570984002

SURFACE IMPOUNDMENT ASSESSMENT

NATIONAL REPORT

OFFICE OF WATER
OFFICE OF DRINKING WATER

U.S. Environmental Protection Agency

Washington, D.C. 20460

December 1983

FOREWORD

Preliminary studies conducted in the early 1970's indicated that the storage, treatment and disposal of liquid wastes in surface impoundments could be a significant source of contamination to ground water. Moreover, it was anticipated that as Federal and State laws governing air and water pollution were implemented, the volume of waste liquids and sludges disposed in impoundments would increase. During the same period, Congress, in passing the Safe Drinking Water Act, expressed concern about the potential effect impoundments might have on ground water. In response to this growing body of knowledge and Congressional concerns, EPA decided in 1977 to inventory impoundments and assess their potential to contaminate ground water. The Surface Impoundment Assessment (SIA) was the outcome of this decision.

The reader should note that the information which forms the basis of this report was collected by the States in 1978, 1979, and 1980. Accordingly, much of the information is dated. In particular, the discussions describing State programs reflects their status at the time the information was gathered; much has changed since. Ground water has been given increased attention in both Federal and State programs and new laws and regulations are being implemented which bring this practice under stricter controls. At the Federal level, for example, the development and implementation of the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Damages, Compensation, and Liability Act (Superfund) provided national controls over the most dangerous segment of impoundments--those handling hazardous waste.

Throughout the report, we use the term "potentially hazardous waste", or "waste hazard potential." The use of "hazardous" and similar terms in this study is not identical to designated hazardous waste as used in the Resource Conservation and Recovery Act (RCRA). The SIA rating system was developed before regulations under RCRA were promulgated, and SIA waste ratings were assigned based on general industry characteristics, or on standard industrial classification codes. A more complete discussion of the SIA rating system is included as Appendix A.

Although the information is dated, the report is a valuable addition to our knowledge. It is perhaps the broadest look at the use of impoundments, and how that use may affect ground water quality. The descriptions of State programs provides an accurate picture of how States managed impoundments in the past, and provides a benchmark against which we may measure improvement.

The reader will also note that we have refrained from identifying specific facilities. The SIA does not provide meaningful data on a site specific basis. The study was designed to be a first-round approximation of contamination potentials and the assessment methodology uses secondary sources of data to perform desk-top analysis of an impoundment's potential to contaminate ground water. The data are designed to provide only a relative ranking of sites. Accurate conclusions can only be made when the data are used in aggregates that are sufficiently large to provide statistical validity. Thus, the report confines itself to general observations based on summary data.

Finally, the results of this study have been used to make a preliminary ranking of contamination potential to help the new hazardous waste protection programs assign priorities to site investigations. The data are also helping States to assess problems related to other types of impoundments which need to be addressed to protect ground water quality.

The data, which have been available since 1979, have been used extensively by both the Office of Solid Waste and the Superfund program. The Office of Solid Waste has used the data to cross check the results of the hazardous waste facilities notification, to identify non-notifiers, and to set permitting and enforcement priorities. The Superfund program used selected SIA data as a source of information for site identification, screening and investigation. More recently, the Superfund program has been seeking to assure the accuracy and comprehensiveness of its data base, and has been using data from the SIA as one tool in this effort.

TABLE OF CONTENTS

LIST OF TABLES

Table

CHAPTER I

EXECUTIVE SUMMARY

In 1978 the Environmental Protection Agency (EPA) began a study in collaboration with the States of the magnitude and potential effects of surface impoundments on ground water quality. This effort was designed to carry out Section 1442(b)(3)(c) of the Safe Drinking Water Act (SDWA). The Agency knew that increased emphasis on air and water pollution controls resulted in an increase in sludge and waste water generation and disposal, but it had little information on the numbers, location and construction of surface impoundments or their potential for groundwater contamination. The Agency developed the Surface Impoundments Assessment (SIA) to provide more information on these issues.

