participants	30	--	--	--	407	100	147	381
Total Hours of Instruction	1,440	--	--	--	41,320	7,200	7,350	258,165

2.2.5 Cross Connection Control

Cross connections are a hazard to almost every distribution system. The very small system serving domestic needs only may escape backflow hazards, but any system serving a mortuary, a hospital, a slaughterhouse, a manufacturing plant, or sewerage facilities has the potential of hazardous backflow connections. Improperly installed dishwashers, washing machines, lawn sprinkling systems, and individual wells maintained for irrigation can affect even the systems that are entirely residential.

Government-owned systems, including those owned by municipalities, water districts, and townships, and investor-owned systems can be vested with authority to look for cross connections and require their elimination. In many areas the authority to look for and require the elimination of cross connections is vested in building inspection or other such government agencies. In any case, the utility is ultimately responsible for contamination from cross connections reaching the distribution system. The utility should urge responsible authorities to establish an effective program and should participate in the program in all possible ways.

The National AWWA has developed renewed interest and concern for cross connection control through seminars and detailed articles in its publication *Willing Water*.

Three Basin States, Ohio, New York, and Michigan, have taken steps to obtain improved cross connection control.

In Ohio the Cross Connection and Backflow Prevention Program includes two phases, one conducted by the Ohio Environmental Protection Agency and one conducted by the Ohio Department of Health. The total Ohio program includes promotion of cross connection control programs in public, semipublic, and private water supply systems; planning and participating in training courses and seminars for waterworks personnel, plumbing and building inspectors, and municipal administrative employees; reviewing and evaluating plans for cross connections to auxiliary water supplies; and the preparation of manuals and booklets on cross connection control for distribution in the State.

The Ohio EPA program is directed towards problems involving the water source, water plants, and the distribution system. As the water enters the premises of the ultimate water user, the cross connection and backflow problems come under the jurisdiction of the State and local health departments. Both Ohio departments are involved in the promotion of cross connection programs, planning and participating in training courses and seminars, reviewing and evaluating programs and in the preparation of cross connection and backflow literature. The Ohio Department of Health program also includes the training of plumbing and building inspectors.

In Michigan and New York the Cross Connection Rules provide a legal basis for the removal of all cross connections within a public water supply system. The responsibility for enforcement of the Michigan rules is delegated to the local governmental entities operating public water supplies, with assistance from the Michigan Department of Public Health. The local inspection and enforcement agencies include the water utility, the local plumbing inspection agency, and the local health department.

Indiana is considering revision of an outdated cross connection control law. In the recent past most water supply authorities have been willing to leave cross connection control to building departments or other plumbing control authorities. Today water supply authorities are becoming more directly concerned with cross connection control. A number of States, including Illinois and Ohio, have emphasized cross connection control by improving training programs to include regularly held courses or seminars on the principals of cross connection control.

The Division of Water Supply, EPA, judges adequacy of cross connection control according to five points:

(1) a modern plumbing code and regulations pertaining to cross connections

(2) fixed responsibility for enforcement with the purveyor as the focal point fully aware of the activities of other participating agencies

(3) inventory of potentially hazardous users

(4) education of personnel to recognize health hazards in their day-to-day work

(5) enforcement of codes and regulations as demonstrated by inspection and action records

2.3 Federal Assistance for Water Systems

Federal assistance for public water supply systems is provided in three separate fields. In the field of public health surveillance, research on health effects of various constitutents potentially present in water, development of water quality analysis methods, and development of improved water treatment methods are vested in the U.S. Environmental Protection Agency. The provision of funds for constructing or improving facilities for public water supply sources, transmission, treatment, and distribution is vested with the Farmers Home Administration, Department of Agriculture; the Community Resources Development Administration, Department of Housing and Urban Development; and the Economic Development Administration, Department of Commerce. The Corps of Engineers, U.S. Army; the Bureau of Reclamation, Department of the Interior; and the Soil Conservation Service, Department of Agriculture, manage the development of public water supply sources wherever it can be included with net benefit in multipurpose water resource development projects. The decision to use a reservoir constructed by the Corps of Engineers, Soil Conservation Service, or Bureau of Reclamation for public water supply is based on the needs of nearby populated areas for additional water supply and the economies of water treatment and transmission to the areas of need. There are no Bureau of Reclamation projects in the Great Lakes Basin.

2.3.1 EPA Water Supply Program

Formerly part of the Department of Health, Education, and Welfare, the Division of Water Supply became a part of the United State Environmental Protection Agency on December 2, 1970, in accordance with reorganization Plan Number 3 of 1970.

Its primary activities include:

(1) updating the Drinking Water Standards

(2) carrying out the provisions of the Interstate Quarantine Regulations for interstate carrier water supplies

(3) providing a research and technical assistance program on the health effects of man's use of water for drinking, recreation, food production and other purposes

(4) providing specialized technical services for public water supplies

(5) providing consultation to other Federal agencies on the public health aspects of water resource planning and water pollution

2.3.2 Facilities Construction

Federal assistance for municipal water treatment plants and contribution systems is primarily available through the Farmers Home Administration (FHA), Department of Agriculture, and the Community Resources Development Administration, Department of Housing and Urban Development. The Economic Development Administration, Department of Commerce, also provides grants, but such funds are primarily directed toward industrial service and water supply, and only indirectly contribute to domestic water supply.

The Farmers Home Administration provides financial assistance and technical guidance to rural communities to develop community water supplies. The FHA makes grants to organizations of rural residents, such as municipalities, authorities, districts, and nonprofit corporations, for the installation of community water facilities. FHA grants for installation of water facilities are made only to communities that cannot finance these facilities through conventional sources. These grants are to communities with a population less than 5,500.

The Department of Housing and Urban Development program provides grants to construct community water facilities needed for orderly areawide community growth and development. Grants cover up to 50 percent of land and construction costs for new water facilities. The projects assisted must conform with the applicable State and regional or metropolitan health plans. Grants are limited to publicly owned systems serving 5,500 people or more.

The primary mission of the Economic Development Adminstration, Department of Commerce, is to alleviate economic distress in designated areas of the nation by creating jobs and raising income levels. This is done through a package of grant and loan programs, and often includes involvement in the development of municipal water supplies, largely for rural areas. The program provides grants for up to 50 percent of the development cost of such facilities. Severely depressed areas that cannot match Federal funds may receive supplementary grants to bring the Federal contribution up to 80 percent of the project cost.

The availability of Federal funds for water supply development and improvement is not without disadvantage. Funds are limited. Applicants for aid are numerous, and the parameters used to establish priorities for grants or loans are inadequately defined. Applicants often find it difficult to determine their chances of obtaining funds. As a result, needed projects are delayed due to the uncertainty of obtaining Federal funds.

2.4 State Surveillance Programs

With some exceptions, State water supply surveillance programs are understaffed. The basic activities in most States consist of surveillance (including plan review and inspection), bacteriological and chemical laboratory support, and technical assistance. Enforcement and planning often receive minor emphasis. Enforcement usually receives minor emphasis due to the small number of cases in which enforcement is needed, the cumbersome legal proceedings required by State law, and the lack of legal support to take effective action with these proceedings. State authorizations seldom provide for planning. With the present funding and manpower provided, few States can meet effectively the needs for all these activities. Much is accomplished, however, through strong associations developed between the State water supply programs and the State AWWA sections.

In June 1971 the Division of Water Supply, EPA, compiled data provided by the States on fiscal support for drinking water supply programs in 1960 and 1970. All Great Lakes Basin States participated in this study.

The total budget expenditures for the eight Great Lakes States were more than $1,300,000 for 1960 (Wisconsin not included) and more than $3,040,000 for 1970 (Table 23-14). A large amount of this increase was absorbed by increases in salaries and the cost of supplies. The 1970 budget adjusted to a 1960 dollar value was more than $1,900,000 ($1,820,000 not including Wisconsin) for an indicated overall program increase of approximately 40 percent. This increase, however, was due to improved funding for only three States: New York, Illinois, and Michigan. Indiana and Minnesota reduced support for water supply programs. In this same period the population for these eight States increased 10 percent.

The 1963 Inventory of Municipal Water Facilities[20] reported 1,574 water supply systems in New York, 1,017 in Pennsylvania, 1,102 in Illinois, 441 in Indiana, 608 in Michigan, 632 in Minnesota, 711 in Ohio, and 453 in Wisconsin. A significant number of these sytems purchased treated water from primary supplies (supplies that obtain water from a

TABLE 23-14 Water Supply Program Expenditures

State[a]	1960	1970	1970 Adjusted to 1960 Value	Adjusted Increase Percent
New York	$ 643,000	$1,598,500	$ 999,062	+55
Pennsylvania	184,935	310,800	194,250	+5
Illinois	66,705	303,311	189,569	+184
Indiana	114,900	144,000	90,000	-28
Michigan	114,700	273,500	179,937	+49
Minnesota	45,000	61,000	38,125	-18
Ohio	130,000	210,000	131,250	+1
Wisconsin	---	143,000	89,375	---
Total	$1,299,240	$3,044,111	$1,911,568	---

[a]Expenditures are for entire State. Data are estimates for several States, because water supply program appropriations and expenditures are not specifically identified in normal accounting procedures. Data do not include expenditures for semipublic or private water supply programs.

surface or ground-water source). The primary supplies numbered 1,031 in New York, 941 in Pennsylvania, 913 in Illinois, 396 in Indiana, 508 in Michigan, 603 in Minnesota, 720 in Ohio, and 426 in Wisconsin. These numbers refer to the total number of supplies in each State.

Based on estimates of the 1970 budget and the 1963 Inventory of Municipal Water Facilities, the average expenditure for surveillance for the 50 States, the District of Columbia, and the Territories was $536 per water system per year. The average 1970 per capita expenditure was 4.9 cents per person.

Studies conducted by the Division of Water Supply, EPA, indicate that a minimum of $650 to $800 per water supply system, or approximately 10 cents per capita, is required for an adequate water supply surveillance program. These figures are based on an estimated yearly expenditure for each primary water system as follows: water system surveillance (inspection, technical assistance, enforcement), $350; one complete chemical analysis, $150; bacteriological analysis, $50 to $100; and central office (data storage, management planning, etc.), $100 to $200.

Based on 1970 funding, primary water supplies listed in the 1963 inventory, and 1970 census figures, the States are funding their water supply programs as shown in Table 23-15.

In funds per capita, every Basin State except New York falls well below the estimated needs figure made by the Division of Water Supply, and also falls well below the national average of 4.9 cents. In funds per water supply, every State except New York and Michigan falls well below the estimated needs figure made by the Division of Water Supply, and also falls well below the national average of $536. The number of water supplies in each State has increased appreciably over those inventoried in 1963. The Division of Water Supply estimates that the number of community water supply systems in the nation doubled from 1960 to 1970.

Because program emphasis varies from State to State, States expending the same amounts per water supply may be providing different services. As shown in Table 23-16, areas of program emphasis for six States in 1970 were management and surveillance in

TABLE 23-15 Expenditures for Water Surveillance Programs, 1970

State	Funds	Water Supplies[a]	Population (Millions)	Funds Per Water Supply	Funds Per Capita
New York	$1,598,000	1,031	18.0	$1,550	$0.089
Pennsylvania	311,000	941	11.7	330	0.027
Illinois	303,000	913	11.0	332	0.028
Indiana	144,000	396	5.1	364	0.028
Michigan	273,000	508	8.8	537	0.031
Minnesota	61,000	603	3.8	101	0.016
Ohio	210,000	720	10.6	292	0.020
Wisconsin	143,000	426	4.4	336	0.032

[a]Primary or source supplies. Inventory of water supplies conducted in 1973 has demonstrated that for most States these numbers are low by approximately 20 percent. The numbers also vary due to differing definitions of water supply used by the States. In addition the use of source supplies does not fully describe the work load because all water supplies including those purchasing water from source supplies require supervisory control for sampling programs, cross connection control programs, and certification of distribution system operators. A more up-to-date definition of these data will be available after completion of the National Municipal Water Supply Inventory.

Michigan; surveillance in Minnesota and Wisconsin; laboratory support in Ohio; and management and laboratory support in Indiana. Table 23-16 also shows areas where additional funding is needed. Because the estimated needs are based on the 1963 inventory of primary water supplies, they are low estimates.

TABLE 23-16 Program Activities Expenditures (1000s of Dollars)[a]

Program Activity	Ill.	Ind.	Mich.	Minn.	Ohio	Wis.
Management and Overhead[b]						
Estimated Need[c]	$ 90	$ 40	$ 50	$ 60	$ 72	$ 45
Amount Funded	9	32	65	9	11	23
Surveillance[d]						
Estimated Need[e]	260	140	175	210	252	160
Amount Funded	242	51	188	46	42	95
Laboratory Support[f]						
Estimated Need[g]	180	80	100	120	144	90
Amount Funded	52	61	20	6	157	25

[a] Present funding based upon estimates for 1970. Data are estimates, because most State accounting procedures do not identify such data for the water supply program. Data do not include expenditures for semipublic or private water supply programs.

[b] Management and overhead includes training, data, handling, and planning.

[c] Estimated need based on $100 per primary water supply.

[d] Surveillance includes field work, enforcement, and technical assistance.

[e] Estimated need based on $350 per primary water supply.

[f] Laboratory support includes chemical and bacterial analysis.

[g] Estimated need based on $200 per primary water supply.

Section 3

RECREATION ASPECTS

This section reviews the effects of water quality and sanitation on recreation and examines the relationship between recreational water quality and health. Using material from Appendix 7, *Water Quality*,[41] the section compares recreational water quality standards with existing water quality in the Great Lakes Basin. It reviews the importance of sanitary development for recreational areas and estimates the status of sanitary development based on ratings from commercial inspection of rated campground areas.

3.1 Water Quality and Health

3.1.1 Health Aspects of Water Quality

Waters polluted with human and other animal wastes may contain agents that can infect man. Diseases transmitted by polluted water include typhoid fever, salmonellosis, shigellosis, leptospirosis, amebiosis, and infectious hepatitis. Although other diseases are also water-borne, their geographic range does not include the United States, or they occur rarely and are not considered to be a water-borne public health problem in the United States. Other illnesses associated with swimming are not as well defined. These include infections of the ear, eyes, and skin, which are caused by several bacteria, fungi, and viruses. Swimmers are also bothered by larger parasites such as the schistosomes, which cause "swimmer's itch," and the cat and dog hookworm which causes "creeping eruption."

None of the diseases, except swimmer's itch, is exclusively a water-borne problem. Transmission usually occurs from person-to-person contact. Disease resulting from water-contact recreation seldom involves large numbers of people, and the infections are usually less serious than those resulting from the ingestion of food or drink. The cases that may occur from recreational use of contaminated water, therefore, may not be recognized among the more numerous reported cases resulting from person-to-person contact, or may not be reported.

Several studies have shown that immersion in polluted water can cause human illness. Three studies conducted by the Public Health Service on the relationship of the quality of bathing water to health demonstrated that swimming in water of any quality increased the minor illness rate of swimmers as compared with nonswimmers (see references 60, 61, and 62). With the increase of illness due to swimming alone, it is difficult to measure an additional increase of illness that can be correlated to increased water pollution. Studies of the effect of grossly polluted water have not been made in the United States because the public does not choose to use such areas for recreational swimming, and because health agencies actively discourage such use. It should be noted that waters that meet the standards for drinking water use with conventional treatment may not be satisfactory for body-contact recreational use.

Unpolluted water presents less of a health risk to recreationists than polluted water, but all surface waters have some contamination. A balance must be struck between the physical and psychological benefits of water recreation and the health hazards involved. There is really no level of contamination that will be completely safe for all persons who might use water for recreation. Past epidemiological studies detected a measurable increase in illness when the total coliform content was 2,300 per 100 milliliters (ml). Newer bacteriological techniques that detect and quantify fecal coliforms give a more direct measure of the health hazard. The fecal coliforms were recently approximately 18 percent of the total coliforms in the stretch of the Ohio River where the level of contamination higher than 2,300 was established. Thus, approximately 400 fecal coliforms per 100 ml can be associated with a measurable health effect.

A fecal coliform level of 200 per 100 ml should provide a quality of water suitable for body-contact recreation without significant health risks. Body-contact recreation normally includes swimming, water skiing, and wading and dabbling by children.

The Division of Water Supply, EPA, recommends bacterial water quality standards for waters used for body-contact recreation.[42] These recommendations state that the fecal coliform density should not exceed 200 per 100 ml as the arithmetic mean, and that it should not exceed 400 per 100 ml in more than 10 percent of at least five samples analyzed during any 30-day period.

Partial body-contact recreation such as boating, fishing, and duck hunting do not involve the same chance for ingestion of water or body contact with water. Water quality criteria for these activities need not be as stringent. At present no guidelines exist for this purpose, except that the water should be as clean as can be obtained. A fecal coliform concentration of 1,000 per 100 ml is considered reasonable for partial body-contact recreational waters.

3.1.2 Recreational Water Quality Standards Compared with 1970 Water Quality

Water quality standards for recreational use have been adopted by all Great Lakes States. These standards are discussed in Appendix 7, *Water Quality*.[41] The standards discussed below were in effect as of June 1973.

Illinois, Ohio, and Michigan have fecal coliform standards similar to the recommended guidelines of the Division of Water Supply, EPA. Pennsylvania, Indiana, Minnesota, and Wisconsin have adopted a 1,000 total coliform per 100 ml criterion as a standard. Although this criterion is considered adequate to protect public health, it may occasionally limit recreational use when health hazards do not actually exist. New York has a standard of 2,400 total coliforms per 100 ml, which may not consistently provide adequate public health protection. Experience with this standard has not, however, demonstrated a need for revision.

To evaluate whether recreational use problems exist in specific areas, the known water quality of specific stream reaches and the classification of water areas for recreational use must be compared with the applicable water quality standard. The results of a sanitary survey for a specific area must be included in the evaluation. The following summaries on water quality and recreation are based on data from Appendix 7, *Water Quality*.[41]

3.1.2.1 Lake Superior

Michigan waters designated for total body-contact recreation include all waters of Lake Superior, except in the immediate vicinity of enclosed harbor areas and river mouths, and all interior rivers of the Lake basin, except one stream reach. Wisconsin waters designated for total body-contact recreation include Lake Superior, except harbor areas and shoreline sections near pollutional outlets, and all inland waters of the Lake basin. Minnesota waters designated for total body-contact recreation include Lake Superior and all inland waters, except the St. Louis River from Cloquet to Fond du Lac.

Some areas in the Lake Superior basin have questionable or impaired bacterial water quality. Planning Subarea 1.1 includes the Superior Slope and St. Louis drainage basins in Minnesota and the Apostle Islands and Montreal River drainage basins in Wisconsin. In the Superior Slope drainage basin, no known areas of significant bacterial water quality impairment occur. There may be some impairment near the towns of Beaver Bay, Grand Marais, Silver Bay, and Two Harbors due to sewage discharge. In the St. Louis River basin, bacterial quality is good with the exception of the St. Louis River from Cloquet to Duluth, and the Floodwood River near its junction with the St. Louis River. In Wisconsin bacterial water quality is generally good except for a reach of the Nemadji River, parts of Chequamegon Bay, and a reach of the Montreal River.[40]

Planning Subarea 1.2 is located entirely in Michigan. Bacterial water quality in this planning subarea is generally excellent with a few exceptions. In the Grand Marais area high coliform levels exist in one reach of the Au Train River. In the Huron Mountains area the Carp River has high coliform levels. In the Sturgeon River basin there is one minor reach where high coliform levels and suspended solids exist. In the Keweenaw Peninsula area there are 10 localized reaches where small communities discharge untreated wastes causing high coliform levels. In the Ontonagon River basin there are five upstream reaches where high coliform and suspended solids levels exist. In the Porcupine Mountain area two reaches have high coliform and suspended solid levels, and one has high coliform levels.

3.1.2.2 Lake Michigan

Waters designated by Michigan for total body-contact use include all waters of Lake Michigan except in the immediate vicinity of the harbors at Menominee, Manistique, Manistee, Muskegon, Grand Haven, South Haven, and St. Joseph. Except as specifically designated, all public waters north of the Grand River basin are designated for total body-contact use. Waters in the Grand River basin and south of the basin are designated for partial body-contact use with the exception of all natural lakes, artificial public lakes, and specifically designated reservoirs or portions of streams that are to be protected for total body-contact use. Except for short reaches of inland waters, harbor areas, and shoreline sections near pollutional outlets, all Wisconsin waters of the Lake Michigan basin should meet the total body-contact recreation standard. Appendix 7, *Water Quality*,[41] notes there are exceptions to this general statement, but does not locate the exceptions. Wolf Lake and the beach areas of Lake Michigan in Illinois are designated for total body-contact recreational use. In the Indiana portion of the basin Lake Michigan shore waters and Wolf Lake are specified for total body-contact recreational use. Certain waters of Lake Michigan not defined by Appendix 7, *Water Quality*,[41] are not designated for total body-contact use. Streams of Indiana in the basin are designated for partial body-contact use.

Objectionable aquatic growths and shoreline deposits of aquatic plants and dead alewife have occurred on many beaches along Lake Michigan, but this problem has been decreasing in the past few years. Coliform levels along the Michigan shoreline have been satisfactory at most beaches recently. Information on water quality in Appendix 7, *Water Quality*,[41] indicates that numerous reaches of the inland waters in both Michigan and Wisconsin are unsatisfactory for total body-contact use because of municipal and industrial waste discharges. Bacterial quality in the main body of Wolf Lake and the inshore areas east of the Indiana inner harbor basin is generally good. Beach closings due to high coliform counts are common on the southwestern shoreline of Lake Michigan. In Lake County just north of Chicago unsatisfactory bacterial quality increased from 1968 through 1971.

3.1.2.3 Lake Huron

Waters designated for total body-contact use in the Lake Huron basin include all waters of Lake Huron, the St. Marys River, and inland waters north of the Saginaw River basin except for specified enclosed harbor waters. All natural lakes, aritificial public lakes, and specifically designated stream reaches in the Saginaw River basin and south of the basin are designated for total body-contact use.