Since the time the study began in 1978, several new Federal programs have come into effect with authority to protect ground water quality. The Resource Conservation and Recovery Act (RCRA) provides controls over the most important kind of impoundments, those handling designated hazardous wastes. Under this legislation, increased Federal grants have assisted many States to expand programs in this area. In addition, the enactment of the Comprehensive Environmental Damages, Compensation, and Liability Act of 1980 (Superfund) will provide resources with which to control the worst of the abandoned hazardous waste disposal sites. Although these Federal programs do not provide coverage over all impoundments, many States have expanded programs to protect ground water and to manage instances in which contamination has been detected. The findings of this study must be viewed in historical perspective. The data was collected in 1978 to 1980 and predated the increased public interest in ground water protection which began later, and the major programs initiated after 1980 as EPA and the States moved toward implementation of RCRA.

In conducting the SIA, EPA attempted to: 1) increase the Nation's data base concerning impoundments; 2) determine numbers, location and potential effects of surface impoundments on groundwater quality; 3) solicit information on existing State approaches to groundwater protection from these facilities; and 4) provide EPA with information to allow for a review of Agency programs regarding groundwater protection and surface impoundments.

The Assessment, with a few exceptions, was essentially a "desk-top study;" States used mainly secondary sources of data such as USGS maps, information from permit files, well drillers reports and other such sources in conducting both the inventory and assessment. Information on waste characteristics, for instance, was often inferred from standard industrial classification (SIC) codes rather than actual knowledge of the waste contained. In most instances, the data were not field verified by the States (or in a few States by contractors) which collected the data. The quality of the information, therefore, varies considerably from State to State. Nevertheless, the data, when used in sufficiently large aggregates and not applied to site-specific situations, characterizes the total population of surface impoundments and their potential impact on ground water quality.

The results of the study confirmed the concerns which led to its initiation. Surface impoundments, without proper siting, design, construction and operation, can threaten ground water quality. On a national level, Federal regulations and most States did not adequately address this problem in the past, although several States, including New York, California, New Mexico, New Jersey and Pennsylvania had or were developing aggressive ground water protection programs.

The data from this study have been useful to States and EPA in providing an inventory of surface impoundments and a preliminary ranking of contamination potentials with which to establish meaningful priorities for the new hazardous waste protection programs. The data will also help States to assess problems related to other types of impoundments which need to be addressed to protect ground-water quality.

The Hazardous Waste Enforcement Task force has used the data to identify high priority sites for field investigations and the Superfund Program used them as a source of information for site identification, screening and investigations. Finally, the Office of Solid Waste used the data to cross check the results of the Hazardous Waste facilities notification, to identify non-notifiers and to set permitting and enforcement priorities.

Briefly, the study was designed to locate and count as many impoundments as possible and to assess the ground water contamination potential of a significant number of the located sites. Table 1.1 provides a summary of the active sites and impoundments located in the inventory, as well as the number of sites assessed. They are presented in five major catagories: Industrial, Municipal, Agricultural, Mining, and Oil and Gas. A small number of sites have been assigned to a category termed "Other" because they do not fit any established category. For example, some States collected information on facilities which went beyond the definition of impoundment used in the national study. These "others" include such facilities as industrial septic systems, multi-family septic systems, safety impoundments around bulk storage tanks, and farm ponds used for stock watering.

TABLE 1.1

Summary Statistics
for Located Active Surface Impoundment Sites

Category	Located Sites*	Assessed Sites*	Located Impoundments*
Industrial	11,760	8,662	27,912
Municipal	19,746	10,822	37,185
Agricultural	14,850	6,646	19,437
Mining	7,364	1,552	25,038
Oil & Gas Brine Pits	24,990*	3,354	65,488
Other	1,553	350	5,913
TOTAL	80,263	31,386	180,973

* SIA site numbers for the mining and oil & gas brine pit sites are usually related to lease or field data, not to actual ownership and should not be referred to as the actual number of legal sites. The number of located impoundments would be a closer approximation for these two categories.

Located sites: Total number of facilities identified in the inventory.

Assessed sites: Total number of facilities evaluated in the inventory.

Located impoundments: Total number of impoundments identified in the inventory. The number is larger than located sites since many facilities had more than one impoundment.