Information on water quality in Appendix 7, *Water Quality*,[41] indicates that a number of stream reaches in Planning Subarea 3.1 are unsatisfactory for total body-contact recreation because of municipal waste discharges. Satisfactory quality exists along the shores of Lake Huron except within harbors and at the mouths of some tributary streams. The data for Saginaw Bay indicate only a limited bacterial problem exists, with one beach showing excessive fecal coliform levels. Extensive algal blooms have occurred in Saginaw Bay, harming swimming use. Substandard water quality is common for reaches of the major rivers of the Saginaw River basin.

3.1.2.4 Lake Erie

Waters in Michigan designated for total body-contact recreation use include the St. Clair River, Lake St. Clair, the Detroit River, the Maumee River, and Lake Erie, except in the immediate vicinity of mouths of tributaries, enclosed harbor areas, and waste water treatment plant outfalls.

In Indiana all waters now used for public or industrial water supply or designated for future water supply use must meet the criteria for water supply. All reservoirs, lakes, and the St. Joseph River (Allen County) are designated for total body-contact recreation use. All other streams must be maintained for partial body-contact recreation use.

In Ohio standards call for maintenance of quality in all waters to permit total body-contact recreation and public and industrial water supply (1969).

Lake Erie basin waters in New York designated for total body-contact recreational use include Outer Buffalo, Dunkirk, and Barcelona Harbors, and Lake Erie shoreline south and east of Buffalo. In Pennsylvania all

Lake Erie waters are designated for total body-contact recreational use, except in Presque Isle Bay and Erie Harbor.

Bacteriorlogical quality of interior streams is unsatisfactory for total body-contact use in many stream reaches. This is clearly shown in Appendix 7, *Water Quality*,[41] for much of Planning Subareas 4.1, 4.2, and 4.3, where few of the main stem streams are suitable for such use. From 1971 through 1973 the Ohio Department of Health conducted a surveillance program of Ohio's Lake Erie bathing beaches. The beaches were sampled twice a week, from May 15 to September 15, for fecal coliform bacteria. The bathing beaches within State administered parks were also included in this surveillance program. Bacterial quality along the Lake Erie shore is generally suitable for total body-contact recreation. High coliform levels found in stream effluents and harbor areas, however, adversely affect nearby beaches on the Lake Erie shoreline. This is particularly important because many beaches are located near the mouths of tributary streams. Impairment of total body-contact recreational use occurs most often near population centers such as Cleveland. Algal blooms and oil waste products also interfere with total body-contact use.

3.1.2.5 Lake Ontario

Stream reach and lake area classifications are not shown by Appendix 7, *Water Quality*,[41] for the Lake Ontario drainage basin.

Algae and alewife deposited on beach areas have a serious unaesthetic effect on the high quality beaches typical of Lake Ontario. In addition, bacterial infections of swimmers' ears may be associated with algal blooms. Waste effluents discharged into the Buffalo River make that river and a portion of the Niagara River unsafe for swimming. Other streams passing through the Buffalo area are also heavily polluted. Several inland lakes have been sufficiently degraded near populated areas to make swimming hazardous and to cause beach closings. Many stream reaches in Planning Subareas 5.1, 5.2, and 5.3 have impaired bacterial quality resulting from industrial and municipal waste effluents.

It is apparent that bacterial quality is not adequate in many areas classified for total body-contact recreational use. Advances in treatment provided by many of the municipal waste treatment plants presently impairing bacterial quality should mitigate this situation in the future.

3.2 Recreation Development

The term recreation area refers to land and water used for public enjoyment. Recreation area development generally involves facilities operated by a public agency, concessionaire, voluntary or private group, or individuals. Recreational developments include parks, campgrounds, shelters, picnic areas, travel trailer parking areas, resorts, motels, hotels, cabin camps, camps sponsored by organizations, marinas, and other facilities relating to a variety of activities such as swimming, fishing, hunting, boating, sailing, hiking, picnicking, camping, touring, and sightseeing.

3.2.1 Recreation Sanitation

In many instances the planning, provision, and maintenance of facilities in recreational areas have not kept pace with the rapidly increasing visitor load. As a result optimum use of such areas is not possible and deterioration of overtaxed facilities frequently occurs. Where facilities for water supply, sewage disposal, and refuse are inadequate or lacking, visitors fend for themselves, often creating conditions that are both aesthetically offensive and serious environmental health hazards for the visitors and neighboring community residents.

According to Appendix 21, *Outdoor Recreation*,[25] the 1970 number of recreation days for land-based water-oriented recreation (including swimming, picnicking, camping, nature study, and hiking) will need to be increased by a factor of 3.5 by the year 2000 to meet the requirement of the Basin's growing population and leisure time. According to estimates adequate environmental health safeguards comprise approximately 30 percent of development costs of new recreation areas. Because these safeguards represent such a large investment, care should be taken in properly planning, constructing, and maintaining adequate facilities.

Experience has demonstrated that when a large number of people gather in one place, health problems are accentuated. The increasing number of visitors to recreation areas has created a need for planning and constructing adequate health-related facilities and for education of the public to observe good sanitary and personal hygiene practices under primitive conditions. Public support should be given to continuing research and studies to develop improved standards and solutions for the environmental health problems associated with recreation areas and activities.

To obtain maximum health protection against environmental health hazards in recreation areas, all governmental and private organizations responsible for recreation areas should apply high standards of public health in the administration and supervision of their programs. Close cooperation and consultation with health authorities will facilitate this objective. The development and review of plans for proposed developments and facilities by qualified public health officials is essential. A program of periodic surveys and inspection of recreation facilities and their operation should be established by public health and recreation authorities.

Areas of public access to recreation waters have common shortcomings. These include inadequate or unsafe water supply, inadequate toilet facilities, poor maintenance of existing facilities, lack of trash collection and disposal, misuse of picnic areas and other areas, and complete lack of supervision or poor supervision of recreation areas. This situation was demonstrated in a recent study of recreation areas around several Federal water resource development reservoirs in Indiana and Ohio.[33]

Subsection 5.4 provides general information on topics of health importance for recreation planners. Information on the need for recreation planning, as demonstrated by present and future demands, is presented in Appendix 21, *Outdoor Recreation*.[25]

3.2.2 Recreation Sanitation Surveillance

Recreation sanitation surveillance varies from State to State, both in the emphasis it receives and in the agencies responsible for it. In most States the county and/or State department of health provides such surveillance. In Ohio, for example, Chapter HE–25 of the Ohio Sanitary Code pertaining to campsite regulations is administered and enforced by local health departments. The Division of Sanitation, Ohio Department of Health, conducts random inspection of the administration and enforcement of recreational sanitation activities conducted by the local health departments. The Ohio Department of Health also conducts sanitary surveys on a cooperative basis with the Ohio Department of Natural Resources for recreation areas administered by the State. A similar cooperative program exists with the Ohio Department of Transportation for roadside rest areas.

In Michigan Act 171 of the Public Acts of 1970 provides for the licensing of publicly and privately owned campgrounds by the Michigan Department of Health. This licensing program is expected to continue to improve campground sanitation throughout the State. The number of campgrounds in Michigan is rapidly growing. State records show that as of 1973, 645 privately owned campgrounds with a total of 40,578 sites and 225 State owned campgrounds with a total of 1,749 sites were operating in Michigan.

Pursuant to the Act, rules controlling campground development and operation were adopted July 2, 1971. These rules provide for the control of location, construction, access, site use, water supply, sewage disposal, service buildings, garbage and refuse disposal, swimming pools and beaches, and other factors.

3.2.3 Present Recreational Sanitary Facilities in Campgrounds

Appendix 21, *Outdoor Recreation*,[25] does not include information on the present sanitary facilities available at public and private campground areas. Such information is available in commercial publications such as Rand McNally's *Campground and Trailer Park Guide*[28] and Woodall's *Trailering Parks and Campgrounds*.[45] These guides provide current information about the wide range of facilities and activities available at many public and private recreational campgrounds.

In addition to these commercial guides, campground guides are available from State departments of health, the U.S. Army Corps of Engineers, and the National Park Service, as well as other government agencies administering park areas. For example, "Family Camping in Ohio—1973," published by the Ohio Department of Health, lists all camps in Ohio by county and describes them by location, character of sites, facilities, and availability of swimming. In 1973 the Corps of Engineers published a series of regional recreational brochures detailing facilities and describing recreation oppotunities at Corps projects.

Public campgrounds are administered by Federal, State, and local governments. Federal campgrounds are located in national parks and forests, and they are also administered by the U.S. Fish and Wildlife Service, the Corps of Engineers, and the Bureau of Indian Affairs. State campgrounds are located in State parks and forests.

Private campgrounds are owned and operated by private interests, including corporations and individuals. Many private campground and recreational vehicle parks are listed in the Rand McNally and Woodall publications.

3.2.3.1 Methodology

The 1971 edition of Rand McNally's *Campground and Trailer Park Guide*[28] was the source of data for an analysis of the relationship between the ratings of private campgrounds and the number of different sanitary facilities available. As of 1972 the Rand McNally guide no longer contained campground ratings.

The Rand McNally ratings were based on guidelines set forth in the "Family Camping Standards" established by the Family Camping Federation (FCF), a national nonprofit organization located in Bradford Woods, Martinsville, Indiana. Mandatory FCF standards include the ratio of toilets and showers to sites, the posting of rules and extra charges, certification of drinking water, and cleanliness. Desirable standards include screening and spacing of sites, drainage, and sanitation.

To qualify for a high rating of three or four stars in the Rand McNally guide, campgrounds were required to meet all 17 mandatory FCF standards and many of the 64 desirable standards. For a one- or two-star rating, campgrounds were required to meet most mandatory standards. Campgrounds judged to be unsafe or without an approved water supply were not included in the Rand McNally guide.

Campgrounds given one-star ratings contained minimum facilities. These campgrounds were judged to be acceptable for an overnight stay while en route, or as a base camp for activities in the area. Campsites were often small.

Two-star ratings were given to campgrounds with more adequate sanitary facilities than one-star campgrounds. Sites were often larger, some hookups were available, and a few activities and facilities located nearby might encourage campers to stay more than one night.

Campgrounds given three-star ratings contained sanitary facilities that were modern and usually well kept. These campgrounds were judged to be places where campers might want to stay several days to enjoy facilities and activities in the park and nearby areas.

Four-star campgrounds qualified for the top category as "destination" or vacation camps where campers could want to stay as long as several weeks. Sites were well spaced, activities were numerous, facilities were plentiful, and grounds were well kept.

The campground analysis was also based on the different kinds of basic sanitary facilities available: drinking water, flush toilets, showers, and sanitary pump-out stations. All campgrounds were stated to have drinking water.

To make the analysis, the number of campsites in campgrounds with one, two, three, and four kinds of basic sanitary facilities were compiled. Figures were determined for the number of campsites in campgrounds with drinking water only; the number of campsites in campgrounds with drinking water and one other sanitary facility, usually flush toilets; the number of campsites in campgrounds with drinking water and two other sanitary facilities, usually flush toilets and showers; and the number of campsites in campgrounds with all four basic sanitary facilities.

Information from the Rand McNally guide was used to prepare Table 23–17, which contains data for private campgrounds in the Great Lakes Basin, and Table 23–18, which contains data for public campgrounds in the Basin.

Table 23–17 indicates the number of campsites in private campgrounds by planning subarea, and within planning subarea, by State. The table also shows the number of campsites by the campground rating (one-star, two-star, and three- or four-star), and within the campground rating, by the number of different basic sanitary facilities available (one, two, three, and four). Campgrounds listed but not rated are those that requested rating but were not inspected by Rand McNally.

Because it was the policy of Rand McNally to delete campgrounds that failed to qualify for the minimum rating from the next edition of the campground guide, Table 23–17 does not include sites located in campgrounds without a drinking water supply and campgrounds

TABLE 23–17 Private Campground Analysis (Number of Campsites)

Planning Subarea	Rand McNally Campground Rating and Number of Basic Sanitary Facilities[a] — One Star Minimum Facilities 1	2	3	4	Two Star More Adequate Facilities 1	2	3	4	Three and Four Star Modern Facilities 1	2	3	4	No Rating Sites	Camp-grounds
PSA 1.1														
Minnesota	49	64	23	60	20	--	18	190	--	--	75	66	13	2
Wisconsin	42	158	--	40	35	--	20	82	--	--	--	--	24	1
PSA 1.2														
Michigan	--	100	80	92	--	--	--	110	--	--	--	--	166	4
PSA 2.1														
Michigan	73	--	116	163	--	--	90	220	--	--	--	200	46	1
Wisconsin	169	36	235	100	--	180	193	810	--	27	--	1793	32	1
PSA 2.2														
Illinois	--	150	100	132	--	--	--	696	--	--	--	--	--	--
Indiana	90	210	75	520	332	174	235	3901	--	--	--	1275	280	3
Wisconsin	30	217	--	--	--	143	315	407	--	--	--	--	--	--
PSA 2.3														
Indiana	70	200	114	120	332	174	235	3456	--	--	--	1005	985	5
Michigan	360	--	288	122	50	44	75	1293	--	--	--	872	163	5
PSA 2.4														
Michigan	66	89	25	15	--	94	295	924	--	--	--	244	265	4
PSA 3.1														
Michigan	--	8	55	70	--	--	--	130	--	--	--	380	55	2
PSA 3.2														
Michigan	--	--	70	58	--	--	74	360	--	--	--	174	11	1
PSA 4.1														
Michigan	--	--	--	50	--	--	--	153	--	--	--	180	30	1
PSA 4.2														
Ohio	396	--	115	332	--	1243	241	337	--	--	262	190	83	3
Indiana	--	75	--	--	--	--	--	--	--	--	--	--	2	1
PSA 4.3														
Ohio	105	133	315	250	--	71	500	1060	--	135	300	1950	384	7
PSA 4.4														
New York	--	--	105	--	50	260	315	951	--	--	--	549	50	4
Pennsylvania	--	--	--	40	--	--	--	177	--	--	100	150	100	3
PSA 5.1														
New York	165	100	40	130	81	322	44	995	--	--	--	549	50	1
PSA 5.2														
New York	95	200	239	45	62	50	243	596	--	--	50	708	568	11
PSA 5.3														
New York	--	--	48	--	--	8	42	270	--	--	--	--	150	5

[a]The four basic sanitary facilities are drinking water, flush toilets, showers, and sanitary pump-out stations. Figures in columns marked "1" are the number of campsites in campgrounds with drinking water only. Figures in columns marked "2" indicate the number of sites in campgrounds with drinking water and flush toilets. Number "3" columns indicate campsites in campgrounds that also provide showers, and number "4" columns indicate campsites in campgrounds that provide all four basic sanitary facilities.

Source: Rand McNally 1971 Campground and Trailer Park Guide

that did not qualify for at least the minimum Rand McNally rating. The table also does not include campgrounds that did not request inclusion in the Rand McNally guide.

Table 23–18 shows similar information for campsites in public campgrounds, except that public campgrounds were not given ratings.

3.2.3.2 Discussion

The planning subareas may be divided into categories of lightly populated areas (less than one person per 100 acres), medium populated areas (one to 50 persons per 100 acres), and heavily populated areas more than 50 persons per 100 acres).

Table 23–19 shows a breakdown of the campground data by these categories by percent of sites in the planning subarea. These data show that approximately seven of 10 private campsites and approximately six of 10 public campsites are located in campgrounds with the four basic sanitary facilities. The number of public campsites (38,400) is approximately equal to the number of private

TABLE 23–18 Public Campground Analysis (Number of Campsites)

Planning Subarea	Sanitary Facilities Available[a] 1	2	3	4
PSA 1.1				
Minnesota	424	674	395	132
Wisconsin	218	291	106	0
Total	642	965	501	132
PSA 1.2				
Michigan	278	604	110	1,879
PSA 2.1				
Michigan	365	787	137	884
Wisconsin	555	686	718	628
Total	920	1,473	855	1,512
PSA 2.2				
Illinois	50	0	0	2,310
Indiana	30	0	410	0
Wisconsin	309	6	25	97
Total	389	6	435	2,407
PSA 2.3				
Indiana	25	0	0	860
Michigan	121	75	172	1,474
Total	146	75	172	2,334
PSA 2.4				
Michigan	773	789	536	4,844
PSA 3.1				
Michigan	1,448	765	251	1,794
PSA 3.2				
Michigan	166	50	24	1,228
PSA 4.1				
Michigan	378	220	198	1,527
PSA 4.2				
Indiana	0	45	17	0
Ohio	365	130	610	206
Total	365	175	627	206
PSA 4.3				
Ohio	503	0	487	827
PSA 4.4				
New York	0	50	75	190
Pennsylvania	0	0	0	50
Total	0	50	75	240
PSA 5.1				
New York	150	70	0	840
PSA 5.2				
New York	0	133	0	1,355
PSA 5.3				
New York	19	449	264	644
Lake Basin Totals				
Plan Area 1				
Superior	920	1,569	611	2,011
Plan Area 2				
Michigan	2,228	2,343	1,998	11,097
Plan Area 3				
Huron	1,614	815	275	3,022
Plan Area 4				
Erie	1,246	445	1,387	2,800
Plan Area 5				
Ontario	169	652	264	2,839
Great Lakes Basin Total	6,177	5,824	4,535	21,769

[a]For a complete explanation of the sanitary facilities available see footnote for Table 23-17

Source: Rand McNally 1971 Campground and Trailer Park Guide

campsites (42,800). As shown below, most public sites are located in lightly populated areas, and most private sites are located in the more heavily populated areas.

Population	Public Sites	Private Sites
Heavy	7,700	16,900
Medium	8,200	17,400
Light	22,500	8,500

The Rand McNally three- and four-star ratings do not indicate the campgrounds that have three or four basic sanitary facilities. The quality of the facilities, the state of maintenance, the availability of the facilities, and other factors affect the rating. In some cases a campground with three basic kinds of facilities may have a four-star rating, and one having four basic facilities may have a two- or three-star rating.

Figure 23–3 shows graphically that private campgrounds are generally better equipped with sanitary facilities than public campgrounds. This is particularly true for campgrounds located in heavily and lightly populated areas. Figure 23–4 shows that modern well-kept facilities are provided for approximately 25 percent of the privately administered campsites. Eighteen percent of the sites were in campgrounds provided with minimal facilities. This category indicates poor care, lack of facilities, and inconvenient access. From the heavily populated areas to the moderately populated areas, the percentage of minimum facilities increased, and the percentage of well-kept modern facilities decreased. From the medium to the lightly populated areas, both the percentage of minimum facilities and the percentage of well-kept modern facilities increased.

Table 23–20 and 23–21 show data by State. Figures 23–5 and 23–6 illustrate the data of these tables. References to the States in the following statements include only those portions of the States within the Great Lakes Basin. Except for Illinois and New York, privately administered campsites are provided with more complete sanitary facilities than publicly administered campsites. This difference is greatest in Minnesota and Wisconsin. States with the greatest percentages of minimal sanitary facilities at publicly administered areas include Michigan, Minnesota, Ohio, and Wisconsin.

TABLE 23–19 Campground Data by Population Density

Planning Subarea	People per 100 Acres	Public Campgrounds Sanitary Facilities[a] (% of Total Sites) 1	2	3	4	Private Campgrounds Sanitary Facilities[a] (% of Total Sites) 1	2	3	4	Star Ratings[b] (% of Rated Sites) 1	2	3/4	No. of Public Sites	No. of Private Sites
Heavy Population Density														
2.2	176	12	0	13	74	5	10	8	77	17	69	14	3,200	9,000
4.1	124	16	9	9	66	0	0	0	100	0	0	100	2,300	400
4.3	130	28	0	27	46	2	7	23	68	17	34	49	1,800	4,800
4.4	59	0	14	21	66	2	10	19	69	5	65	30	400	2,700
Total[c]	130	16	4	15	65	4	8	12	74	15	58	27	7,700	16,900
Medium Population Density														
2.3	28	5	3	6	86	9	5	8	78	14	64	21	2,700	8,800
3.2	25	11	3	2	84	0	0	20	80	17	59	24	1,500	700
4.2	26	27	13	46	15	12	41	19	27	29	57	14	1,400	3,200
5.1	36	14	7	0	79	10	17	3	69	18	59	23	1,100	2,400
5.2	24	0	9	0	91	7	11	23	59	25	42	33	1,500	2,300
Total[c]	27	10	6	10	73	9	14	12	65	19	59	22	8,200	17,400
Light Population Density														
1.1	4	29	43	22	6	15	24	14	47	46	39	15	2,200	900
1.2	3	10	21	4	65	0	26	21	53	71	29	0	2,900	400
2.1	9	19	31	18	32	6	6	14	75	20	34	46	4,800	4,400
2.4	6	11	11	8	70	4	10	18	68	11	75	14	6,900	1,800
3.1	3	34	18	6	42	0	1	9	90	21	20	59	3,200	600
5.3	6	1	33	19	37	0	2	24	73	13	87	0	1,400	400
Total[c]	5	18	22	11	48	6	9	15	70	23	44	33	22,500	8,500
All Areas[c]	34	16	15	12	57	6	11	13	70	18	56	26	38,400	42,800

[a]For a complete explanation of the sanitary facilities available see footnote for Table 23-17

[b]Figures in column "1" are percentages of campsites in campgrounds with one-star ratings (minimum facilities). Figures in column "2" are percentages of campsites in campgrounds with two-star ratings (more adequate facilities). Figures in column "3/4" are percentages of campsites in campgrounds with three- and four-star ratings (modern facilities).

[c]All figures are averages, except for the last two columns, which are totals.