METHODOLOGY

The SIA used an evaluation methodology developed specifically to assess the potential effects of surface impoundments on ground water quality. This method assigned ratings to a site based on the following factors:

1. the permeability and thickness of the earth material above the water table (a measure of the relative rate at which liquid waste could migrate through the ground to reach the ground water);

2. the quantity of ground water available (the permeability and thickness of the aquifer);

3. the quality of the ground water (combining Step 2 and Step 3 provides a rating of the usability of the aquifer);

4. the potential hazard or toxicity of the waste (based on general industry waste characteristics-the term "hazard" and "hazardous" is not equivalent to designated "hazardous waste" under RCRA since RCRA definitions were developed after the study began);

5. the overall potential for ground water contamination (the sum of the first four steps); and

6. the potential for a nearby water supply well or surface water body to become contaminated (this involves the estimation of the flow path of contaminated ground water and whether it would intersect a well or surface water).

In addition to conducting an inventory of all known surface impoundments and conducting assessments, States provided information on impoundment bottom liners and ground water quality monitoring. States also submitted representative case studies of contamination caused by impoundments, and descriptions of their State programs.

FINDINGS

The major findings of the study are outlined below:

Site Selection

° Unsaturated Zone;

Nearly 50 percent of all sites are located over unsaturated zones that are either very thin or very permeable. Such siting, given improper design, construction and/or operation, may allow leachate to attenuation of contaminants. For industrial sites, over 50 percent are so sited.

- Saturated Zone;

  Approximately 70 percent of all sites are located over thick and very permeable aquifers that allow relatively rapid movement of any plumes that may develop. For the industrial category, the percentage rises to nearly 80 percent.

- Total Hydrogeologic Setting;

  Approximately 30 percent of the sites are located in areas that have thin or permeable unsaturated zones, and overlie highly transmissive aquifers containing water that is currently used or of high quality. These sites provide the least natural protection to ground water quality. For the municipal and industrial categories, the percentage of sites so located rises to approximately 40 percent. Only about 7 percent of all sites appear to be located in areas which have hydrogeologic settings that offer the maximum protection from ground water contamination.

- Proximity to Potential Water Supplies;

  Less than 2 percent of the sites are located in areas where there is no drinking water within 1 mile, or where the water contains in excess of 10,000 parts per million total dissolved solids (>10,000 ppm TDS).

<u>Waste Characteristics</u>

- Approximately 15 percent of all sites (excluding oil and gas related facilities) contain waste which may be considered hazardous as the term is used in the SIA (e.g. hazard rating in excess of 6. See Appendix A for an explanation of the rating system.). In the industrial category, about a third of the sites contain potentially "hazardous waste." The SIA used <u>general</u> industry waste characteristics or SIC codes to assign waste ratings. Thus, "hazardous," as used in the SIA, does not correspond directly to designated "hazardous waste" under RCRA.

<u>Ground-Water Protection</u>

- As previously mentioned, nearly half of the sites assessed are located over unsaturated zones that afford little protection to ground water supplies.

- Approximately 30 percent of the industrial sites are lined. There is little or no apparent correlation between the type of waste, the siting characteristics and the use of liners.

- In addition, data on monitoring show little apparent correlation between the potential for aquifer contamination and the use of monitoring wells.

State Programs

The State staff conducting the SIA provided information on the State programs and, in most instances, conclusions and recommendations relative to the programs. It is important to note that these conclusions primarily reflect State staff opinions, and not necessarily official State views. Moreover, these data represent the status of State programs at the time of the assessment which began in 1978, and many States have revised ground water related programs since that time. The information and data submitted to EPA, show the following findings:

- Most States derived their statutory authority from a prohibition against "polluting the waters of the State." Although this includes ground water, the laws are generally surface water oriented.

- State regulations concerning surface impoundments generally covered only the treatment and/or discharge of waste to surface waters, not ground water.

- Only six States had developed regulations which specifically address ground water contamination from surface impoundments at the time the study was conducted.

- Despite the fact that oil and gas pits are strictly regulated and their use limited to emergency and mud pits, oil and gas pits accounted for more impoundments than any other category (approximately 65,000).

CONCLUSIONS

The study leads to the following conclusions:

- Without proper design and siting, impoundments have a high potential for contaminating ground water.

- Treatment, storage and disposal of liquids in surface impoundments is a common practice. There were over 180,000 impoundments located in the inventory.

- In general, impoundments have historically been sited and constructed without apparent regard for the protection of ground water quality.

- In the past, the practice has been virtually unregulated by the Federal government and many States from the perspective of ground-water protection. However, with the implementation of RCRA, and increased attention at the State level, sites handling designated hazardous wastes will be more strictly controlled in the future. Beyond regulatory controls, the Federal programs are providing the States with resources to help administer programs to control designated hazardous wastes and generally expand programs to protect ground water quality.

CHAPTER II

OVERVIEW OF THE SIA

The Environmental Protection Agency decided to conduct the Surface Impoundment Assessment (SIA) because of the findings of several preliminary studies, and as a result of Congressional concerns reflected in §1442 of the Safe Drinking Water Act. The preliminary studies indicated that the storage, treatment, and disposal of liquid wastes in surface impoundments (pits, ponds, and lagoons) may be a significant source of contamination to ground water and that the extent of the problem was unknown.

The Agency determined that an inventory and assessment of surface impoundments was required, one that was comprehensive and in line with Congressional intent as expressed in both the Safe Drinking Water Act (SDWA) and the Resource Conservation and Recovery Act (RCRA).

SCOPE OF THE SIA

The Surface Impoundment Assessment (SIA) is a one time only inventory and hydrogeologic evaluation of the ground water pollution potential of waste pits, ponds, and lagoons funded under the SDWA.

The goals of the SIA were to study the magnitude and potential effects of surface impoundments on ground water. In order to carry out these goals, five objectives were established. These objectives were:

(1) To inventory (locate and count) the number of surface impoundments in existence in the United States and its territories.

(2) To provide a <u>first-round approximation</u> of the ground water <u>pollution potential</u> of these practices.

(3) To assist the States and EPA in developing a better understanding of the problems caused by surface impoundments.

(4) To provide a data base on which EPA and the States may develop a strategy to control or regulate pollution from these sources.

(5) To provide data for review of State and Federal authorities and to recommend legislative programs to address the problem, if necessary.

As part of determining the pollution potential, a hydrogeologic evaluation of ground water contamination which used existing data was devised. Evaluations were performed on as many randomly selected sites as time and resources permitted. The system was based in part on the system developed by Harry Le Grand. The rating gives a numerical score which indicates the relative potential for ground water contamination. Appendix A gives a detailed explanation of the rating methodology.

To provide for consistency of coverage nationwide, it was necessary to develop a uniform definition of "impoundment" and to list exclusions that were not to be included in the assessment.

The definition of a surface impoundment as used in this study is:

> A natural topographic depression, artificial excavation, or dike arrangement with the following characteristics:
>
> (1) it is used primarily for storage, treatment, or disposal of wastes in the form of fluids;
>
> (2) it may be constructed above, below, or partially in the ground;
>
> (3) it may or may not have a permeable bottom and/or sides potentially allowing contamination of ground water by infiltration of its contents.
>
> (4) it has a surface dimension greater than its depth.

The list of exclusions consists of the following:

> Farm ponds used for stock watering or for fisheries; product storage tanks; ponds related to sand and gravel operations; swimming pools; natural lakes and ponds; furrow irrigation fields; rice paddies; irrigation re-use pits; sediment control basins; borrow pits resulting in sand pit lakes; storm water basins; individual and residential septic systems; well drilling mud pits; emergency pits; steel and/or concrete wastewater treatment unit process impoundments.

These exclusions are listed because they are deemed "non-problems" or contain fluids only intermittently on an emergency basis or are so numerous as to make it unrealistic to inventory. In certain cases and for compelling reasons, some of these have been included by certain States in the "Other" category.

METHODOLOGY OF THE SIA

EPA Funding for the SIA

EPA made available $5,000,000 in grants to the States for the conduct of the SIA. These grant funds, made under §1442(b)(3)(C) of the Safe Drinking Water Act, P.L. 93-523, were distributed among the States by a formula which took into account ground water use, population, number of manufacturing establishments, area, oil and gas sites, and mining sites. The institutions that were granted funds to conduct the SIA are outlined below:

- EPA awarded funds for conduct of the SIA to:
    - contractors or universities in six States and Territories
    - State agencies in 49 States and Territories.
- Of the 49 State agencies which took grants, the SIA was:
    - conducted either partially or totally by subagreements with...
        - another State or Federal agency in 13 States
        - a university in five States
        - a consultant in nine States
    - conducted totally by the Grantee agency in 22 States.