Source: Rand McNally 1971 Campground and Trailer Park Guide

TABLE 23–20 Public Campsites by State[a]

State	Sanitary Facilities[b] 1	2	3	4	Total Sites
Indiana	55	45	427	860	1,387
Illinois	50	0	0	2,310	2,360
Michigan	3,529	3,290	1,428	13,630	21,877
Minnesota	424	674	395	132	1,625
New York	169	702	339	3,029	4,239
Ohio	868	130	1,097	1,033	3,128
Pennsylvania	0	0	0	50	50
Wisconsin	1,082	983	849	725	3,639
Total	6,177	5,774	4,460	21,579	38,305

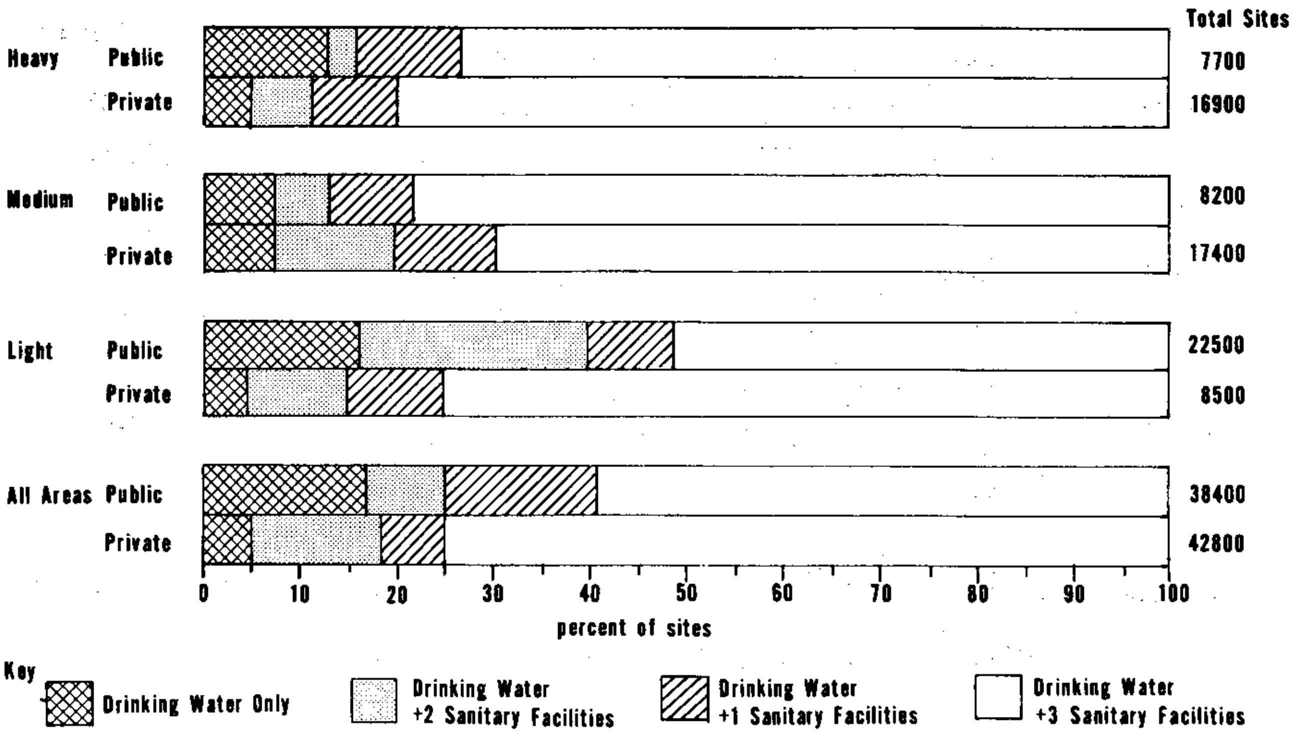
[a]Figures are for the Great Lakes Basin portion of each State

[b]For a complete explanation of the sanitary facilities available see footnote for Table 23-17

Source: Rand McNally 1971 Campground and Trailer Park Guide

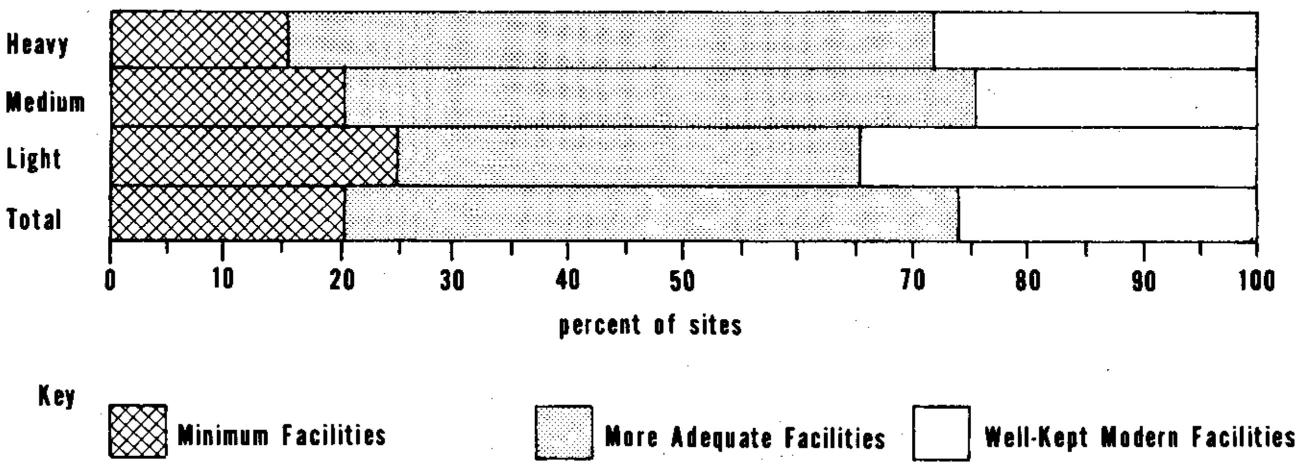
Privately administered campsites predominate in Indiana, New York, Ohio, and Wisconsin. The opposite is true for Illinois, Michigan and Minnesota.

The difference in campground sanitary facilities available in each State does not appear to have a great effect on the campground ratings. The poorest ratings are for campgrounds located in Illinois, and the best ratings are for campgrounds in Ohio and Wisconsin. This indicates that the ratings are affected by the condition of sanitary facilities and their convenience to campsites. The ratings may also indicate the adequacy of each State's sanitary surveillance of these facilities.



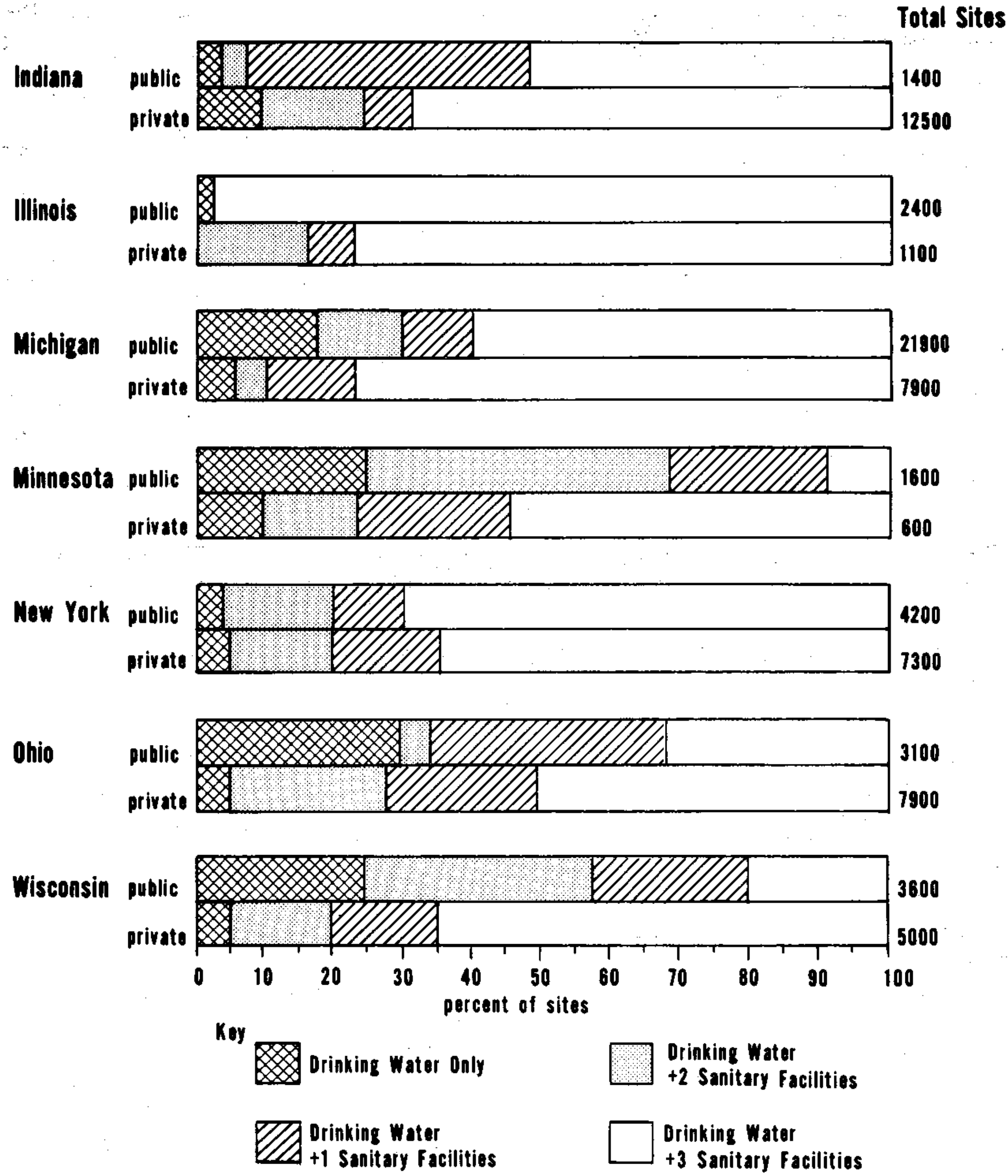
Source: Rand McNally 1971 Campground and Trailer Park Guide

FIGURE 23–3 Campground Sanitary Facilities Available by Population Density



Source: Rand McNally 1971 Campground and Trailer Park Guide

FIGURE 23–4 Ratings of Private Campgrounds by Population Density



Source: Rand McNally 1971 Campground and Trailer Park Guide

FIGURE 23–5 Campground Sanitary Facilities in the Great Lakes Region by State

TABLE 23-21 Private Campsites by State[a]

State	Total Sites	Basic Sanitary Facilities[b]				Star Ratings[c]		
		1	2	3	4	1	2	3/4
Illinois	1,078	0	150	100	828	382	696	0
Indiana	12,593	824	833	659	10,277	1,474	8,839	2,280
Michigan	7,862	549	335	1,168	5,810	1,900	3,912	2,050
Minnesota	565	69	64	116	316	196	228	141
New York	7,312	453	940	1,126	4,793	1,167	4,289	1,856
Ohio	7,935	501	1,582	1,733	4,119	1,646	3,452	2,837
Pennsylvania	467	0	0	100	367	40	177	250
Wisconsin	5,032	276	761	763	3,232	1,027	2,185	1,820
Total	42,844	2,672	4,665	5,765	29,742	7,832	23,778	11,234

[a]Figures are for Great Lakes Basin portion of each State.

[b]For a complete explanation of the sanitary facilities available see footnote for Table 23-17.

[c]One-star ratings are for campsites with minimum facilities, two-star ratings are for campsites with more adequate facilities and three- and four-star ratings are for campsites with modern facilities.

Source: Rand McNally 1971 Campground and Trailer Park Guide

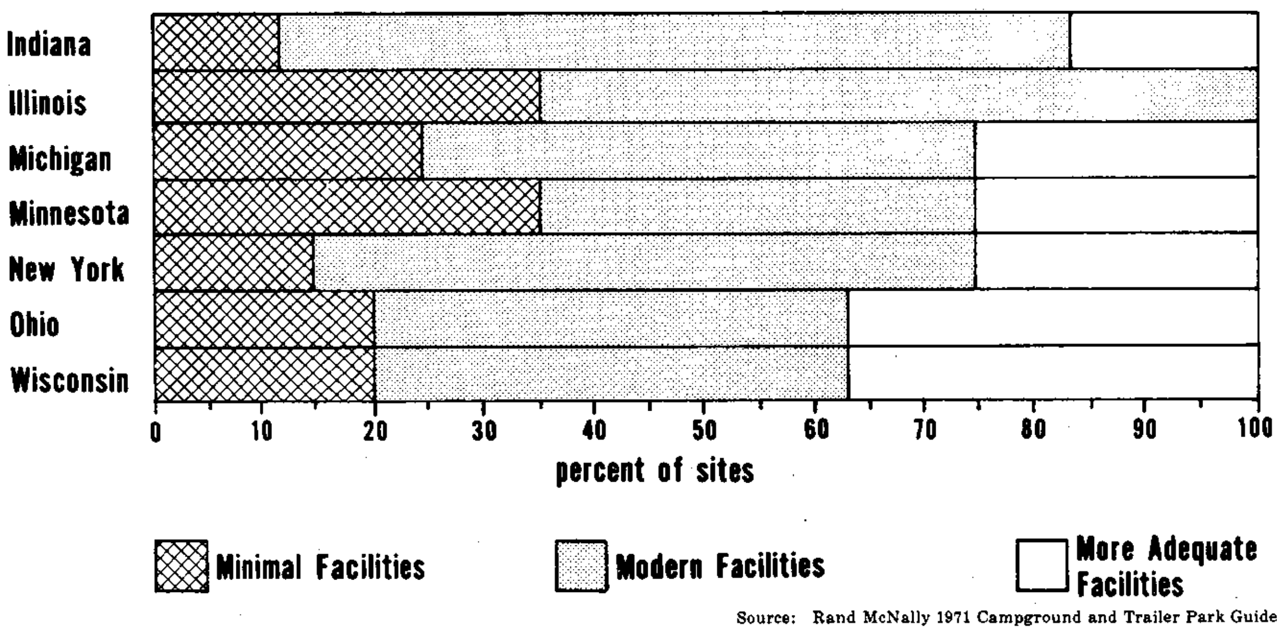


FIGURE 23-6 Private Campground Ratings in the Great Lakes Region by State

Section 4

AIR POLLUTION, SOLID WASTE, RADIOLOGICAL HEALTH, AND INDIVIDUAL WATER SUPPLY ASPECTS

Management and development of water resources affect all aspects of the environment through influences on economy, sociological patterns, industrial development, and ecology. This section includes brief discussions on air pollution in the Great Lakes Basin, solid waste management, individual water supply health aspects, and radiological health aspects. Additional information on individual water supply may be found in Appendix 6, *Water Supply—Municipal, Industrial, and Rural.*[43]

4.1 Air Pollution

Air pollutants play an interrelated role with other environmental contaiminants in effective water resource and land use management. It is quite important that air pollution factors receive careful consideration in the planning and management of an areas's water and land resources.

A few years ago a popular conception existed that air pollution affected only heavily-industrialized urban areas. Today it is well recognized that air pollution affects suburban and rural areas as well. It is also recognized that the harmful effects of air pollution are not limited to human health. It also causes negative aesthetic and social effects, and harms property, materials, and vegetation.

Air pollution control should be combined with the control of other environment pollutants. It should also be attacked on the basis of regional and urban growth patterns.

4.1.1 Nationwide Management and State Abatement of Air Pollution

The Clean Air Act strongly established the leadership of the Federal government in providing research, financial assistance, and leadership to develop effective State, regional, and local programs to prevent and control air pollution. The Federal program is administered by the Environmental Protection Agency.

The Clean Air Act requires that Federal authorities establish air quality criteria, define control techniques, establish air quality standards, and designate air quality control regions. State authorities are required to establish implementation plans which use these control techniques. These plans are designated to meet the standards within a specified time. The degree of control established by the States varies from State to State.

4.1.2 Air Quality Control Regions (AQCRs)

Air quality control regions (AQCRs) are designated on the basis of meteorological, social, and political factors that indicate a group of communities should be treated as a unit for setting limitations on cencentrations of atmospheric pollutants. The development of the AQCR concept allowed establishment of more than 200 regions in the United States. Federal policy requires that implementation plans be submitted by State authorities to achieve and maintain the standards within a reasonable time frame. These AQCRs should be considered and applicable air quality control regulations should be evaluated for relationships to Great Lakes planning. Figure 23-7 shows the major AQCRs in the Great Lakes Basin by county. Major problems and control activities in these AQCRs are summarized below.

4.1.2.1 Duluth (Minnesota)-Superior (Wisconsin) Interstate AQCR

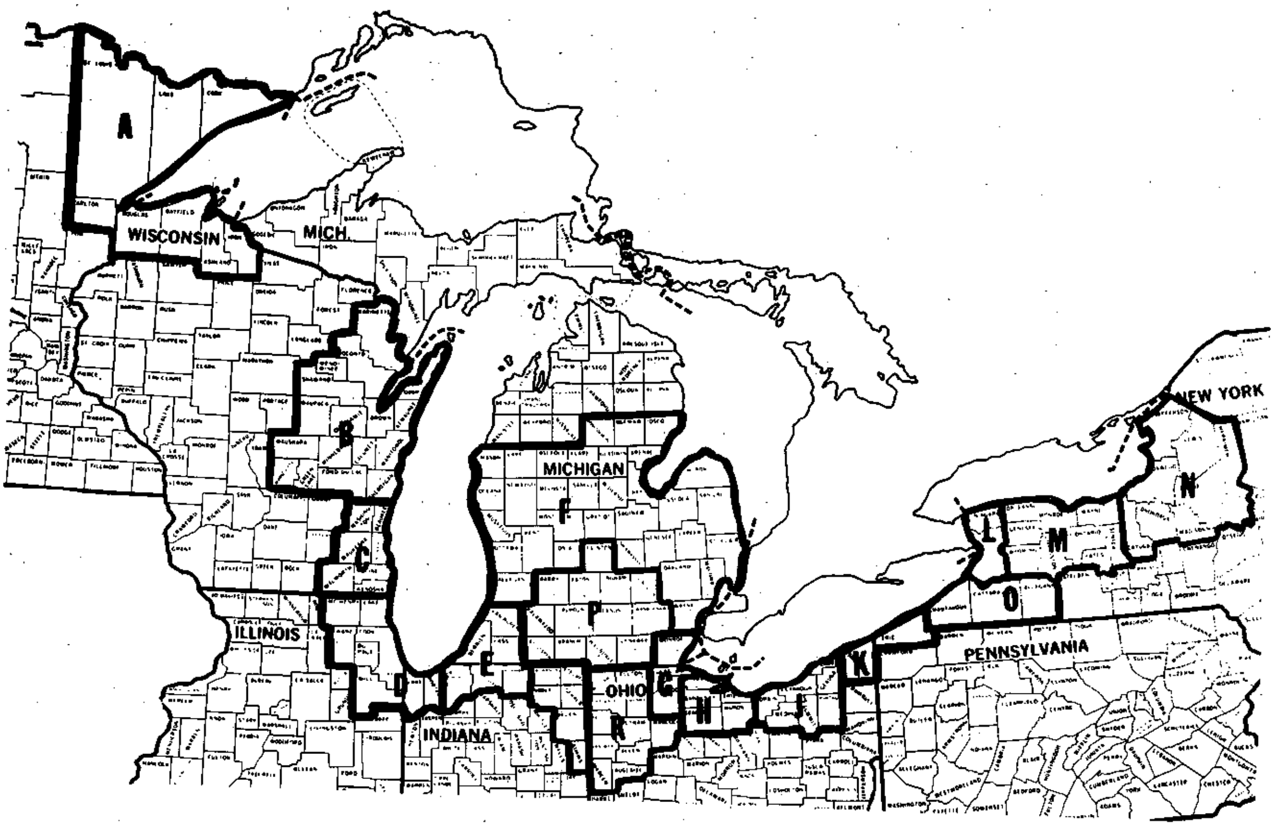
St. Louis County, Minnesota, has the only local air pollution control agency in this region. The rest of the region is under jurisdiction of the Minnesota and Wisconsin State agencies. Major problems in the area are taconite plants, a steel mill, and an oil refinery. At present control equipment is required for the taconite plants and compliance schedules are being developed for other major air pollution sources.

4.1.2.2 Lake Michigan Intrastate AQCR (Wisconsin)

The Wisconsin State agency is responsible for pollution control in this region, and no local agencies exist. Major air pollution sources are paper mills, power plants, and metal industries. The State is working with these industries to achieve air pollution control.

4.1.2.3 Southeast Wisconsin Intrastate AQCR

Three agencies, Wisconsin State, Milwaukee County, and Racine County, are active in this region, with Milwaukee County having the most pollution. The region contains diversified heavy industry and transportation sources. Milwaukee County has developed compliance schedules for all industries



A Duluth-Superior
B Lake Michigan, Wisconsin
C Southeast Wisconsin
D Metropolitan Chicago
E South Bend-Benton Harbor
F Central Michigan, Detroit-Port Huron
G Metropolitan Toledo
H Sandusky, Ohio
J Metropolitan Cleveland, Ohio
K Northwest Pennsylvania-Youngstown
L Niagara-Frontier
M Genesee-Finger Lakes, New York
N Central New York
O Southern Tier New York
P South Central Michigan
Q Northeast Indiana
R Northwest Ohio

FIGURE 23–7 Major Air Quality Control Regions in the Great Lakes Basin

in its jurisdiction. The Racine County agency is working with major pollutors to obtain air pollution control.

4.1.2.4 Metropolitan Chicago Interstate AQCR

In Illinois control services are provided for the City of Chicago and Cook County by the city and county agencies and the State agency, and for the outlying area by the State agency. In Indiana agencies in Hammond, Gary, East Chicago, and Lake County provide control efforts for their jurisdictions. In the remaining area the Indiana State agency handles air pollution control activities. The region has heavy industry, steel mills, oil refineries, power plants, and transportation sources. These agencies are limiting the sulfur content in fuels, tightening the steel mills' compliance schedules, obtaining compliance schedules for the oil refineries, and proceeding with other enforcement activities.

4.1.2.5 South Bend-Benton Harbor Interstate AQCR

The only major source of air pollution in this region is the power plant in Michigan City, Indiana. The Michigan City air pollution control agency has developed a compliance schedule for this plant.