The timetable for the activities of the study is included in Figure 2.1.

State SIA Organization

State SIA grantees organized their functional units and teams to suit their own needs. The following describes how the State SIA teams were organized and how they functioned.

Figure 2.2 shows the functional responsibilities of the grantees. It demonstrates that the responsibility for conducting the SIA rested with a State agency rather than a consultant or university in the vast majority of the States.

The educational composition of the SIA teams is represented nationally by the bar graph in Figure 2.3. Although the educational backgrounds of the people who worked on the SIA involve many fields, the majority were in the fields of geology and hydrology.

SURFACE IMPOUNDMENT ASSESSMENT SCHEDULE

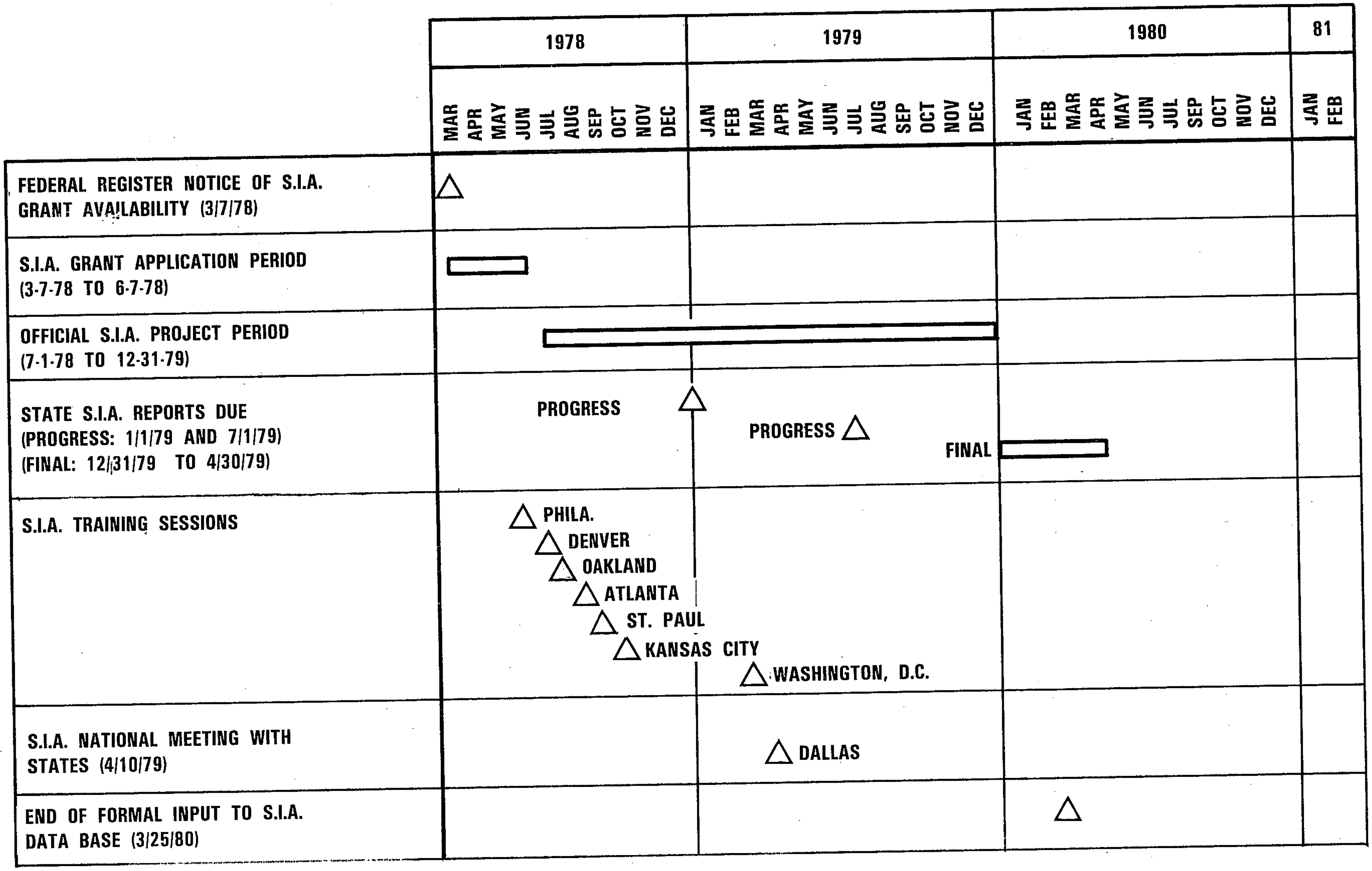


Figure 2.1

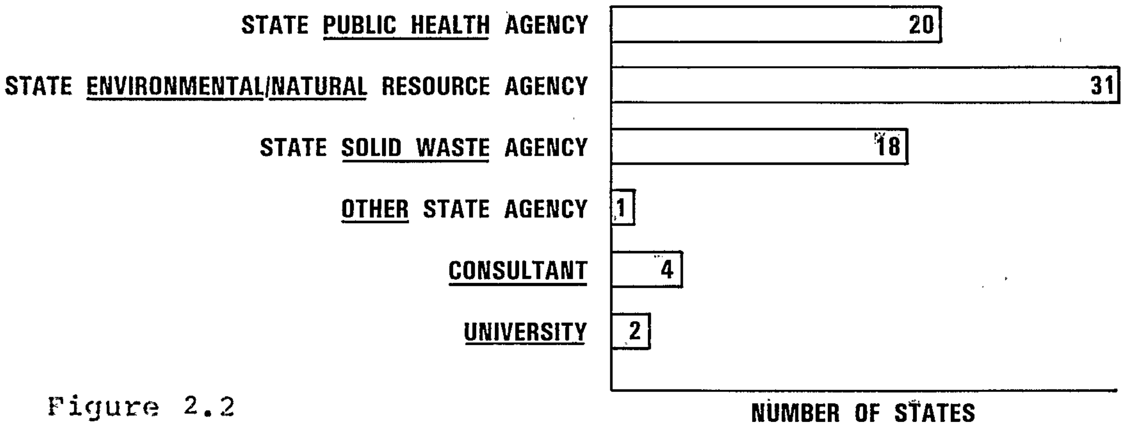


Figure 2.2

FUNCTIONAL RESPONSIBILITY OF THE GRANTEE *

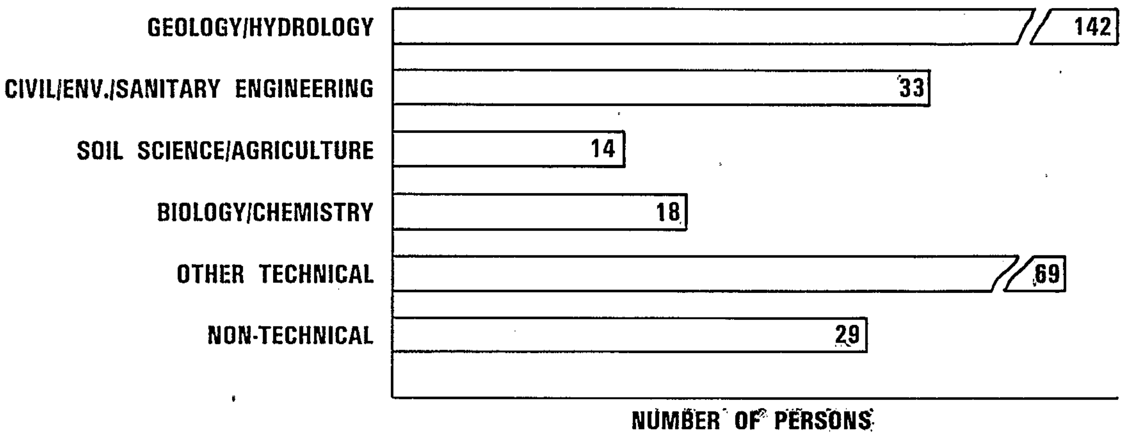


Figure 2.3
EDUCATIONAL COMPOSITION OF THE S.I.A. TEAMS

*The total exceeds the number of States and territories since, in some instances, more than one State agency worked on the SIA in a State.

SIA TRAINING

To standardize the data collected, the SIA Work Group developed and administered training courses for the people who were to conduct the SIA in the States. This three-day training course was given seven times during the period June 1978 through February 1979.