4.1.2.6 Central Intrastate AQCR (Michigan) and Detroit-Port Huron AQCR (Michigan)

Michigan contains two major air pollution problem areas. One is in Muskegon County, adjacent to Lake Michigan, where the local agency is working with industry to obtain compliance schedules. The other major pollution area is in the Detroit-Port Huron region where the Wayne County air pollution control agency and the State Air Pollution Control Division are working with heavy industry to obtain compliance schedules. This area has a unique problem created by the international flow of pollution between Canada and the United States. The International Air Pollution Advisory Board to the International Joint Commission has been established to deal with such transboundary problems between the United States and Canada. The State handles all the other regions which have no serious air pollution problems.

4.1.2.7 Metropolitan Toledo Interstate AQCR

Most of this area's pollution problems result from power plants and oil refineries located in Toledo, which has the only air pollution control agency in the region. This agency has begun legal action against some pollutors and is obtaining compliance schedules for the rest.

4.1.2.8 Sandusky Intrastate AQCR

This region has no local agencies. Air pollution control efforts are limited to the Ohio State agency which is working with industry.

4.1.2.9 Greater Metropolitan Cleveland Intrastate AQCR

Air pollution control agencies have been developed by the City of Cleveland, the City of Lorain, and Lake County. Much heavy industry is located in this region including steel mills, power plants, and several chemical plants. The control agencies have obtained compliance schedules for several major sources, and are taking legal action against the others.

4.1.2.10 Northwest Pennsylvania-Youngstown Interstate AQCR

There are no local agencies in this region. The Ohio agency is controlling industries under its jurisdiction. In Pennsylvania there is diversified industry including a steel mill and a power plant. The Pennsylvania agency is working with these sources to obtain compliance schedules.

4.1.2.11 Niagara-Frontier Intrastate AQCR

The two county agencies in this region are in Erie County and Niagara County, New York. The region has diversified heavy industry, steel mills, and oil refineries. The agencies have compliance schedules from industries in the area.

4.1.2.12 Genesee-Finger Lakes Intrastate AQCR

The only local agency is in Monroe County, New York. The region has light industry. The industries are installing abatement equipment.

4.1.2.13 Central Intrastate AQCR

There are no local agencies in this area. The New York State agency handles air pollution control activities around Lake Ontario. There are no major sources of pollution, and the smaller sources will be controlled by the State implementation plan.

4.1.2.14 Southern Tier West Intrastate AQCR

The New York State agency has control responsibility in this region. The region's problems are not significant because of its rural nature.

4.2 Solid Waste Disposal

Solid waste disposal represents a significant environmental problem for the nation. The National Survey of Community Solid Waste Practices[59] in 1968 showed a solid waste production of 190 million tons per year. It found that 94 percent of existing land disposal operations and 75 percent of incinerator facilities were inadequate. Collection systems were also found to be inadequate. Authorities estimate that it will require $835 million per year for a five-year period to upgrade collection and disposal practices to a satisfactory level in the United States. In addition it is important to provide suitable land for solid waste disposal in future years.

In the Great Lakes Basin room and facilities must be provided for disposal of 53,497 acre-feet of solid waste by the year 2020. Solid waste production is shown for each Lake basin in Table 23-22. By 2020 solid waste disposal will require the use of more than 5,000 additional acres of land for each year, unless major breakthroughs occur in source reduction or resource recovery.

As living standards increase, there is an increase in per capita refuse generation. To prevent public health hazards and nuisances from developing, solid wastes must be regularly collected, transported, and disposed of in a satisfactory manner.

Poor refuse storage practices or infrequent collection causes propagation of flies and other vectors. Flies may carry and transmit several diseases including dysentery, gastroenteritis, and typhoid. Mosquitoes may transmit encephalitis or malaria. Rodents may transmit salmonellosis, plague, murine typhus, leptospirosis, and rat bite fever. Loss of life and property may result from improper storage practices and inadequate collection of rubbish, which increase fire and accident hazards at the source.

Where refuse collected includes garbage, a weekly collection program will permit the propagation of flies. The only sure method to reduce the number of flies produced is to collect waste twice a week during the fly breeding season which is generally June 1 through September 30 for the Great Lakes Region. Studies have shown that this measure results in more than a 95 percent reduction in fly production.

TABLE 23-22 Production of Solid Wastes in the Great Lakes Basin

Plan Area		Acre-feet per Year			
		1960	1980	2000	2020
1	Lake Superior	545	538	595	669
2	Lake Michigan	12,041	15,542	19,645	24,830
3	Lake Huron	1,057	1,411	1,809	2,324
4	Lake Erie	10,466	13,300	16,794	21,281
5	Lake Ontario	2,256	2,776	3,495	4,393
	Total	26,365	33,567	42,338	53,497

Open dumping and open burning create public health problems and nuisances. Such practices can result in pollution of both surface and ground water supplies. Disease vector problems with refuse disposal are similar to problems with refuse collection in which fly, mosquito, and rat propagation are most serious.

Since the mid-1960s, State and Federal efforts have been increased to reduce air, water, and land pollution problems resulting from improperly operated refuse disposal facilities. These efforts include development and application of improved practices, elimination of open burning and open dumps, centralization of waste disposal on a county basis, and development of waste management plans for county and multicounty areas.

Waste disposal sites that border water resources may cause water pollution resulting from improper design or operation of disposal sites and flooding of waste disposal sites from water resource development projects. Water pollution from improper waste disposal may affect ground or surface waters. These interfaces are discussed in Section 5.

To reduce the problems of solid waste disposal, a number of actions are needed in much of the Great Lakes Basin:

(1) A refuse disposal plan should be developed to serve present and future community needs.

(2) Adequate collection services should be provided for developed areas.

(3) Refuse transportation should be controlled along streets and highways.

(4) To reduce the litter problems, public information and enforcement, if necessary, should be increased.

(5) An expanded refuse container system should be developed along roads and public gathering places.

(6) Salvage centers for large metal items such as stoves, refrigerators, and auto hulks should be established where these salvageable waste materials could be processed for resale.

4.3 Individual Water Supply

Where population density is inadequate to support development of a public water supply, or where the community is insufficiently organized to support such development, individual home owners must develop their own sources of water. These include purchased bottled water, hauled water, surface water, dug wells, cisterns, springs, and drilled or driven wells. Drilled or driven wells are the preferred sources. Other sources may be properly developed and used, but should only be considered as a last resort.

Mandatory well driller registration can improve individual water supplies. Where drillers are required to pass a certifying examination before they can drill wells, there is some assurance that they will be competent in locating and constructing wells. Strict well construction rules require a well to be located where there is the least chance of contamination and where the source water is adequate and of good quality, and that it be properly constructed. The enforcement of such rules ensures safe drinking water supplies for individual well owners. The requirement to submit well logs is also beneficial because such records make it possible to estimate the quality and amount of water that may be available at associated locations. In short, an individual is more likely to have a safe water supply if his well has been constructed according to strict codes by a competent well driller.

All States in the Great Lakes Basin except New York have regulations covering well drillers. However, the regulations vary from requiring only a license fee to strict rules governing drillers, well construction, and pump installation. Illinois, Michigan, and Wisconsin have the most comprehensive laws in the Basin. In Ohio the regulation of well drilling is encouraged at the county level. The Ohio Department of Health has developed and distributed a model regulation for this purpose. A summary survey of local water regulations, however, revealed that only seven of 26 Ohio counties in the Great Lakes Basin have well regulations, and that these regulations have no uniformity. This situation indicates the need for uniform Statewide regulations.

4.3.1 Bottled Water

Bottled water is expensive, usually costing approximately 40 cents per gallon, and its quality may be uncertain. The bottled water industry is largely self-policed. State regulations dealing with bottled water quality are summarized below.

Illinois regulations state that water shall be of safe, sanitary quality from an approved system in conformance with applicable State and local laws, ordinances, and regulations (Food Manufacturing, Processing, Packing or Holding, General Rules and Regulations, with Interpretive Regulations for Bottlers of Soft Drinks and Water, 1970).

According to Indiana regulations, no bottled water offered for sale may show bacterial or chemical content deleterious to public health. Samples must be submitted for potability and suitability at intervals designated by the State board (Water Supply, Chapter 157, Acts of 1949 Indiana General Assembly).

In Michigan, regulations pertaining to nonalcoholic beverages and food apply. The only reference to water says that it must meet USPHS standards for bacteriological purity (Michigan Department of Agriculture, Regulations No. 549, Non-alcoholic Beverages, Michigan Food Law of 1968, Act 39 of 1968 as amended).

In Minnesota, regulations pertaining to nonalcoholic beverages apply. Water used must be of safe, sanitary quality and from an approved source (State of Minnesota Department of Agriculture Rules and Regulations Relating to Non-alcoholic Beverages, AGR 985–994, Non-alcoholic Beverages Chapter 34).

In New York, specific regulations covering the sale of bottled water exist. Bottled water cannot be sold unless the source, equipment, method of handling, and routine sampling procedures are approved by the State Commissioner of Health (New York State Sanitary Code, Part 5, Drinking Water Supplies).

In Ohio, bottled water is classed as a soft drink in an agriculture regulation. Regulations state that all water used shall be safe, potable water free from pathogenic bacteria; the label must not be misleading; prepared or compounded water shall not be described as natural waters; and mineral waters must be of good quality when judged by sanitary chemical analysis (Ohio Revised Code, Sections 913.22 to 913.28 and Section 913.99).

Pennsylvania regulations state that bottled water must not be impure, that it must not bear evidence of potential pollution, and that its use must not be injurious or detrimental to public health. A permit application must be accompanied by a report of bacterial analysis and sanitary chemical analysis (Act No. 396 of the Pennsylvania General Assembly, 1929, Commonwealth of Pennsylvania Department of Health Regulations Pertaining to the Manufacturing, Bottling, and Selling of Certain Waters, Chapter 4, Article 421, 1959).

In Wisconsin, bottled water is classed as soda water beverage by the Wisconsin Department of Agriculture. All water used must be pure and free from pollution and contamination (Wisconsin Statutes, Chapter 97, 1969, Wisconsin Department of Agriculture Statutes, Chapter AG41).

State inspection is usually limited to the sanitation aspects of the bottling process and seldom includes inspection of the source. Water quality samples are seldom analysed by the State and, when analyses are done, they are limited to bacteriological tests. An exception is in Pennsylvania where bottled water sources in the State are required to have two chemical analyses made before a permit is issued. These chemical anlyses, one made by the permit holder and the other by the Department of Environmental Resources, are required annually along with a monthly bacteriological analysis of the bottled water by the licensee. In addition, the department performs periodic chemical and bacterial analyses of bottled water purchased at retail outlets.

4.3.2 Other Individual Water Supply Sources

Cisterns use a system such as roof gutters for rainwater collection. When this storage becomes exhausted during droughts, water is often hauled. Hauled water sources are often the nearest public water supply. Although the source may be good, unsanitary conditions may occur at the watering point, in the vehicle used for hauling, and during dumping. Design and maintenance of the watering point and the tank truck used are important. Batch disinfection of the water hauled is advisable.

Surface water is seldom used for individual drinking water supply because turbidity, bacterial contamination, and tastes and odors are often highly variable qualities. This variability requires the use of sophisticated treatment equipment and few homeowners have the skill and perseverance to maintain such equipment.

Most individuals use ground water for private water supply. Ground water comes from rain that has seeped into the earth. This rain water is often contaminated on the surface of the ground, but as it seeps down through the soil its contamination is usually removed by the soil's filtering action. Therefore, water from near the ground surface, less than 25 feet, is more likely to be contaminated than water from greater depths.

Because springs and dug wells are located on or near the surface, they are much more likely to be contaminated than drilled or driven wells. A location that minimizes the possibility of contamination is of primary importance in individual water supply development. Individual water supply sources should be located on high ground not subject to flooding, away from the path of large area surface runoff, and far removed from known contamination sources such as privies, septic tanks, leaching fields, manure piles, and ditches.

A number of studies have demonstrated that individual water supplies are often contaminated. A major study in southeastern Ohio covering seven counties and more than 6500 individual water supplies determined that contamination from coliform organisms occurred in 25 percent of the drilled wells, 79 percent of the dug wells, 60 percent of the cisterns, and 77 percent of the springs.[44] In Wisconsin a study of a county where groundwater pollution was caused by septic tanks found that 15 to 24 percent of the wells sampled were contaminated.

These studies demonstrate that individual water supply problems exist in certain areas of the country and the Great Lakes Basin. County health authorities should provide homeowners using individual water supplies with information and technical assistance to assure development of safe drinking waters. Through county health departments or the State health department, most States presently provide analysis of individual water supply samples upon request.

4.4. Radiological Health

The sources of radioactive pollutants are numerous and include hospitals, industrial laboratories, nuclear reactors, and fuel fabrication and reprocessing plants. Because of the large population that borders the Great Lakes, this area represents one of the most significant receptors of radionuclides resulting from the commercial use of nuclear power and the discharge of radionuclides used in medicine and industry. The Great Lakes Region has been particularly active in the application of nuclear power.

This subsection includes discussions of the various sources of radiation and the surveillance and controls provided by State and Federal agencies to prevent adverse impacts from nuclear power development.

4.4.1 Sources

Radiation sources can be either natural or man-made. Throughout history man has been exposed to cosmic radiation that enters the earth's atmosphere and to radioisotopes contained in the earth's crust. The naturally occurring radioisotopes give rise to both external and internal irradiation of man. This natural background radiation constitutes approximately 70 percent of the total radiation dose received by the average American each year. Radiation exposure from natural sources varies with time, location, and many other factors. The following estimated doses are given to provide numbers for comparison purposes and to help keep the subject in perspective.

The annual cosmic dose is estimated to be 50 millirad to the average individual located in the Great Lakes Region. The annual dose from the earth's crust is estimated to be 80 millirad around the Great Lakes. Therefore, the estimated total annual dose from naturally occurring radiation in the Great Lakes is the same as the estimated 130 millirad average dose in the United States.

Radioactivity from the earth's crust is present in the environment because naturally radioactive isotopes are constituents of a number of elements in the earth's crust. The nuclear interaction of cosmic rays with nuclei in the atmosphere, soil, and water also produces several radionuclides. The most significant potential exposures from natural radionuclides are the external gama radiation from potassium-40 and the decay products of uranium and thorium and internal radiation exposure from tritium, carbon-14, potassium-40, and radium-226 and 228.

Man-made sources of radionuclides include fallout from nuclear tests, peaceful applications of nuclear explosives, medical radiation, occupational radiation, and nuclear power. In 1961 and 1962 atmospheric testing by the United States and the Soviet Union introduced radioactivity into the stratosphere, which continues to be deposited. During more recent years a few tests by the French and Chinese have been sufficient to maintain a relatively constant annual fallout deposition. In estimating exposures from fallout, it is assumed that the present rate and type of testing will continue through 2000. The total whole-body dose from fallout was 13 millirem per person in 1963. In 1969 the dose was 4.0 millirem. It is estimated that in 1980, 1990, and 2000 the dose will increase to 4.4, 4.6, and 4.9 millirem respectively.[11]

A number of possible uses of nuclear explosives may develop sometime in the near future. Experimental programs indicate that these may include excavation, mineral recovery, underground storage, waste and water management, and use of geothermal energy. These uses should be included in future reviews and projections as sufficient information becomes available.

The use of radiation in the healing arts is recognized as the largest man-made component of radiation exposure to the general population. This includes diagnostic radiology, radiation therapy, and occupational exposure of medical and paramedical personnel. The medical use of X-rays has been increasing since their discovery in 1895. According to the results of many surveys conducted between 1953 and 1964, the estimated genetic significant dose (GSD), for the U.S. population ranged from 18 to 136 millirem. In two X-ray exposure studies by the U.S. Public Health Service the GSD was estimated to be 55 millirem in 1964 and 36 millirem in 1970. Another source of exposure is the use of radiopharmaceuticals which began less than 30 years ago. Sales of radiopharmaceuticals were estimated at $32 million in 1969. The growth rate was approximately 25 percent in 1969, and it is expected to continue at this rate for several years.[24] Three of the eight largest U.S. cities border the Great Lakes, and hospital disposal of radionuclides in the Great Lakes represents a potential problem. At present it appears that long-term effects of such discharges are relatively small compared to potential effects of nuclear power facilities.

The contribution of occupational exposure to the population dose from radiation is not well documented in the scientific literature. Available data, however, indicate that the average dose per worker has declined since 1960.

The nuclear power industry has grown rapidly during the last decade and is expected to grow considerably more by the year 1980. The development of nuclear power in the United States has been reported to the public periodically by the nuclear industry and the U.S. Atomic Energy Commission (AEC). These reports indicate that nuclear power plants have apparently become competitive with fossil fuel plants in many geographical areas. Recognition of this fact and the overall expanded United States electrical power requirements have resulted in a substantial increase in the number of nuclear power plant orders by both private and public utilities. In 1970 the AEC estimated that approximately 150,000 megawatts of electricity (30 percent of the nation's estimated use) will be generated using nuclear power by 1980.[3]

The Great Lakes Region has participated substantially in the development of nuclear power for commercial use. One of the first commercial boiling water reactors, Big Rock Point, is located on Lake Michigan in the State of Michigan. The first commercial fast breeder reactor, the Enrico Fermi Plant, is located on Lake Erie, also in Michigan. The first commercial fuel reprocessing plant is located at West Valley, New York, on the Cattaraugus Creek, which drains into Lake Erie. Reactors on the borders of the Great Lakes account for 38 percent of all reactors now operating or ordered in the United States. Table 23–23 shows the AEC forecast of nuclear power plants (megawatts electric) for the United States and the Great Lakes area. Table 23–24 shows the nuclear power plants built or scheduled to be constructed on the Great Lakes, indicating the number and size of plants by location.

The principal types of power plants presently operating in the United States are pressurized water reactors (PWR) and boiling water reactors (BWR). These two reactor types will probably continue to dominate the U.S. nuclear power industry until the fast breeder reactor is developed to the point where it is economically competitive with water reactors. PWRs and BWRs have been designed so that radiological hazards during normal operation are minimal. Table 23–25 gives liquid waste discharge data for three plants operated in 1970. These data show the discharges to be well within the limits established by AEC. The release of radioactive contaminants in the unlikely event of a major reactor accident, however, would represent a significant radiological exposure hazard to the health of a large number of people, and is the major factor considered in the siting and safety review of nuclear power plants.

Nuclear Fuel Services, Inc. has a spent fuel processing plant located on the Western New York Nuclear Service Center in Ashford, New York. All of the tributaries and, therefore, all the ground water on the site feed into Buttermilk Creek. At the site boundary Buttermilk Creek empties into Cataraugus Creek, which in turn flows into Lake Erie, 39 stream miles from the site.

To illustrate typical liquid releases from the spent fuel processing plant, data were obtained from a Nuclear Fuel Services, Inc. operating report. For the period January through September 1967, 0.038 curie of gross alpha activity, 16 curies of gross beta activity, and 3,700 curies of tritium activity were reported as being released. Comparisions were made with liquid releases reported in other Nuclear Fuel Services Quarterly Reports and the releases for January through September of 1967 were found to represent a typical liquid release over a nine-month period. Presently this is the only spent fuel processing plant discharging into the Great Lakes, and the future sitings of other plants in this area have not been estimated.

The Midwest Fuel Recovery Plant, located approximately 35 miles southwest of Chicago, is scheduled for operation in 1973. The plant is designed to discharge only radioactive gaseous wastes.

Because the future development of nuclear power will be influenced by the availability of water for cooling purposes, siting on the Great Lakes appears to have greater potential than siting on inland waterways. Therefore, a large proportion of nuclear facilities for the States adjacent to the Lakes will be located on the lakeshores.

4.4.2 Control of Nuclear Power Development

In the United States the Atomic Energy Commission has the responsibility for licensing and regulating nuclear power plants. The AEC's reactor licensing procedure includes a comprehensive safety evaluation of the design features and operating characteristics needed to assure safe operation of these plants. State and Federal agencies responsible for public health and environmental protection play an important role in these evaluations and are concerned with the monitoring of such facilities. The U.S. Environmental Protection Agency (EPA) has been delegated the responsibility for providing assistance and guidance to State radiological protection agencies. Within EPA the Office of Radiation Programs administers radiation activities which include evaluations of nuclear facilities, monitoring of radiation levels in the environment, and technical assistance to State agencies responsible for assuring maintenance of acceptable radiation levels in the environment.

Under the National Environmental Policy Act of 1969 AEC provides the Office of Radiation Programs (ORP) with copies of the design safety analysis reports and environmental reports submitted by applicants proposing to build and operate nuclear facilities. The ORP reviews nuclear facilities, drafts environmental impact statements, and prepares comments for the AEC. In these comments the ORP evaluates site suitability and determines if all technology is being used to achieve the lowest practible discharges, if all possible environmental dangers have been considered, and if undue environmental risk is associated with the facility from abnormal or accidental situations. The review constitutes EPA's independent position on the specific facilities.

TABLE 23–23 Atomic Energy Commission Forecast for Nuclear Power Plants (Megawatts)

Year	United States	Great Lakes
1970	5,000	1,200
1975	59,000	11,500
1980	150,000	16,000

The ORP environmental monitoring program includes a comprehensive, continuing measurement of radioactivity levels in the environment by means of several national surveillance networks. Information from these networks is used to estimate public exposure and doses relatable to environmental radioactivity. The current surveillance activities in and adjacent to the Great Lakes include the collection and analysis of air-borne particulates, water, milk, total diets, and human bones.

States operate similar Statewide networks that are coordinated with the ORP network system. In addition environmental surveillance programs are conducted in the vicinity of operating nuclear facilities by the operator and State agencies.

To assure compatibility of the surveillance data from both Federal and State programs, an Analytical Quality Control Service is provided. In addition recommended guides for site selection and environmental surveillance around nuclear power plants are developed.

Although source control is the responsibility of the reactor operator, assurance of public health and environmental protection is a responsibility of government agencies. The environmental surveillance program may be conducted by the facility operator and local or State government agencies on either a cooperative or unilateral basis. There does not appear to be a particular pattern established in the United States, but in most cases the facility operator conducts the program with some State agency participation.

The environmental surveillance program recommended by ORP consists of two phases, the preoperational phase and the operational phase. The preoperational phase provides data that can be used to evaluate increases in radioactivity in the vicinity of the plant after the plant begins operating. The evaluation must also determine whether an increase is attributable to plant operations or to a general increase in environmental radioactivity. Therefore, the operational surveillance program must include control data from sample sites considered to be beyond the measurable influence of the nuclear facility as well as data from the areas expected to be most affected. The operational surveillance program will provide the data required for estimation of population dose. This dose may be compared with that calculated using a dose model and radionuclide discharge data for the specific nuclear facility. In all cases the surveillance program must emphasize sampling and measurement of the environmental media that contribute most significantly to radiation exposure of the public.[10]

4.4.3 Conclusions

Excluding medical radiation, exposure to man-made radiation for most people in the Great Lakes Region is only a small amount compared to natural background exposure. In fact, people who live in stone houses or at high altitudes are exposed to far greater amounts of radiation.

TABLE 23–24 Nuclear Power Reactor Locations and Megawatts Produced

Lake	Plant	State	First year of Operation		Megawatts Produced
Michigan	Zion I	Illinois	1972		1,100
	Zion II	Illinois	1973		1,100
	Bailly	Indiana	1976		686
	Big Rock Point	Michigan	1962		75
	Cook I	Michigan	1973		1,100
	Cook II	Michigan	1974		1,100
	Palisades	Michigan	1971		812
	Point Beach I	Wisconsin	1970		524
	Point Beach II	Wisconsin	1971		524
	Kewaunee	Wisconsin	1972		527
				Total	7,548
Huron	Midland I	Michigan	1975		526
	Midland II	Michigan	1976		855
				Total	1,381
Erie	Fermi I	Michigan	1967		70
	Fermi II	Michigan	1974		1,075
	Davis-Besse	Ohio	1974		906
				Total	2,051
Ontario	Nine Mile Point I	New York	1969		642
	Nine Mile Point II	New York	1977		875
	Station 13 I	New York	1970		517
	Station 13 II	New York	1979		1,000
	Fitzpatrick	New York	1973		850
	Bell	New York	1977		853
	Undecided	New York	1979		1,100
				Total	5,837
Great Lakes Basin Total					16,817

	Illinois	Indiana	Michigan	New York	Ohio	Wisconsin	Total
Megawatts Produced	2,200	686	5,613	5,837	906	1,575	16,817

Medical radiation exposure ranges from an order of magnitude below natural exposure to the same order of magnitude as natural exposure. The amounts and types of isotopes used, however, make serious contamination of an area's environment unlikely. Individual poisoning, however, could occur.

Serious contamination of an area's environment could result from major accidental discharges from nuclear power, nuclear fuel, or nuclear waste processing plants. Because of this possible hazard a great deal of effort is expended in developing fail-safe facilities. Environmental and health protection agencies provide further control by developing environmental monitoring systems and by assuring their maintenance.

The subject of radiation creates much public concern because of the serious effects that occur with heavy exposure. With continued use of fail-safe design features and proper surveillance of operation, the nuclear industry can serve the needs of the public without undue risk to public health and the environment.

TABLE 23-25 Liquid Discharge Data for Three Power Plants

	Robert E. Ginna[a]	Big Rock Point[b]	Nine Mile Point[c]
Condenser Water for Dilution Flow Rate (gpm)	334,000	50,000	600,000
1970 Total Annual Liquid Waste Discharged Less Tritium (curies)	9.02	4.64	9.44
Percent of Concentration Limit	4.5	3.1	21.0
1970 Total Tritium (curies)	106.0	53.6	10
Percent of Concentration Limit	0.05	0.05	0.0003

[a]The Robert E. Ginna plant is a pressurized water reactor. Liquid treatment includes filtration, evaporation, demineralization, and gas stripping.

[b]The Big Rock Point plant is a boiling water reactor. Liquid treatment includes filtration, evaporation, and demineralization.

[c]The Nine Mile Point plant is a boiling water reactor. Liquid treatment includes filtration and demineralization.

Section 5

HEALTH GUIDELINES FOR WATER AND RELATED LAND RESOURCE PLANNING

5.1 Introduction

The health guidelines presented in this section are for the guidance of agencies concerned with water resource development in the Great Lakes Basin. The guidelines were taken from the "Health Guidelines for Water and Related Land Resource Planning, Development and Management,"[14] published by the Division of Water Supply, United States Environmental Protection Agency. The guidelines are not intended to be used as a comprehensive design document. They are intended to provide a basic document which defines areas that require special attention by planning authorities.

Health departments are operated by most counties and a number of cities in the Great Lakes Basin, as shown by Figure 23–8. These local health departments are often the first to deal with environmental problems. In general, State environmental health and control agencies are primarily responsible for more technical problems affecting many people. Consultation with public health and environmental control authorities will insure the inclusion of adequate public health protection in water resource development plans. State and local health agency standards may vary from these guidelines in certain instances.

Federal agencies active in water resource development, such as the Corps of Engineers and the Soil Conservation Service, are required to obtain reviews of proposed projects from appropriate Federal, State and local agencies, including the Environmental Protection Agency and interested citizens' conservation and environmental groups.

Subjects discussed in this section include public water supply systems, irrigation with sewage treatment plant effluent, recreation area development, vector control, and solid waste management.

5.2 Public Water Supply Systems

5.2.1 General

In the Public Health Service Drinking Water Standards[27] a water supply system is defined to include "the works and auxiliaries for collection, treatment, storage and distribution of the water from the source of supply to the free-flowing outlet of the ultimate consumer." A public water supply system is intended to furnish water for drinking, food preparation, and other individual human uses, as well as for a variety of commercial, industrial, and municipal uses.

The exact definition of a public water supply system differs from State to State, depending on the number of customers served. For purposes of this study, it includes the idea of service to a community and/or the availability of the system for service to the general public.

The safety of a public water supply system depends on the sanitary environment, the quality and quantity of source waters, the effectiveness and reliability of treatment processes, the quality and capacity of storage and distribution systems quality control surveillance, and the qualifications and effectiveness of the operating personnel. Details regarding sanitary maintenance for public water supply systems and an evaluation of all aspects of such are covered in the "Manual for Evaluating Public Drinking Water Supplies."[17] Reference should also be made to the "Recommended Standards for Water Works"[30] (ten States' standards) which is used as a basis for design by the Great Lakes Basin States.

5.2.2 Relation of Public Water Supply to Water Resources Development

Planners of reservoir projects should consider the quality of available water as well as

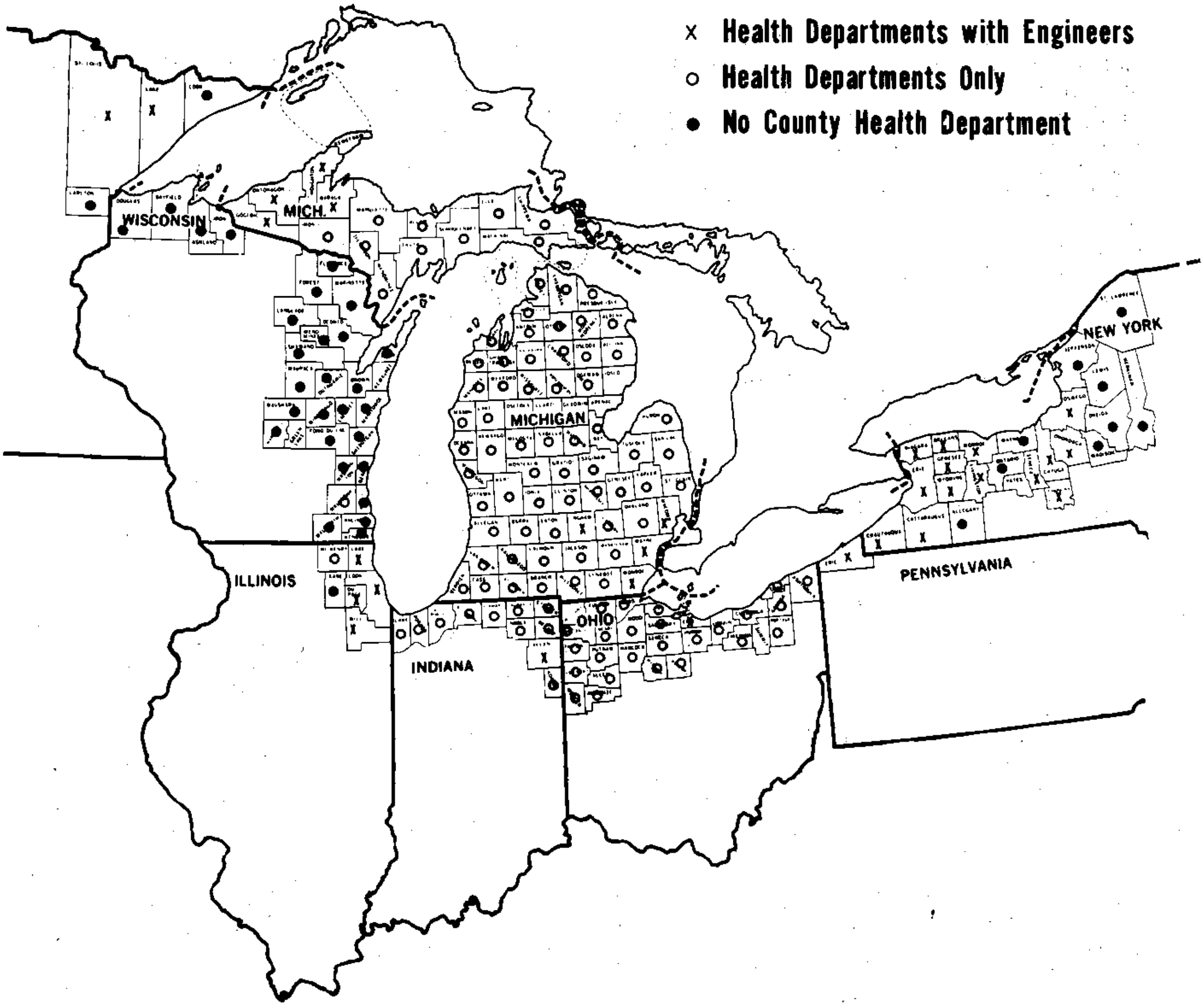


FIGURE 23–8 County Health Departments in the Great Lakes Basin

the quantity needed. They should also consider the effect of water resource developments on the quality of existing public water supplies.

Considerations of water quality should include a sanitary survey and analysis of future raw water quality and how it may be affected by planned water pollution control efforts.

The sanitary survey and analysis of the watershed should be performed by sanitary engineers or other public health specialists. It should include examination and evaluation of all existing and potential public health hazards and sources of contamination. Elements considered in the survey should include possible future residential, industrial, and recreational developments; plans for zoning controls; and proposed ownership of watershed land, expecially adjacent to the reservoir. The survey should also consider major sources of natural contamination, including animal wastes, drainage from swamps and bogs, and mineral deposits and silt from soil erosion. Major sources of man-made contamination that should be considered include wastes from industries, farms, municipalities, and individual homes.

Determination of raw water quality is often difficult because of lack of data on elements important to drinking water; variable conditions in the stream, which may cause temporary changes in quality; and uncertainty about the effects of impoundment on water quality. Sampling and analysis of a stream should include the bacterial, chemical, physical, and radiochemical measures that are important to drinking water quality. Water should be analyzed frequently, with sampling timed to give an accurate portrayal of the stream's water quality. Samples should be analyzed by methods described in *Standard Methods for the Examination of Water and Wastewater*,[36] or by other recognized techniques.

Water pollution and river basin authorities should be contacted about trends in contaminant levels and future forecasts. Such an analysis could indicate that current problems may be solved before stored water is planned for municipal use. The analysis could also indicate that new problems may occur.

5.2.3 Raw Water Quality and Treatment

The quality of source waters determines the treatment processes required to produce water that meets USPHS Drinking Water Standards.[27] To produce potable water high quality water will require minimal treatment, and low quality water will require extensive treatment. In the economic analysis of reservoir projects, planners should consider water treatment costs and evaluate alternate ways to provide municipal water supply. Municipal supply intakes should be constructed with multilevel inlets so that the best quality water can be taken into the system when stratification occurs. As an alternate method, provision should be made for mixing to prevent stratification.

Many public water supplies have properly isolated and installed well systems that are used with no treatment and serve the consumer with water of satisfactory quality at all times. Continuous chlorination of all water supplies serving the public is, however, a justifiable goal. The use of chlorination, however, does not relieve the utility of the necessity to provide for protection of the water source, to implement a satisfactory cross connection control program, and to use accepted public health practices regarding main repairs, extension, and other system changes. To reduce the impact of bacterial contamination that may be introduced into distribution systems by backflow or back siphonage and to prevent possible bacterial contamination of the source from reaching distribution systems, EPA recommends disinfection as the minimum treatment for all public water supplies.

The following guides for treatment are presented in two main categories, one for water requiring disinfection only, the other for water requiring conventional treatment. Some water requires an intermediate degree of treatment beyond disinfection, and some water requires an advanced degree of treatment beyond conventional treatment. Raw water quality standards for some Great Lakes Basin States differ from these guidelines (Appendix 7, *Water Quality*).

5.2.3.1 Disinfection Only

For ground water that contains only low levels of contamination, disinfection may be adequate. The raw water quality considered satisfactory for receiving disinfection only should meet the following requirements.

(1) Bacteriological

(a) The coliform group should be less than 100/100 ml as measured by a monthly arithmetic mean.

(b) If the fecal coliform density is measured, the total coliform density above may be exceeded, but the fecal coliform density should not exceed 20/100 ml as measured by a monthly arithmetic mean.

(2) Physical

Physical characteristics should meet Public Health Service Drinking Water Standards, including these limits:

Turbidity	5 units
Color	15 units
Threshold Odor Number	3 units

The proposed 1973 Drinking Water Standards would change the maximum turbidity level to one unit.

(3) Chemical

Chemicals present should not exceed the concentrations listed in Table 23–26.

(4) Radioactivity

(a) Radioactivity should not exceed the maximum levels established in the Public Health Service Drinking Water Standards. Radium-226 should not exceed 3 micro-microcuries per liter ($\mu\mu c/l$), Strontium-90 should not exceed 10 $\mu\mu c/l$. When these concentrations are exceeded, the water will still be acceptable if surveillance of total intakes of radioactivity from all sources indicates that such intakes are within the limits recommended by the Federal Radiation Council for control action.

(b) In the absence of Strontium-90 and alpha emitters, the gross beta concentrations should not exceed 1,000 $\mu\mu c/l$. When the concentrations are exceeded, the water will still be acceptable if more complete analyses indicate that concentrations of nuclides are not likely to cause exposures greater than the Radiation Protection Guides as approved by the President on recommendation of the Federal Radiation Council.

(5) Pesticides

Pesticides should not exceed the maximum concentrations presented in Table 23–27.

Normally disinfection can be accomplished by chlorination with a minimum residual in distant parts of the distribution system equaling 0.1 to 0.2 milligrams per liter for free chlorine or 1.0 milligram per liter for cloramines. The manual "Evaluating Public Drinking Water Supplies"[17] gives details about chlorination and other types of disinfection treatment.

TABLE 23–26 Allowable Concentrations of Chemicals in Drinking Water

Substance	Concentration (mg/l) 1962 DWS[a]	Proposed 1973 DWS[b]
Arsenic	0.01	0.1
Barium	1	no change
Cadmium	0.010	no change
Carbon-Alcohol Extract	not included	3.0
Carbon-Chloroform Extract	0.2	0.7
Chloride	250	no change
Chromium	0.05	no change
Copper	1	no change
Cyanide	0.01	0.2
Detergents	0.5	deleted
Foaming Agents	not included	0.5
Fluoride		
Annual Average of Maximum Daily Air Temperature (°F)[c]		
50.0 to 53.7	1.7	---
53.8 to 58.3	1.5	---
58.4 to 63.8	1.3	---
63.9 to 70.6	1.2	---
70.7 to 79.2	1.0	---
79.3 to 90.5	0.8	---
65 or lower	---	1.5
66 to 79	---	1.3
80 or higher	---	1.2
Iron	0.3	no change
Lead	0.05	no change
Manganese	0.05	no change
Mercury	not included	0.002
Nitrate	10	no change
Phenols	0.001	deleted
Selenium	0.01	no change
Silver	0.05	no change
Sulfate	250	no change
Total Dissolved Solids	500	deleted
Zinc	5	no change

[a]1962 U.S. Public Health Service Drinking Water Standards.

[b]Proposed 1973 U.S. Environmental Protection Agency Drinking Water Standards.

[c]Temperature categories for allowable fluoride concentrations are different for 1962 and Proposed 1973 Drinking Water Standards.

5.2.3.2 Intermediate Treatment

Many surface waters are pure enough to meet the recommended guide limits for disinfection only. Such waters are derived from grassy, wooded terrain with little swampland or land that is exposed or under cultivation. High quality raw water can usually be obtained when storage provided in reservoirs is adequate and strict control of contamination is practiced on the catchment and storage areas.

However, water quality in all surface waters may temporarily deteriorate through increased levels of turbidity, algal growths, and miscellaneous contaminants. Such contaminants hinder the effectiveness of disinfection treatment and may reduce the aesthetic properties of drinking water. All surface waters, therefore, should receive treatment more extensive than disinfection only.

TABLE 23–27 Allowable Concentrations of Pesticides in Drinking Water

Pesticide	Maximum Acceptable Concentration (mg/l)
Aldrin	0.001
Chlordane	0.003
DDT	0.05
Dieldrin	0.001
Endrin	0.0005
Heptachlor Epoxide	0.0001
Lindane	0.005
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.02
2,4,5-TP or Silvex	0.03
Total Organophosphorous and Carbamate Compounds[a]	0.1

[a]Expressed in terms of parathion equivalent cholinesterase inhibition

Source: December 1973 Proposed Drinking Water Standards, Environmental Protection Agency

Where surface waters meet or almost meet the recommended guide limits for disinfection only, they should also receive some intermediate treatment such as flocculation, sedimentation or filtration, or some combinations of these treatments.

Some ground waters contain chemicals or other substances that can be removed by less than conventional treatment. These waters should receive an intermediate degree of treatment. In any case, the objective of water treatment is to provide a continuously adequate quantity of safe water, which meets

Public Health Service Drinking Water Standards.

5.2.3.3 Conventional Treatment

Waters that are too contaminated for intermediate treatment require conventional treatment, which includes predisinfection, coagulation, sedimentation, rapid granular filtration, and postdisinfection.

Although conventional treatment is provided, every effort should be made to prevent and control contamination of the raw water source. If recreational use is permitted on a reservoir, sanitary controls should be provided, and recreation should be prohibited in a restricted area surrounding the water supply intake.

Water treatment plant design varies with local condition; the design should be based on quality problems in the water to be treated.

In addition to the applicable State water quality standards, the raw water quality considered satisfactory for conventional treatment should meet the following standards.

(1) Bacteriological

Total coliform density should be less than 20,000/ml as measured by a monthly geometric mean. If the fecal coliform density is measured, the total coliform density may be exceeded but fecal coliform should not exceed 4,000/100 ml as measured by a monthly geometric mean.

(2) Physical

Elements of color, odor, and turbidity contribute significantly to the treatability and potability of water.

(a) Color should not exceed 75 units. This limit applies only to nonindustrial sources. Industrial concentrations of color should be handled on a case-by-case basis and should not exceed levels that are treatable by conventional means.

(b) The threshold odor number should not exceed 5.

(c) The maximum turbidity level is variable. The nature, size, and electrical charge of different particles causing turbidity require a variable limit. Turbidity should remain within a range that can be easily treated by complete means. It should not overload the water treatment works, and it should not change rapidly either in nature or in concentration where such rapid shift would upset normal treatment operations.

(3) Chemical

Because conventional treatment generally produces little reduction in chemical constituents, raw water should meet the limits given for disinfection only.

(4) Radioactivity

Radioactivity should meet the requirements shown for disinfection only.

(5) Pesticides

Pesticides should meet the requirements shown for disinfection only.

5.2.3.4 Advanced Treatment

Water of poorer quality (but not sewage) should receive advanced treatment as determined by an engineer or consultant. Advanced treatment should be used only if no raw water supply of better quality is available. The treated water should continuously meet limits of the Public Health Service Drinking Water Standards unless an exception, related to potability and aesthetic properties, is approved by the State agency responsible for public water supply systems. Additional measurements for constituents not covered in the Public Health Service Drinking Water Standards may be necessary under these circumstances.[14]

5.3 Irrigation with Sewage Treatment Plant Effluent

5.3.1 General

Municipal sewage treatment effluents have long been used for irrigation, although not in the Great Lakes Basin. In the United States sewage farming began in the late 19th century in Wyoming, Colorado, California, Utah, and Montana. At present extensive sewage farming is done in the arid western States. Because little water is available, the bacteriological quality of the water supply receives little attention. In water-short areas, available streams frequently receive sewage discharges from small communities, drainage from cattle feed lots, runoff from infrequent storms, and return irrigation water. Because the streams are often small, these polluted discharges quickly exceed the normal self-purification capacity of most streams. This extends the zone of potential health hazard downstream to other water users, generally farmers who use irrigation water. To prevent disease transmission, the use of raw, settled, or undisinfected sewage has been prohibited on vegetables grown for direct human consumption in most States. In Michigan, a major irrigation project has been established at Muskegon using effluent that has received tertiary treatment.

5.3.2 Sewage Irrigation and Disease

Experience with unrestricted sewage irrigation has demonstrated that disease outbreaks and worm infestations can be caused by contaminated vegetables and fruits. Today health department restrictions, low levels of population infection, and curative medicine have practically eliminated disease and worm infections in the United States from food contaminated by irrigation practices. This does not mean, however, that no threat exists from this source. Irrigation will play an important role in providing the higher food production necessary for an expanding population. As more acreage is developed for irrigation, the demand for water will increase, but the quality of water available will often be poor because of greater reuse.

It is well established that disease-causing bacteria, viruses, protozoa, worms, and fungi are found in fecal material, sewage, and sewage polluted water. Consequently, these substances may contaminate the soil and crops that they contact. Animal as well as human wastes are implicated because many species of pathogens infect both men and animals. Eating uncooked foods contaminated with fecal material may spread disease in livestock as well as human beings. Microorganisms known to be pathogenic for plants can also be isolated from polluted irrigation water, but the role that water and sewage play in plant disease transmission is not yet completely understood.

The diseases most frequently linked with fecal contamination are typhoid and paratyphoid fevers, salmonella gastroenteritis, bacillary dysentery, cholera, leptospirosis, infectious hepatitis, viral gastroenteritis, and amoebic dysentery. Typhoid fever, cholera, and amoebic dysentery are now practically nonexistent in the United States because of effective sanitation of water treatment practices. Less common diseases associated with irrigation agriculture are brucellosis, tuberculosis, tularemia, swine erysipelas, coccidiosis, ascariasis, cysticercosis, fascioliasis, schistosomiasis, and hookworm and tapeworm infections. Although the route of infection is usually by ingestion, larvae of hookworms and flukes can enter the body directly through the skin.

5.3.3 Public Health Policy

The only reliable way to prevent public exposure to contaminated produce is to prevent such contamination from occuring. This has been achieved in the past by health department regulations prohibiting the use of night soil (human excrement) and municipal sewage to irrigate produce. Improvements in sewage treatment practice and the wide-scale use of secondary and tertiary treatment have prompted efforts to obtain approval of the use of treated waters for unlimited irrigation. Health authorities are generally reluctant to approve this practice because of the hazards associated with the water sources, the unknow factors of pathogen survival, and the inconsistency associated with many treatment plant operations. The conservative approach adopted in these guidelines will generally assure safe use of irrigation water.

Selection of agricultural irrigation water sources should be based not only on the availability of the water supply, but also on the bacteriological and chemical quality of the water. The scarcity of water supplies of acceptable quality in irrigation areas is fully recognized. Unfortunately, surface waters in arid and semiarid regions are often small streams with disproportionately large pollution loads from domestic wastes, sugar beet lagoon discharges, feedlot drainage, and irrigation returns. These pollution sources transmit varying numbers of pathogenic organisms to irrigation waters, which ultimately come into contact with field crops. Reduction of the public health hazard can be accomplished only through multiple safeguards designed to prevent raw plant food from contact with pathogens.

The National Technical Advisory Committee on Water Quality Criteria has established bacterial quality guidelines for irrigation water at 1,000 fecal coliforms per 100 ml. Enforcement of these guidelines should result in reduced exposure of raw plant foods to pathogens. Data correlating fecal coliform levels to salmonella occurrence indicate that the proposed standard is realistic if the safeguard measures and sanitary practices described are observed, and if water of the specified quality is used. The standard represents the best scientific information presently available. The fecal coliform limits for irrigation water may be modified after additional microbiological and epidemiological studies have been made. The primary objective of irrigation water standards is the protection of public health, but these standards may also be based on the importance of multiple use in water-short areas and the specific uses for which the water is needed. The fecal coliform level suggested is attainable only at the cost of adequate waste treatment by all stream users.

In special cases when environmental conditions are favorable to pathogens, and time of exposure to hostile conditions is short, the local or State health department should make an appropriate determination of the water quality to be used for irrigation. Because receiving streams may be small and of lesser volume than the sewage effluent, secondary treatment and disinfection of domestic sewage are necessary to ensure substantial reductions of pathogens in irrigation waters. Wastes from food processing plants, meat packing plants, and sugar beet mills, and runoff from cattle feedlots should be diverted to lagoons and held for 20 to 30 days to reduce the number of pathogens before discharge.

The method of water application influences the amount of fecal contamination to which farm crops are exposed. Flooding, spraying, subirrigation, and furrow irrigation are used in various agricultural areas. To limit the contact of disease-causing microorganisms on plant surfaces of crops that may be eaten raw, waters that are not of potable quality should be applied by furrow or subirrigation methods. Primary effluent should not be used for spray irrigation.

As a further safeguard against pathogens on raw plant foods, farm management of irrigation water should include a program of selective application based on the bacterial quality of available water. Irrigation water from nearby sources may be applied during the various stages of cultivation, but application should be discontinued four weeks prior to harvest to diminish the risk from water-borne pathogens. Water applied after this period should be derived from ground-water supplies or farm holding ponds.

5.3.4 Ground-Water Protection

Ground water is a valuable resource that must be protected from contamination. The continual availability of high quality ground water is required for the safe operation of many public and private water supply systems. Proposals for irrigation projects using waste disposal effluents must be carefully reviewed to assure that aquifers used for water supply will not be harmed. Several factors must be determined during preliminary development of such proposals. These factors include the location of all ground-water users that may be affected; the physical characteristics of the wells used to obtain ground water; the geology, hydrology, and soil classification of the area; and the current ground-water quality. In States that permit sewage effluent irrigation projects, the minimum data required for consideration of such a project should be specified by the State health department or environmental control agency. Where such projects are permitted, monitoring wells should be spaced around the irrigation site, especially in the direction of normal ground-water flow and between the site and wells used for water supply. Pollutants or parameters indicative of the contaminants introduced into the aquifer should be monitored at depths and frequencies indicated by the specific situation, including location of the site and ground-water users, use of the site, and ground-water withdrawal factors. Interception of ground-water flow may be required to protect ground-water users from any possible adverse effects. Any ground-water source used for drinking water should be replaced with an adequately protected, treated source, as soon as contamination is evident.

5.3.5 Guidelines for the Use of Sewage Effluents for Irrigation

The practice of irrigating agricultural crops with sewage effluents raises a number of health questions concerning the bacterial quality of the water used and necessary vector control activities. The factors relating to mosquitoes and other vector problems are primarily those of hydraulics and drainage. These are discussed in Subsection 5.5, Vector Control. Recommended water quality criteria for polluted stream waters used for irrigation are presented in the Report of the Committee on Water Quality[42] published by the U.S. Department of the Interior.

The guidelines presented below are considered the minimum for the direct use of sewage or treated sewage for irrigation. Local and State recommendations and requirements regarding this use should be followed if they are more stringent than these guidelines.

5.3.5.1 Irrigation with Raw Sewage

Raw sewage should not be used for irrigation.

5.3.5.2 Irrigation with Effluent

Sewage used for irrigation should be treated either by being held in a series of stabilization ponds with a minimum detention period of 20 days and a recommended detention time of 30 days, or by a minimum of secondary sewage treatment and disinfection. After treatment the effluent should meet the requirements established by the State or other agency with jurisdiction for water pollution control. In no case should fecal coliforms exceed 1,000 per 100 ml.

5.3.5.3 Necessary Precautions Before Irrigation

Before effluents are used for irrigation, the following precautions should be taken.

(1) The areas to be irrigated should be clearly designated with signs in clear and visible letter warning that sewage effluent irrigation is being carried out.

(2) The pipe network for effluent irrigation should be completely disconnected from potable water supply networks.

(3) All necessary steps should be taken to prevent the breeding of mosquitoes and flies in the area to be irrigated.

(4) All necessary steps should be taken to prevent the spread of odors to residential areas, recreation areas, and other populated areas.

(5) Spray irrigation with effluent should not occur within 200 yards of residential areas and 50 yards of roads.

(6) Ridge and furrow irrigation with effluent should not occur within 100 yards of residential areas and 25 yards of roads.

5.3.5.4 Crop Limitations for Irrigation with Effluent

Irrigation with sewage effluent should not be used for crops that may be consumed raw, or for pasture lands. Sewage effluent irrigation may be used for crops that are normally cooked before being consumed, crops with peels or husks that are normally not eaten, crops grown for industrial use and fodder, and nursery plants.

5.3.5.5 Irrigation of Lawns with Effluent

Effluent should be used to irrigate lawns only if the lawns are closed to the public from the time the effluent is applied until after the lawns have dried.

5.4 Recreation Area Development

5.4.1 General

This subsection summarizes factors of concern to health authorities in the development of recreation areas. Winter activities are not considered. The guideline is directed primarily to land-based water-oriented activities, including swimming, picnicking, camping, nature study, hiking, and sightseeing. Material in Public Health Service Publication No. 1195, "Environmental Health Practice in Recreational Areas,"[9] was used in the preparation of this subsection. This publication should be consulted for additional details.

In many cases the planning, provision, and maintenance of facilities in recreation areas have not kept pace with the rapidly increasing visitor load. As a result, optimum use of such areas is not possible and deterioration of overtaxed facilities frequently occurs. Where water supply, sewage disposal, and refuse handling facilities are inadequate or lacking, the visitors fend for themselves. This often creates conditions that are aesthetically offensive and present serious environmental health hazards to the visitors and neighboring community residents. Recreation day requirements in the Great Lakes Basin are expected to increase by a factor of 2.1 by the year 2000. Recreation day requirements in the Basin today exceed the recreation day supply for land-based water-oriented activities by a factor of 1.8. In addition, the supply is not always located in close proximity to the requirement. Thus, some planning subareas may have a surplus of supply while others have unmet requirements. According to estimates, adequate measures to safeguard the environment and public health comprise 30 percent of development costs for new recreation areas. Because these measures represent a large investment, adequate facilities should be carefully planned, constructed, and maintained.

Active cooperation between health and recreation agencies will assure adequate planning for good public health facilities. Qualified public health engineers should review the planning and development of recreation facilities, including site selection. Recreation and public health authorities should establish a program of periodic inspections of recreation facilities and their operation. It is recognized that remote areas and low-density-use areas are often served by primitive sanitary facilities. The guidelines specified in this section are considered to be minimum criteria. Criteria and standards established by State and local health and environmental protection agencies may be more stringent and should be followed in their areas of jurisdiction.

5.4.2 Site Selection

Sites selected for recreational areas should be well drained, gently sloping, free from topographical or geological hindrances, and suitable for the development of a safe and adequate drinking water supply and sewage disposal works.

Sites should also be free from heavy traffic and sources of air pollution and noise. An entomological survey of the area should be made. Avoiding locations near swamps and marshes where mosquitoes and other insects breed will enhance the public's enjoyment of the area. Safe entrances and exists should be planned, and roadways within the area should be surfaced and looped. Undergrowth should be controlled in developed places. The area should not be subject to high wind conditions, and sanitary facilities should be located in areas not subject to flooding.

5.4.3 Watershed Management

Watershed management involves the supervision, regulation, maintenance, and wise use of the total resources of a drainage basin. The goal of these activities should be to provide an optimum yield of high quality water and to control erosion, pollution, and floods. The condition of the soil and the growth it supports have a marked influence on the quality and quantity of water in a watershed. For this reason the use of various soil conservation control measures and management practices is essential to conserve water and land resources and to prevent economic losses to municipal, industrial, and agricultural water supplies, fisheries, and recreation.

It is essential that satisfactory watershed conditions are not damaged by activities carried out on watershed lands. These activities include livestock and game grazing, logging, road and building construction, fire control, sewage disposal, and recreation. Erosion control should be practiced both during and after road and building construction. The disposal of liquid and solid wastes from domestic and industrial sources should be carefully controlled in and near recreation areas and watercourses. Logging, mining, and ore-processing operations also should be carefully controlled. Overgrazing by livestock and game should be prevented. Before pesticides and other chemicals are used, their toxicity, persistence, and exposure factors should be considered. Uncontrolled camping in areas without basic facilities should be prohibited.

5.4.4 Water Supply

An adequate supply of water under pressure that meets the source protection, bacterial, chemical, physical, and radiological requirements of the Public Health Service Drinking Water Standards[27] is essential for the comfort and health of visitors and resident staff members at outdoor recreation areas.

Several factors should be considered:

(1) Where feasible, a State approved public water supply system should be extended to the recreation area.

(2) The quality and quantity of water supplies available should be determined.

(3) The degree of treatment necessary to provide water meeting USPHS Drinking Water Standards should be determined.

(4) Appropriate steps should be taken to prevent chance contamination and provide disinfection.

(5) A sanitary survey should be completed by a qualified person as part of the collection of initial engineering data on the development of the water supply source and its capacity.

(6) The proposed water facilities should be constructed and supervised to minimize vandalism.

(7) The water treatment equipment should be supervised, operated, and maintained by qualified personnel.

(8) Water quality should be protected by

the design, construction, and maintenance of the distribution system. Sampling should be adequate to monitor quality.

(9) The system should be designed to permit emergency operations.

5.4.5 Sewage Disposal

Safe disposal of human and domestic wastes in recreation areas is necessary to preserve surface and ground waters and to restore these waters to the best possible condition consistent with public health and welfare. Proper sewage disposal prevents damage to the propagation and preservation of fish and wildlife, and it protects the visiting public, employees, and nearby communities from diseases transmitted through sewage.

Several important health-related factors should be considered in the design of sewage disposal systems for recreation areas.

(1) Water-carried sewage disposal systems should be properly designed, constructed, and supervised. Pit toilets are a poor second choice and should only be used for remote and lightly used recreation areas.

(2) Outfalls should be located to minimize the potential adverse effects of sewage effluents.

(3) Septic tank and subsurface disposal systems should not be located near buildings, beaches, camping and picnic areas, and water supply systems.

(4) Sludge disposal should be properly planned.

(5) Plans for the installation of sewage disposal facilities should provide for adequate operation and maintenance.

5.4.6 Plumbing

Plumbing includes the labor, materials, and fixtures used in the installation, maintenance, extension, and alteration of all piping, fixtures, appliances, and appurtenances in connection with a number of facilities. These include sanitary drainage or storm drainage facilities, venting systems, and the public or private water supply systems within or adjacent to any building, structure, or conveyance. Plumbing also includes the labor and materials used to install, maintain, extend or alter systems used to carry storm water, liquid waste, sewage and water supply from any premises to their connection with the public sewer system (or public water system) or other acceptable disposal facility.[22]

Two important factors should be considered when plumbing facilities are planned:

(1) The minimum number of plumbing fixtures should be based on peak visitor day use (Table 23–28).

(2) Material used and installation methods should conform to the minimum standards of the National Plumbing Code[22] (as revised) or to local and State codes if they are more restrictive.

5.4.7 Building and Housing Hygiene

Housing must fulfill the physiological needs of man. These needs include a thermal environment that is comfortable and promotes efficiency of living; air that is chemically pure and free from objectionable odors; humidity that is healthful and comfortable; and air movement that provides air changes that help maintain the desired thermal conditions and air purity. Housing should be free of noise that may impair health. Lighting, including both natural and articificial sources, should be adequate in quality and quantity. All buildings and dwelling units should be constructed and maintained in accordance with the minimum requirements set forth in the "Recommended Housing Maintenance and Occupancy Ordinance,"[2] prepared by the American Public Health Association and the U.S. Public Health Service, or requirements that are substantially equivalent. The "Basic Principles of Housing and Its Environment"[4] is another good reference in the field of housing. Those concerned with the design, operation, and maintenance of public buildings should consult these references for more complete coverage of this subject. Plans and specifications covering housing, dormitories, camps, hotels, restaurants, and similar facilities should be submitted to authorities with jurisdiction for review and recommendations.

A number of features should be included in adequate housing:

(1) Adequate openable window areas should be provided for all habitable rooms.

(2) Where electric service is available, a sufficient number of outlets should be provided.

(3) Heating facilities should be adequate and safe.

(4) Doors and openable windows should have screens during seasons when they are

TABLE 23–28 Sanitary Facilities for Recreation Areas

Facility	Waterclosets Male	Waterclosets Female	Urinals	Lavatories	Showers
Swimming Pools[a] (Based on maximum load of bathers)	1/75	1/50	1/75 males	1/100 males 1/100 females	1/50 males 1/50 females (minimum of 2)
Campgrounds[b]					
Sites					
1–20	1	2	1	2	---
21–30	2	3	2	4	---
Picnic Areas					
Parking Spaces					
1–40	1	2	1	2	---
41–80	2	4	2	4	---
81–120	3	6	3	6	---

[a] One drinking fountain, not installed in toilet room, should be provided.

[b] Each comfort station should be designed to provide service for sites no further than 500 feet away.

Source: National Park Service Building Construction Handbook (Reference 21)

Note: These numbers vary from State to State. Information on requirements for a specific location is available from the appropriate State agency, usually the State department of health. More information is also available from the National Park Service.

necessary to protect against mosquitoes, flies, and other insects. Buildings should be protected against rodent entry.

(6) Water closet compartments and bathroom floor surfaces should be constructed of material impervious to water.

(7) Adequate fly-tight refuse containers should be provided at convenient locations, with provision for frequent pick-up and conveyance of refuse in a closed, water-tight truck to approved sanitary landfills or incinerators.

5.4.8 Milk and Food Sanitation

Despite the progress that has been achieved in food protection programs, food-borne illness continues to be a major public health problem. The incidence of such illness can be reduced by the application of the basic principles of food protection. To achieve this on a day-to-day basis, however, many food service employees and employers must develop a better understanding of these principles. This in turn will require maximum cooperation between public health agencies and the food service industry. The need for even greater attention to this problem in recreation areas is due to the seasonal operation of many areas and widely fluctuating visitor load that must be accommodated by the food service facilities. Additional hazards are caused by seasonal employees who lack adequate training in good food-handling practices. The applicable State and local milk sanitation laws and regulations and the Public Health Service "Grade 'A' Pasteurized Milk Ordinance"[13] should be followed for the dispensing of milk and milk products. The "Food Service Sanitation Manual,"[12] including "A Model Food Service Sanitation Ordinance and Code, 1962 Recommendations of the Public Health Service," is a basic reference in the field of food sanitation. Where ice is produced for public use the "Sanitary Standard for Manufactured Ice"[32] should be applied. Another basic reference is "The Vending of Foods and Beverages,"[39] a sanitation ordinance and code recommended by the Public Health Service. Before construction of a food service establishment is initiated, properly prepared plans and specifications should be submitted for approval to the appropriate health authority. These plans should include layout, arrangement, and construction materials, and the location, size, and type of fixed equipment and facilities.

5.4.9 Solid Waste Disposal

Public health problems in recreation areas are often created by improper storage, collection, and disposal of solid waste. Experience has shown that application of the basic principles of sanitation to solid waste handling results in substantial reductions in rodent, fly, and other insect problems.[65] Inadequate handling and disposal of solid wastes may also result in the increased incidence of certain diseases in humans and animals (see references 1 and 34). Many hazards and nuisances, such as fire, smoke, odors, and unsightliness, are also created by poor solid waste handling practices. The disorder of accumulated solid waste often diminishes the public's appreciation of recreation areas.

To prevent this from happening and to assure health protection, waste disposal handling should be properly planned. Solid wastes should be collected in containers that are durable, rust-resistent, nonabsorbent, easily washable, and covered. To prevent unsightliness and fly and rodent problems, an adequate number of containers should be provided, and waste collection should be frequent. Trash and garbage can be disposed of by sanitary landfill, incineration, or garbage grinding and disposal to a sewage system. Except for campfires, open burning should be prohibited.

5.4.10 Compatibility of Recreation and Public Drinking Water Supply

The competition among multiple uses of our land and water resources demands assessment of the compatibility of uses such as recreation and domestic water supply (see references 31, 49 and 56). Where multiple use calls for both water supply and recreation, the following factors should be considered:

(1) The present physical, chemical, and bacterial quality of the water resource should be evaluated.

(2) A comparison should be made between the probable degree of water contamination resulting from recreational use and other uses such as mining, logging, road building, and right-of-way maintenance. The resulting water quality should meet health guidelines and the applicable State or Federal standards for recreational and water supply use.

(3) A determination should be made of the degree of toxic contamination and deterioration of water quality caused by wasted oils, motor fuels, pesticides, and other chemicals used to maintain and operate recreation facilities and equipment.

(4) Algal growths that cause taste, odor, and color should be controlled.

(5) A determination should be made of the degree of water treatment required to handle the anticipated pollution loads to produce water meeting the USPHS Drinking Water Standards.

(6) Provision of multiple-elevation withdrawal points in the water supply intake should be considered to allow planned withdrawal of the highest quality water under varying conditions in the reservoir.

(7) An area where recreation is prohibited around the water supply intake should be designated to prevent vandalism and provide holding time for the recreation water before it is used for public drinking water supply.

(8) This restricted area should be completely cleared of vegetation, buildings, manure deposits, swamp debris, and other sources of contaminants.

(9) Water quality should be monitored regularly.

These factors are normally considered in any drinking water supply development project. They are included here to remind planners that they should not be overlooked in multiple-use projects.

5.4.11 Body-Contact Recreation Water Quality

Biological, chemical, and physical water quality guidelines for body-contact recreation are outlined below.[42] Where questions arise about the health aspects of water quality, local and State health or environmental control authorities should be consulted. Reference should also be made to State water quality standards and the water pollution control authorities responsible for the administration of such standards. A complete sanitary survey and continuous surveillance of possible hazards should be made. This should include a review of epidemiological data and appropriate safety considerations.

Final judgment on the acceptability of the use of any water classified under these guidelines should also include consideration of the significance of these findings.

5.4.11.1 Biological

The fecal coliform density should not exceed an arithmetic mean of 200/100 ml, with a sampling frequency of five samples per 30-day period taken during peak recreational use. Not more than 10 percent of the samples' fecal coliform densities during any 30-day period should exceed 400/100 ml.

5.4.11.2 Chemical

The water should contain no chemical that could cause toxic reaction if ingested, or irritation to the skin or eyes upon contact. The pH should be within the range of 6.5 to 8.3.

5.4.11.3 Physical

Water color should not exceed 15 standard units, and turbidity should not exceed 30 standard units.

5.4.12 Swimming Pools and Outdoor Bathing Places

Public health authorities have been concerned with sanitation and safety problems involving swimming and bathing for many years. Although accidents and drownings are the most dramatic safety hazards of swimming, transmission of communicable disease is also an important problem.

The following factors should be considered:

(1) Swimming pools should be designed, constructed, and operated in accordance with requirements of the responsible health authority, or in accordance with the standards outlined in the "Suggested Ordinance and Regulations Covering Public Swimming Pools"[37] and "Environmental Health Practice in Recreation Areas."[9]

(2) The water supply system proposed to serve as a potable water source for the pool area should be acceptable to health authorities.

(3) The swimming pool water should be discharged through an air gap to the wastewater receiver. The swimming pool should also be recharged through an air gap.

(4) The swimming pool should be properly designed for use loading.

(5) Pool water should be continuously disinfected where possible.

(6) Bacterial samples taken from swimming pools and bathing places should be routinely examined.

(7) Decisions to permit use of natural bathing areas should be based on the results of chemical analyses, bacterial examinations, and a sanitary survey of the proposed natural bathing areas. Such surveys should include examination of slope and currents present.

(8) Possible gross animal pollution should be eliminated in the bathing area.

(9) Effects of peak visitor days on water quality and recreational use should be evaluated.

5.4.13 Bathing Load for Outdoor Pools and Beaches Without Disinfection

In swimming pool water derived from a public supply or other supply of drinking water quality, the presence of organisms of the coli-aerogenes group is considered an indication of pollution by fecal matter. The presence of such bacteria in natural bathing places, however, may be an indication of generally harmless soil bacteria. The portion of the total coliforms that are of fecal origin varies radically in surface waters. Routine bacterial tests can detect the degree of the more hazardous fecal contamination through determinations of fecal coliform density. Fecal contamination in beach waters may be caused by sewage from boats, individual dwellings, hotels, factories or other establishments, public sewerage systems, refuse dumping, warm-blooded animals, and bathers themselves.

Where cleansing and dilution of beach water depends on stream flow or lake circulation, the amount of water flowing past the beach during the time of its use should be determined. Unless disinfection is provided, any small stagnant pool used by a number of bathers is certain to show bacterial pollution in considerable amounts. While no specific amount of diluting water for outdoor beaches can be set on a scientific basis, a figure of 500 gallons per bather per day has been used in the past. The American Public Health Association publication, "Recommended Practice for Design, Equipment and Operation of Swimming Pools and Other Public Bathing Places,"[29] states "the total number of bathers using a fill and draw swimming pool shall not exceed one person for each 500 gallons of water in the pool between complete changes of pool water without disinfection."

The Becker formula has been used in New York State[29] as a practical guide to determine necessary volumes of diluting water for outdoor beaches. This formula is $Q = 6.25T^2$ where Q equals the quantity of water per bather in gallons, and T equals the replacement time in hours. For example, if the water circulation is such that the beach volume will be replaced in eight hours, then Q will be 400 gallons per bather. The number of bathers permitted in eight hours will be the total volume of the swimming area divided by 400.

Whether or not disinfection is used, all sources of sewage pollution should be eliminated on small streams or lakes used for bathing. Careful sanitary surveys of the watershed are also recommended. Bathing should be limited to clear bodies of water, and muddy bottoms, which will cause turbid water, should be avoided.

5.4.14 Recreation Vehicle Parking Areas

The great increase in the number of recreation vehicles on the highways during vacation months reflects the increasing amount of leisure time and extra spending power being enjoyed by more people each year. It also points out the continuing need to expand recreation vehicle parking areas and related facilities that meet standards of health and safety.

The following factors should be considered:

(1) Parking facilities should be designed for both self-contained and non-self-contained recreation vehicles.

(2) A sanitary station for the disposal of holding tank wastes should be provided. The design for such a station is given in the publication "Environmental Health Practice in Recreation Areas."[9]

(3) Recreation vehicle parking areas should be designed for either overnight or destination use.

(4) Each parking site should contain an adequate water supply and satisfactory means for sewage disposal.

(5) Approach roads for trailer traffic should be well-designed.

(6) The spacing of recreation vehicles should conform to the minimum 15-foot separation specified by the National Fire Protection Association.

(7) A minimum 60-foot separation should exist between the recreation water tank filling station and the sanitary station.

(8) Special provisions should be made for the disposal of sink wastes.

(9) Detailed plans should be developed for solid waste storage, collection, and disposal.

(10) Service buildings should be convenient and adequate for their anticipated use.

(11) Electrical service should be provided by underground cable.

(12) Detailed plans and specifications for recreation vehicle parking areas should be submitted to the health authority having jurisdiction for review and approval.

5.4.15 Boating

The boating industry reported that in 1962 more than eight million pleasure boats were being used for recreation in U.S. waters, and that recreational boating is increasing. More and more pleasure boats are being equipped with gallies and toilets, and as a result, increasing amounts of sewage, galley wastes, and other debris are being discharged into watercourses. These increasing wastes threaten to damage the water quality necessary for swimming, fishing, and other aquatic sports. A number of Great Lakes States have recognized this threat and have prohibited such discharges. Holding tanks on board such vessels are most often used to store discharges until properly disposed. The dredging of boat basins and the construction of small craft harbors, marinas, boat launching ramps, and docking floats are projects being planned for recreation areas. Such new developments attract and serve boating enthusiasts, and may create water pollution and related health problems. For this reason it is important that these developments be planned to avoid environmental health hazards.

The following factors should be considered:

(1) The planning and design of marinas should include adequate separate facilities for collection and disposal of sewage, waste oils and fuel, and solid wastes accumulated on boats.

(2) Permanent toilet facilities for both sexes should be provided.

(3) A water-carried sewage disposal system with adequate treatment should be provided.

(4) Wastes from floating facilities should be disposed of on land.

(5) Measures should be taken to eliminate

waste and spillage during the storage and dispensing of gasoline from floating facilities.

(6) The construction of boats with marine toilets and their use should be regulated.

(7) A good solid waste disposal method should be included in the design.

(8) Restricted areas around water supply intakes should be established.

(9) Boats should meet safety requirements recommended by the U.S. Coast Guard, and regulations should be established to control health and accident hazards associated with boating.

(10) Boating and swimming facilities should be completely separated.

(11) Adequate parking facilities should be provided for automobiles and trailers.

5.4.16 Fish Cleaning Facilities

Many visitors enjoy fishing while visiting recreation areas, especially in waters where natural reproduction or stocking occur. Where fishing is productive, the installation of fish cleaning facilities near boat docking and launching areas should be considered. These facilities are essential to control nuisances, odor, and pollution caused by the indiscriminate cleaning of fish and disposal of the resulting wastes in lakes and reservoirs and along shorelines.

In planning these facilities, the following factors should be considered:

(1) The facility should be screened or fully enclosed.

(2) Tables with impervious, nonabsorbent surfaces sloping to central drains or adequately maintained wood tables should be provided.

(3) The facilities should include potable water under pressure, adequately protected against back-flow.

(4) Collected wastes should be adequately disposed and facilities should be maintained in a clean condition.

5.4.17 Insect and Rodent Control

Several groups of arthropods and rodents may create serious public health and nuisance problems in recreation areas. These include species that are vectors of human disease organisms, serve as reservoirs of these organisms, or otherwise interfere with man's health, welfare, and comfort. A number of aquatic insects may be encountered at recreation areas located along the shore of impoundments. Mosquitoes are undoubtedly the most important of these insects. Several species serve as vectors of encephalitis and malaria, and others create public health problems resulting from their vicious biting habits.[54] Other groups of aquatic insects such as deer flies, horseflies, black flies, and biting midges are vicious biters of man and sometimes are involved in transmission of disease. People who visit recreation areas are often exposed to terrestrial arthropods as well. These include ticks, mites, fleas, and flies. Rodents that may transmit disease include ground squirrels, rats, and mice (see references 7 and 15). These arthropods and rodents may cause a number of human diseases including Rocky Mountain spotted fever, Colorado tick fever, tularemia, relapsing fever, tick paralysis, typhus, bubonic plague, bacillary dysentery and typhoid fever. Irritation, discomfort, and annoyance caused by arthropod bites can seriously reduce the use of an otherwise attractive recreation area. It is most important that measures be taken to eliminate or reduce such insect populations. State health agencies should provide preconstruction surveys and technical assistance in preparing control programs.

Control programs should be based on the following principles:

(1) Mosquito production sites should be delineated.

(2) Mosquito control practices should be used in the reservoir basin prior to impoundage.

(3) Natural and source reduction measures should be used to limit mosquito production.

(4) Maintenance practices should be planned to control arthropod production within flight range of recreational and inhabited areas.

State and Federal health agencies will also provide technical information about methods to control terrestrial arthropods and rodents, and about hazards to humans and animals posed by proposed chemical control measures against insects and rodents.

5.4.18 Campgrounds, Playgrounds, and Picnic Areas

Camping is often a necessary part of any outdoor recreation outing that extends beyond one day. Although many vacationers stay in motels and hotels, tents and recreation vehicles have become more and more popular in recent years. Camping is increasing at a faster rate than the provision of sites and facilities for camping. Increases in camping will most certainly accompany increases in travel, because camping allows families to enjoy weekends and vacations far from home at relatively little expense.

When resources are developed for boating, fishing, hunting, and related activities, adequate facilities for camping also should be provided. Studies of participation in outdoor recreation have shown that substantial numbers of campers prefer remote areas, while many others prefer camping in an area where they can visit with other campers.[58] Consequently both types of camping areas are needed.

A number of environmental health factors should be considered in the design and maintenance of camping areas:

(1) Tent areas should be level and well drained.

(2) Grounds should be maintained regularly. Maintenance should include cleaning, mowing, and removing poisonous plants and other hazards.

(3) Playgrounds should be remote from traffic areas, hazardous topographic features, and hazardous land uses.

(4) Water supply hydrants and comfort stations should be conveniently located.

(5) Camping units should be located on one-way loop roads or cul-de-sacs.

(6) Solid waste storage, collection, and disposal should be provided.

5.4.19 Stable Sanitation

The stabling of horses and related manure disposal are the primary environmental health concerns associated with the use of these animals. Accumulations of such wastes create breeding places for flies, and unless these accumulations are controlled, they will invariably produce large numbers of flies. Public health officials recognize that flies constitute a public health hazard and that the abatement of fly population is essential to the control of certain communicable diseases.

These principles should be applied:

(1) Stables should be convenient to recreation areas, but located to minimize potential odor and nuisance problems.

(2) Water outlets should be provided for hosing down feed and tack rooms and the outlets should be protected against back-flow.

(3) Adequate water supply and drainage lines should be provided.

(4) Insect and rodent control should be practiced.

(5) The handling and disposal methods used for manure should prevent the breeding of flies.

5.4.20 Conclusion

If the health guidelines outlined in Subsection 5.4 have been followed in the design and development of recreation areas, then health considerations have received adequate attention. If these guidelines have not been considered, the health and well-being of recreationists will be endangered, and the project will fall short of its optimal development and use. The use of additional funds for sanitary and related facilities is often justified in achieving optimal results from the expenditure of basic development funds. Health agencies at the local, State, and Federal level can assist in providing the technical direction necessary to insure a healthful environment in the development of water resources.

5.5 Vector Control

5.5.1 General

The guidelines outlined in Subsection 5.5 should assist in the study and evaluation of vector control problems and in the prevention and control of disease vectors and pests that are associated with water and related land resources.

The guidelines can be broken down into two categories: principles and practices for the prevention and control of vector problems; and field surveys and epidemiological surveillance.

Major vectors considered include mosquitoes from water resources and terrestrial arthropods and rodents from the related land resources.

The major diseases transmitted by mosquitoes are malaria, yellow fever, dengue, encephalitis, and filariasis. Control programs and climate have now reduced malaria, yellow fever, dengue, and filariasis to minor or historical importance in the United States. Five types of encephalitis continue to occur in epidemic form in many parts of the United States, however, and these are the most important mosquito-borne diseases in the United States today. From 1956 to 1968, 3,121 cases of human encephalitis were identified as mosquito-borne.[18] The incidence from various strains is listed in Table 23–29.

Maps in Figure 23–9 illustrate the relative occurrence of the major types of encephalitis in the United States.

At present ticks are known to transmit five groups of deadly diseases: rickettsial, such as spotted fever; bacterial, such as tularemia; spirochetal, such as the relapsing fevers; viral, such as Colorado tick fever; and protozoal, such as Texas cattle fever. Ticks also produce a toxic paralysis. Tick-transmitted diseases have occurred primarily in the south Atlantic, Appalachian, and western States. Lowest incidences occur in New England, New York, the west-central States, Hawaii, and Alaska. Because ticks are so widespread, however, the hazard from them should be considered in all regions.[38]

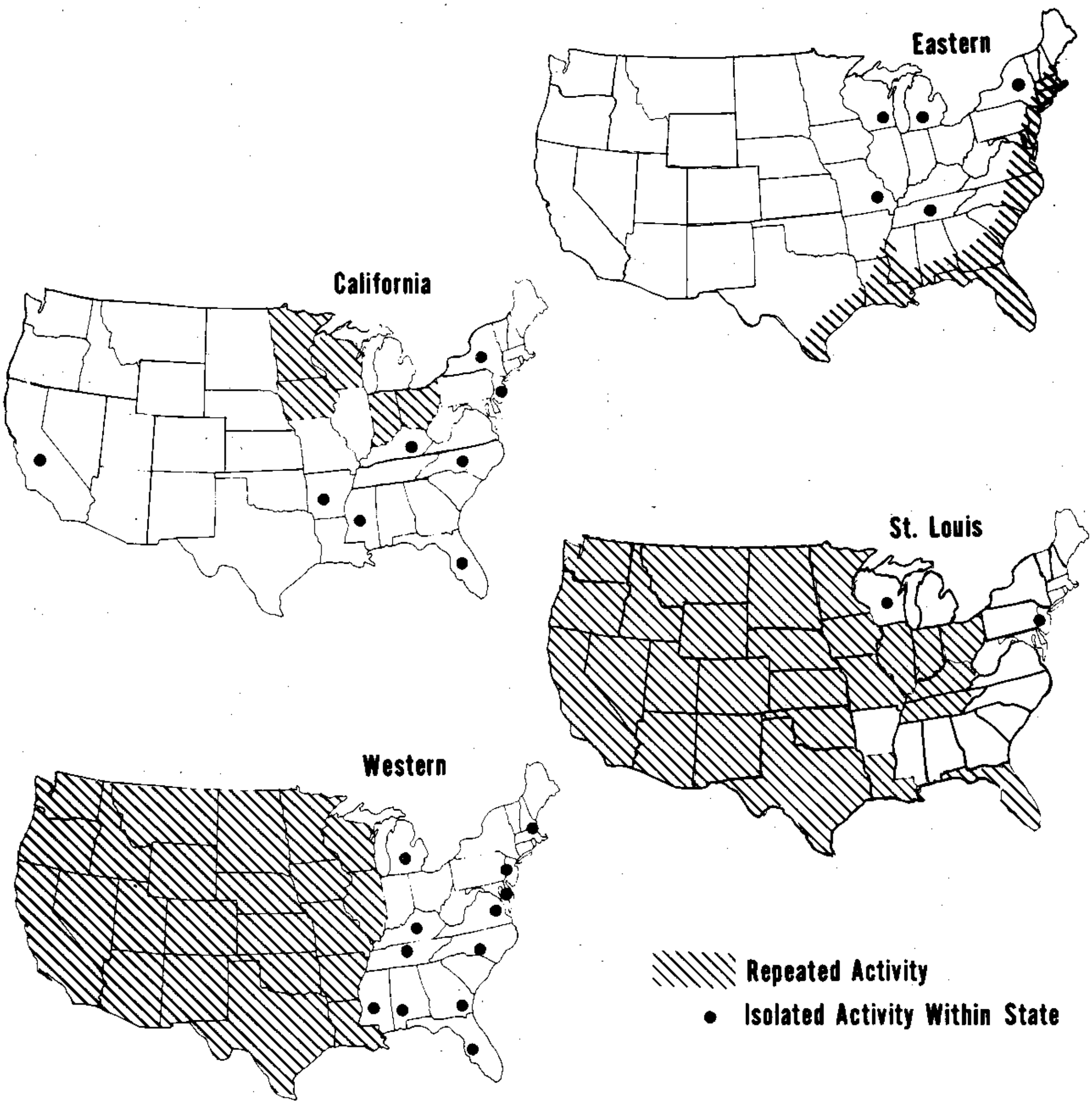


FIGURE 23–9 Mosquito-Borne Encephalitis

TABLE 23–29 Cases of Human Encephalitis in the United States, 1956 to 1968

Encephalitis Strain	Cases
Western	665
Eastern	92
St. Louis	2,127
California[a]	236
Venezuelan	1
Total	3,121

[a]California Encephalitis was not identified by most laboratories before 1964

5.5.2 Practices for the Prevention and Control of Vector Problems

To prevent and control vector problems, special emphasis must be placed on preventing physical conditions that may result in increased vector populations and establishing physical conditions that will minimize or eliminate existing vector problems. Other important factors are the maintenance of basic sanitation standards, programs for the application of insecticides, and location of habitable areas away from potential mosquito production areas. The following principles and practices to prevent and control vector problems should be followed in the planning, design, construction, operation, and maintenance of water and related land resource projects.

5.5.2.1 Impoundments

The following practices lead to the prevention and source reduction of mosquito and other aquatic insect breeding sites in impoundment areas:

(1) Borrow pits and other potential ponding areas can be caused by dam construction, road relocation, or other factors. When these areas are located above maximum pool level, they should be made self-draining.

(2) Before impoundment, the reservoir basin should be prepared according to the following guidelines:

(a) The normal summer fluctuation zone of the permanent pool should be selectively cleared, except for isolated trees and sparse vegetation along abrupt shorelines that will be exposed to wave action.

(b) Dense stands of timber rooted below the normal summer minimum pool level but extending above that level should be selectively cleared.

(c) Borrow pits, depressions, marshes, and sloughs that will be flooded by the reservoir at maximum pool level and that would retain water at lower pool levels should be provided with drains to insure complete drainage with fluctuation of water levels.

(d) If the summer fluctuation zone of the permanent pool is only a few feet, consideration should be given to "building out" mosquito-producing areas located within flight range of population or recreation areas through the use of measures such as deepening and filling. This would minimize the need for repeated measures to control vegetation and mosquito production.

(e) If releases of water during portions of the year coincident with the mosquito breeding, season are quite small, low-flow channels in drainage systems below the dams should be considered.

(3) After impoundment the following maintenance measures should be carried out in all potential mosquito-producing areas located within flight range of human population centers or recreation areas frequented by significant numbers of persons:

(a) All dense vegetation should be removed periodically from flat, protected areas within the normal summer fluctuation zone of the permanent pool.

(b) Vegetation, debris, and flotage should be removed periodically from all drains to insure free flows.

(4) To minimize conditions favorable for mosquito production, water levels should be controlled to the maximum degree permitted by the primary purpose of the reservoir. This will minimize the need for repeated measures to control vegetation and mosquito production.

(5) As a general principle, waterside recreation areas, particularly those with facilities for overnight human occupancy, should be located along sections of the reservoir with a low production potential for mosquitoes and other aquatic insects of public health importance.

(6) Biological control measures, such as maintaining populations of mosquito larva predators, should be exercised as needed.

5.5.2.2 Recreational Areas

The following guidelines should be used to control disease vectors in recreational areas.

(1) Solid and liquid wastes should be properly stored, collected, and disposed of, so as not to attract flies, wasps, mosquitoes, other noxious insects, rats, other wild rodents, and other small mammals.

(2) All buildings in recreation areas should be rodent proofed.

(3) Brush and weeds along paths, trails, and roadways should be treated with herbicides or removed to reduce the likelihood of tick and chigger infestation. Insecticides should also be applied along paths and roadsides to control tick and chigger infestations, but only in accordance with recommendations and requirements of the State departments of agriculture and health. Containers including tree holes, tires, and similar receptacles should be filled or removed to eliminate breeding places for mosquitoes and biting gnats.

5.5.2.3 Waterfowl Refuges

(1) Whenever possible, waterfowl habitat developments should be constructed to minimize mosquito problems.

(2) Waterfowl areas that are flooded during the mosquito season should be diked or prepared with steep shorelines to prevent shallow water areas favorable for mosquito production. Banks should not be made steep enough to impair stability.

(3) Water levels should be managed in waterfowl areas to minimize mosquito production. This recommendation is particularly applicable to shallow areas used to provide food-producing vegetation.

5.5.2.4 Irrigation

(1) Project Conveyance and Distribution Systems

(a) Lining or other satisfactory seepage control measures should be provided for all sections of canals and laterals located in porous soil where excessive leakage would result in water logged areas, seeps, and ponds.

(b) Drains should be installed to prevent ponding of excess irrigation water and natural runoff along the upper side of canals and laterals. All drainage crossing or inlet structures should be placed on grade to prevent ponding.

(c) Borrow areas should be made self-draining to prevent retention of ponded water.

(d) Where possible provision should be made to prevent idle turn-outs and other hydraulic structures from retaining residual water.

(e) Effective measures should be provided to prevent ponding of leakage from water control structures.

(f) Water delivery schedules should provide farmers with adequate but not excessive amounts of water at proper intervals to insure efficient crop irrigation.

(g) Where feasible pipe should be used instead of open channels.

(h) Vegetation and debris that would retard normal flows should be periodically removed from conveyance channels, water control structures, and drains.

(2) Project Drainage Systems

(a) Trunk drainage systems should be installed to insure complete removal and proper disposal of excess irrigation water, natural runoff, and seepage from both irrigable and nonirrigable lands affected by the distribution and use of irrigation water on the project.

(b) Drainage ditches should be designed, constructed, and maintained to minimize ponding in the channels and insure free flows at all times.

(c) Water should be prevented from ponding behind spoil banks.

(d) Underdrains, culverts, and inlets should be placed on grade to prevent ponding.

(3) Irrigated Farms

The sponsoring agency and other organizations concerned with irrigation agriculture and mosquito control should encourage irrigation farmers to use the following irrigation and drainage practices to prevent or minimize mosquito sources:[19]

(a) The farm supply system, drainage system, and field layouts should be suited to the topography, soil, water supply, crops to be grown, and irrigation methods to be used.

(b) All surface-irrigated fields should be leveled or graded to provide efficient application of water and removal of excess water without ponding.

(c) Drainage systems should remove excess irrigation water from all portions of the farm.

(d) Irrigation methods used should provide optimum irrigation efficiencies.

(e) Application of irrigation water should be limited to the amount required to fill the crop root zone plus the amount needed to cover unavoidable losses and prevent upward movement of salts.

(f) Where feasible, sprinkler systems should be used for irrigation.

5.5.2.5 Ponds

(1) Pond basins should be cleared of trees, brush, and other dense vegetation before impoundment.
(2) Ponds should be constructed with steep banks to discourage growth of vegetation. Banks should not be made steep enough to impair stability.
(3) All dense vegetation should be removed periodically from shallow water areas.
(4) A minimum depth of two feet should be maintained.

5.5.2.6 Channel Improvements and Drainage

(1) Borrow areas resulting from construction of the project should be made self-draining.
(2) Material excavated from channels should be disposed of in a way that will not cause ponding of water.
(3) Adequate drains should be installed to prevent ponding of water on berms and behind spoil banks, levees, and dikes.
(4) Drainage ditches should be designed, constructed, and maintained to concentrate low flows and reduce silt deposits and subsequent ponding, thereby insuring free flows at all times.
(5) Underdrains, culverts, and inlets should be placed on grade to prevent ponding.
(6) Collection sumps should be constructed with steep side slopes, and any emergent vegetation should be removed periodically.
(7) Sections of natural channels that are cut off or bypassed by new channels should be filled or provided with adequate drains.
(8) Interior drainage facilities should be well maintained to avoid excessive ponding.
(9) Biological control measures should be used where feasible. One such method is stocking with mosquitofish or top minnows such as *Gambusia affinis*.

5.5.2.7 Waterways, Terraces, Floodways, Diversion Channels, and Drainage Ditches

(1) Waterways, terraces, floodways, diversion channels, and drainage ditches should be designed, constructed, and maintained to prevent retention of ponded water or creation of ponded areas that would be suitable for mosquito production.
(2) Biological control measures should be used where feasible.

5.5.2.8 Supplemental Chemical Control Measures

Places where adequate vector control is not obtained through prevention and source reduction measures, insecticides and rodenticides should be used as supplemental methods to achieve the desired level of control. The use of such chemicals should be closely regulated to prevent water pollution resulting from their use.

5.5.3 Field Survey and Epidemiological Surveillance

Routine field surveys and epidemiological surveillance should be conducted to insure that good principles and practices are being implemented, that vectors are being controlled, and that diseases and nuisances are being prevented. Routine field surveys should include inspection for implementation of physical measures and inspections for the presence of adult and larval mosquitoes and other vectors. Periodic information on vector populations or disease occurrence is essential in guiding control programs and instituting new programs to cope with existing vector problems and emergency situations.

5.5.4 Adverse Effects of Vector Control on Fish and Wildlife

The principal means of vector control, removal of habitat and pesticide application, are often damaging to fish and wildlife. Obviously the elimination of swamps or marshes and the removal of brush or underbrush can destroy the habitat of birds, animals, and fish as well as the habitat of insect vectors. Pesticide application damages the food chain of fish and wildlife, can poison fish and wildlife, and can also accumulate in the flesh of fish and wildlife until consumption by humans becomes hazardous.

As an example, attempts to control black flies in the early 1950s in the Adirondacks were made using DDT blocks, airplane spraying and other spraying. This pesticide application successfully reduced the population of black flies, midges, and other arthropods, but adverse effects also resulted:

(1) Excessive concentrations of DDT metabolites were found in fishing lakes and ponds.

(2) A possible loss of natural reproduction in lake trout, whitefish, and other fish species occurred.

(3) The fish forage base and food chain were possibly damaged.

(4) In some fish species, DDT accumulated to levels unsafe for human consumption.

(5) Birdlife was possibly damaged.

Vector control efforts should be coordinated with fish and wildlife interests at the planning stage. Such coordination should provide for protection of important fish and wildlife resources that may be destroyed by vector control efforts.

5.6 Solid Waste Management

5.6.1 General

The management of solid wastes is a growing national problem. Solid waste management methods must be designed to promote public health, environmental protection, and economic resource recovery. Local and State agencies concerned with solid waste management, public health, environmental protection, water pollution, and water resources development should be consulted about such requirements on a case-by-case basis.

Proper solid waste management improves the safety and quality of the environment in a number of ways:

(1) It eliminates harborage and food supply for rats, flies, mosquitoes, and other disease vectors or nuisances.

(2) It controls air pollution through the elimination of open burning and through more efficient combustion where incinerators are used. Proper combustion control, design, and operation and the use of appropriate air pollution control equipment reduce odors, fly ash, and smoke.

(3) It safeguards against surface-and ground-water pollution caused by improperly managed solid waste.

(4) It reduces accident and fire hazards through elimination of the open burning or dumping of solid waste.

(5) It makes solid waste disposal facilities aesthetically acceptable.

Such problems are more costly to control than to prevent through proper planning. In the interest of public health protection and economy, solid waste management and its potential effects should be considered early in the planning of water resources development projects, particularly where recreation and water quality are important.

5.6.2 On-Site Storage

Solid waste management begins with the method used to store wastes generated at specific sites. Normally such facilities consist of insect- and rodent-proof containers large enough to hold the maximum amount of waste generated between collections.

5.6.3 Collection

Solid wastes should be collected at appropriate intervals to prevent fly and insect breeding and the occurrence of odor problems. Collection frequency should be adjusted for varying rates of accumulation and climatologic and geographic factors.[64]

5.6.4 Disposal

After accumulation and collection, solid wastes must be properly treated and disposed of. Acceptable disposal occurs when no significant deterioration of the environment results from disposal operations. Modern practices for disposal are discussed below.

5.6.4.1 Sanitary Landfill

Sanitary landfill is an engineered method of solid waste disposal. Wastes are spread in thin layers, compacted to the smallest practical volume, and covered with earth each day to minimize environmental pollution.[63] Sanitary landfill is sometimes mistakenly associated with open dumping. Dumps, however, are a source of environmental degradation.

There are many advantages associated with sanitary landfill:

(1) Where suitable land is available, sanitary landfill is usually the most economical method of solid waste disposal.

(2) The initial investment is low compared with other disposal methods.

(3) Sanitary landfill is a complete or final disposal method, as compared to incineration and composting, which require additional treatment or disposal operations for residue, quenching water, and unusable materials.

(4) Sanitary landfill can be put into operation within a short period of time.

(5) With the exceptions of liquid waste and toxic chemicals, sanitary landfill can receive all types of solid wastes, eliminating the need for separate collections.

(6) A sanitary landfill is flexible because increased quantities of solid wastes can be disposed of with little additional personnel and equipment.

(7) Submarginal land may be reclaimed for use as parking lots, playgrounds, golf courses, airports, and other uses.

However, there are also disadvantages associated with sanitary landfill:

(1) In highly populated areas, suitable land may not be available within economical hauling distance.

(2) Proper sanitary landfill standards must be enforced daily, or the operation may result in an open dump.

(3) Sanitary landfills located in residential areas can result in extreme public opposition.

(4) A completed landfill will settle and require periodic maintenance.

(5) Special design and construction must be used for buildings constructed on completed landfill because of settlement.

(6) Methane, an explosive gas, and other gases produced from waste decomposition may become a hazard or nuisance problem and interfere with use of completed landfill.

5.6.4.2 Incineration

Properly designed incinerators can be used for treatment of solid wastes. Incineration does not eliminate the need for a sanitary landfill. It simply reduces the volume of material requiring eventual disposal.

Incineration has two main advantages:

(1) It reduces the amount of solid waste that requires final disposal.

(2) When the incinerator is located near waste sources, it may reduce hauling distances and allow more efficient collection practices.

There are also two main disadvantages:

(1) Capital costs and operating costs are higher than for the sanitary landfill.

(2) Incineration requires full-time operators to assure proper operation.

5.6.5 Water Resource Aspects of Solid Waste Disposal

5.6.5.1 Recreation Areas

Recreation areas and their supporting facilities generate significant amounts of solid waste and present varying problems of solid waste management. Solid waste management for recreation areas is discussed in Subsection 5.4.

5.6.5.2 Reservoir Planning

Before reservoir impoundment, a survey should be made to locate solid waste disposal sites that will be inundated. This survey should be part of a general assessment of pollution sources, levels, and potential. If it is determined that these sites could cause a significant pollution problem, the objectionable material should be removed or the location of the reservoir should be altered to avoid the solid waste site.

The filling of a reservoir represents a change in hydrologic conditions, which will raise the nearby ground-water table. If the higher ground-water table intrudes upon a solid waste disposal site, pollution could result. Further investigation and corrective or protective measures should then be taken.

5.6.5.3 Water Quality

Most solid waste is ultimately placed in contact with the ground, permitting possible contact with both ground and surface water which could cause subsequent impairment of water quality.[50] Investigations about water contamination resulting from solid waste disposal have established that the physical, biological, and chemical quality of surface and ground water may be affected by nearby solid waste disposal sites.[55] Turbidity is normally a problem only in the immediate vicinity of disposal sites. Taste and odor may be particularly affected by hydrogen sulfide absored by water in contact with anaerobically decomposing wastes. Although color may be present, it is normally removed by natural purification processes.

Very high levels of bacterial contamination may occur within and near disposal sites. For sandy or granular aquifers, bacterial contamination does not normally persist at depths greater than seven feet below a disposal site. In ground water contamination seldom persists in the direction of flow for more than 50 yards.[8] In limestone, lava rock, most sandstones, granite, and other crystalline rocks, however, water travels through discrete openings including tubes, parting planes between layers, and fissures produced by earth movements. No filtering action occurs as water moves through these openings, and contamination can travel long distances, modified only by dilution.

Mineral and organic substances in solid wastes are present in quantities that can cause gross contamination of surface- and ground-water supplies. Soluble inorganics such as chlorides, ammonium hydroxide, and ammonium salts are not rapidly removed by natural means. Decomposition of organic matter produces carbon dioxide, water, methane, ammonia, and hydrogen sulfide. The increase in hardness caused by carbon dioxide and the increase in nitrate content caused by the oxidation of ammonia are among the most significant effects on water quality. The highly soluble carbon dioxide also forms a weak acid which can dissolve metals and other substances to produce undesirable contaminants.

5.6.5.4 Mechanisms of Contamination

Five major natural processes, in addition to direct dumping, will produce or introduce contaminants in ground or surface water. These include infiltration and percolation, solid waste decomposition processes gas production and movement, leaching and ground-water travel, and direct runoff.[16]

Infiltration and percolation of rainfall, runoff, irrigation, and flood water can produce contaminating leachates. Decomposition of wastes by chemical and bacterial action depends upon time, composition, availability of oxygen, temperature, moisture, salinity, and other factors. It produces many chemical products that may become contaminants. Aerobic decomposition produces a rise in temperature and two primary products, carbon dioxide and water. Anaerobic decomposition produces ammonia and methane as the primary products, accompanied by a rise in temperature.

For leaching and ground-water travel to occur, three conditions must be satisfied:

(1) The disposal site must be over, adjacent to, or in an aquifer.

(2) The fill or a portion of it must be saturated.

(3) Leached fluids that have access to an aquifer must be produced.

The possibility of contamination from a solid waste disposal site depends on several factors, including the composition and quantity of waste involved, the physical environment, the operation of the site, and the volume and original quality of the water.

5.6.5.5 Sanitary Landfill Site Selection and Operation

The possibility that a landfill will pollute ground and surface waters in the area of the fill must be considered. Solid wastes may contain various substances that can cause contamination of surface- and ground-water supplies.

A competent sanitary engineer should be consulted to evaluate the water pollution potential associated with disposal sites and the protective measures that may be necessary. The services of a soil scientist or a ground-water geologist may also be useful.

To minimize the potential of surface- and ground-water contamination, the following guidelines should be used:

(1) Solid waste should never be buried in direct contact with ground-water or surface-water supply. Burial areas should also be located to minimize contamination of waters that may be used for municipal or drinking water supplies.

(2) Surface water passing over or through a disposal site should be minimized by proper drainage. Finished sites should be covered and graded to control the flow of runoff across the fill area.

(3) Water should not intentionally be added to a solid wastes disposal site, except to extinguish fires.

(4) Site selection should be based on evaluation of the entire physical environment surrounding proposed sites.

(5) Recommended procedures for the operation and maintenance of a sanitary landfill should be followed using sound engineering practices and judgment.[63]

(6) In the planning and implementation of solid waste disposal, consultation should be sought from local, State, and Federal agencies concerned with environmental protection, public health, solid waste management, water pollution, and water resources development. This should be done to minimize the hazard of water contamination and to institute corrective engineering measures where needed.

SUMMARY AND RECOMMENDATIONS

Disease Vector Control Aspects

Diseases transmitted by mosquitoes, ticks, and rats occur in numbers sufficient to be of concern in the Great Lakes Basin. In addition, people in many areas suffer severely from the bites of mosquitoes, flies, and ticks. Vector control activity is limited in the Great Lakes Basin.

To improve vector control activity, the following steps should be taken:

(1) Enabling legislation should be enacted for the creation and operation of vector abatement districts in Wisconsin, Michigan, and Indiana. Enabling legislation for New York should be revised to permit the operation of vector abatement districts throughout all parts of the State.

(2) Minnesota, Wisconsin, Michigan, Indiana, and Ohio should develop comprehensive vector control programs, preferably within the State departments of health.

(3) Organized local vector abatement programs should be developed, particularly in and around populated areas.

(4) Authorization and funds should be provided for vector control as an integral part of the planning, construction, and operation of Federal water resources developments.

(5) Vector control costs and benefits should be included in feasibility calculations for water resource developments.

(6) Fish and wildlife interests should be represented at the planning stage of vector control programs.

(7) A public information program should be developed dealing with the health problems caused by vectors and with the limitations of vector control.

Public Water Supply Aspects

For many years public water supplies have proved capable of supplying safe and potable water. This does not mean, however, that there is no room for improvement. Deficiencies, such as inadequacies in quality, facilities, operation, and surveillance, occur primarily in those supplies serving fewer than 100,000 people. In addition, chemical contaminants that may be health hazards are being introduced into water sources. Because many treatment facilities are designed primarily for turbidity removal and disinfection, their capability for removal of many chemicals is uncertain. Research is needed to determine the acceptable limits for these chemicals and to determine the treatment techniques and facilities necessary to remove them.

Disease outbreaks attributable to water supply occur infrequently, but affect large numbers of people when they do occur. Fluoridation of public water supply is required in four of the Great Lakes States. Fluoridated water is provided for approximately 60 percent of the Basin's population.

Training for public water supply operators needs improvement throughout the Great Lakes Basin. Cross connection control programs are quite limited, and few water supply officials are active in cross connection control programs. With the exception of New York, Michigan, and Illinois, State water supply surveillance programs are inadequately funded to assure consistent delivery of adequate quantities of safe water.

To correct water supply deficiencies in the Great Lakes Basin, the following steps should be taken:

(1) All water supply operators should be certified by examination under mandatory State certification programs.

(2) Training programs should be further developed in each State to prepare personnel to enter the industry, to upgrade training for current personnel and to allow certification of water supply operators.

(3) Federal assistance for water supply operator training should be extended to all States in the Basin.

(4) Wherever economically and operationally feasible, fluoridation should be provided by public water supplies.

(5) Cross connection control programs should be established by all public water supplies.

(6) Adequate funding for effective surveillance of public water supplies should be provided by all States.

(7) State water supply surveillance programs should provide laboratory services to

all public water supplies for chemical analyses specified by the 1962 USPHS Drinking Water Standards.

Recreation Aspects

Immersion in polluted water may cause illness. The number of cases and the seriousness of the diseases caused by immersion increase as the amount of water pollution increases. There is, however, little hard evidence to support this. Appendix 7, *Water Quality*,[41] shows that many stream reaches do not meet State water quality standards for recreational use. Beach areas near urban developments are often made unusable by bacterial pollution. Beach closings because of pollution are common on Lake Michigan in the Chicago area and on Lake Erie near Cleveland. Rapidly expanding leisure time and increasing outdoor activity have produced severe overcrowding at many recreation areas. The outlook indicates that crowding will continue, particularly during summer holiday weekends. Evaluation of commercial data on campgrounds indicates that most campgrounds (more than 60 percent) are provided with drinking water, flush toilets, showers, and sanitary pumpout stations, the four basic sanitary facilities. Commercial ratings of campgrounds indicate that a large portion of these facilities require physical improvement or better operation. Publicly owned campsites are concentrated in lightly populated areas, and privately owned campsites are concentrated in medium and heavily populated areas. Private campgrounds are generally better equipped than public campgrounds.

The following steps should be taken to improve recreation in the Great Lakes Basin:

(1) State and local surveillance of beach water quality should be maintained, and sources of beach pollution should be abated.

(2) Water resource development projects should provide for recreational use. Wherever camping is included, the four basic sanitary facilities should be provided.

(3) State surveillance of recreational areas should be improved to assure safe water supply and proper sanitation.

(4) The development of publicly owned recreational areas near populated areas should be encouraged.

Air Pollution, Solid Waste, Radiological Health, and Individual Water Supply Aspects

Air pollution control and solid waste management can affect and be affected by water resource development. Both air pollution control and solid waste management are especially important for water resource development projects planned in and near urban areas. Radiological health aspects are considered primarily for nuclear power projects.

Properly installed drilled wells are the best type of individual water supply. Individual water supplies, particularly supplies using sources on or near the ground surface, are likely to be bacterially contaminated.

To improve individual water supply, the following steps should be taken:

(1) Individuals responsible for the project planning and execution of water resource developments should be familiar with the health aspects of these developments.

(2) Those responsible for water resource development projects should maintain liaison with local and State environmental health agencies to minimize possible adverse effects resulting from any project.

(3) The local health agencies should provide technical assistance to individual water supply owners to help them obtain and maintain safe water supplies.

(4) Rural water supply developments should be considered and assisted where water quality problems exist. Such development should occur where economically and operationally feasible, and where adequate planning is assured. Such developments should be controlled by State health and environmental control agencies and should conform to State design standards.

Health Guidelines for Water and Related Land Resource Planning

The health guidelines presented in Section 5 are provided for agencies concerned with development of water resources in the Great Lakes Basin. The guidelines are taken from the "Health Guidelines for Water and Related Land Resource Planning, Development and Management,"[14] prepared by the Division of Water Supply, part of the U.S. Environmental Protection Agency. The guidelines are not intended to be used as a comprehensive design document, but they present basic information which points out areas that require special attention by planning authorities.

Consultation with public health authorities and State and local environmental health and control agencies will insure the inclusion of adequate public health protection and improvement in water resource development plans. State and local health agency standards may vary from these guidelines in certain instances.

Federal agencies active in water resources development, such as the Corps of Engineers and the Soil Conservation Service, are required to obtain reviews of proposed projects from appropriate Federal, State and local agencies including the Environmental Protection Agency and from interested citizens and conservation and environmental groups. Guidelines are provided for public water supply systems, irrigation with sewage treatment plant effluent, recreation area development, vector control, and solid waste management.

GLOSSARY

arbovirus—a virus transmitted by an arthropod.

arthropod—any member of a large group of invertebrate animals with jointed legs and a segmented body, such as spiders and insects.

back-flow—the flow produced by the differential pressures existing between two systems, both of which are at pressure greater than atmospheric.

back siphonage—siphon action in an undesirable or reverse direction, caused by the force of atmospheric pressure exerted against a pollutant liquid, forcing it towards a potable water supply system that is under a negative pressure or vacuum.

chlorination—the practice of adding sufficient chlorine to a water supply to disinfect it.

coliform bacteria—bacteria that are present in feces. Water is tested for the presence of coliform bacteria to determine whether the water has been contaminated.

collection sump—a pit designed to receive drainage from a sanitary landfill.

cross connection—the link or channel connecting a source of pollution with a potable water supply.

enzootic—an animal disease peculiar to a locality or constantly present in a locality.

epidemiology—the science of the occurrence of disease.

epizootic—a disease that affects many animals at one time, corresponding to an epidemic in man.

etiological agent—the invading organism that causes a disease.

filtration—the process of passing water through a filtering medium, such as sand, for the removal of suspended or colloidal matter usually of a type that cannot be removed by sedimentation.

flocculation—the formation of small gelatinous masses, formed in water by the addition of coagulants, through biochemical processes, or by agglomeration. Flocculation makes it possible to remove otherwise nonsettleable or nonfilterable supended or colloidal solids from water.

fluoridation—the purposeful addition of a fluoride-bearing chemical to a water supply to increase the fluoride content of the water to an optimal level for the reduction of tooth decay.

leptospirosis—any of several diseases caused by spirochetes, a type of bacteria.

methemoglobinemia—the conversion of hemoglobin in blood to an inactive form of hemoglobin.

myiasis—the infestation with, or disease caused by, fly maggots.

night soil—the excrement removed from a cesspool or privy and used as fertilizer.

potable water—water suitable for drinking.

salmonellosis—the infection with, or disease caused by, bacteria of the genus *Salmonella*, typically marked by gastroenteritis.

sanitary landfill—a method of disposing refuse on land without creating nusiances or hazards to public health or safety. By following engineering principles, refuse is confined to the smallest practical area, reduced to the smallest volume, and covered with a layer of earth at the end of each day's operation, or at more frequent intervals if necessary.

sedimentation—the process of subsidence and deposition of suspended matter carried by water by gravity. It is usually accomplished by reducing the velocity of the water below the point where it can transport the suspended material.

shigellosis—infection with, or dysentery caused by, the bacteria *Shigella*.

solid waste—unwanted materials resulting from community, industrial, or agricultural operations which are solid rather than liquid or gaseous.

spoil bank—a bank alongside a ditch, composed of the material removed in the excavation of the ditch.

turbidity—a condition of water caused by fine visible material in suspension that may not be of sufficient size to be seen as individual particles by the naked eye, but interferes with the passage of light through the liquid.

vector—any object or organism that is the carrier of a disease-producing organism. An example is mosquitoes, which transmit hepatitis and malaria to man.

virema—the presence of a virus in the blood of a host.

LIST OF ABBREVIATIONS

AEC—Atomic Energy Commission

AQCR—air quality control region

AWWA—American Water Works Association

BWR—boiling water reactor

CE—California encephalitis

DHEW—Department of Health, Education, and Welfare

EE—eastern encephalitis

EPA—Environmental Protection Agency

FCF—Family Camping Federation

FHA—Farmer's Home Administration

GSD—genetic significant dose

MW—megawatts

μg/l—micrograms per liter

mg/l—milligrams per liter

ORP—Office of Radiation Programs

PHS—Public Health Service

PWR—pressurized water reactor

SCS—Soil Conservation Service

SLE—St. Louis encephalitis

WE—western encephalitis

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