Coverage of the SIA

There was a random selection of the inventoried sites to identify sites to be assessed. Then within each site, a random selection was made of all impoundments to determine which impoundment should be evaluated. This random selection procedure was repeated for each category. Thus, not all sites or all impoundments within a given site were assessed. Some States assessed all sites located; other assessed every impoundment located. As a result, it is difficult to make meaningful comparisons between States on a national level on the total number of impoundments. Figure 2.4 shows the percentage of located sites which are assessed.

When considering impoundments alone, independent of sites, it is significant to note the reasonably wide distribution of assessed impoundments as a percentage of located impoundments. Figure 2.5 shows the statistics on percentage of located impoundments which were assessed. Nationally, 80,263 sites were located and 39 percent or 31,386 of them were assessed. However, 180,973 impoundments were located and 21 percent or 38,089 of them were assessed. The Location and Count phase consisted of "finding" and "inventorying" as many surface impoundments as was reasonably possible by any legal means available to the State SIA Teams. The sources of data varied from State to State as did the State's best estimate of what percentage of all sites were located (see Figure 2.6).

HYDROGEOLOGIC EVALUATION METHODOLOGY

One of the primary objectives of the SIA was to provide a first-round approximation of the ground water pollution potential of surface impoundments. The system was not designed to discover if contamination had indeed actually occurred. Such detailed studies could logically follow the SIA with priority given to those sites having high contamination potentials. The steps used in this system are outlined in Figure 2.7. The SIA Manual for Evaluating Contamination of Potential of Surface Impoundments is reprinted in Appendix A. Figure 2.8 illustrates the sources of data used in this study. Here are some of the more common sources listed as "Other":

- Well Drillers Logs
- County Governments - i.e. Sanitarians

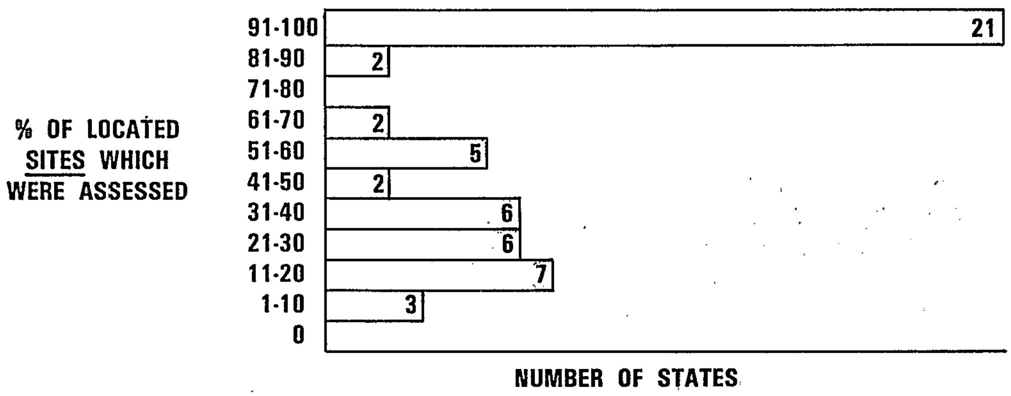


Figure 2.4

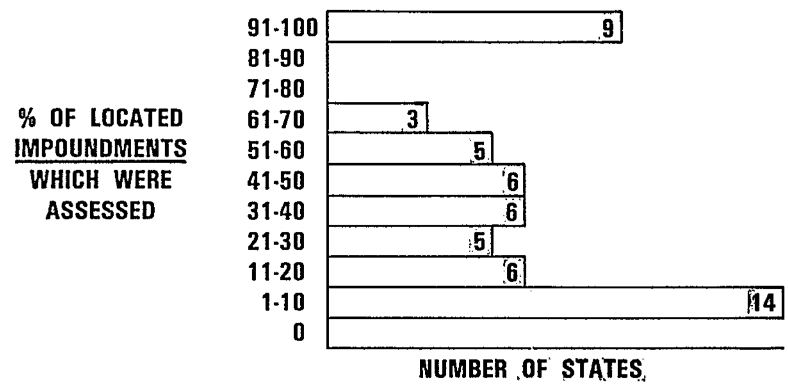
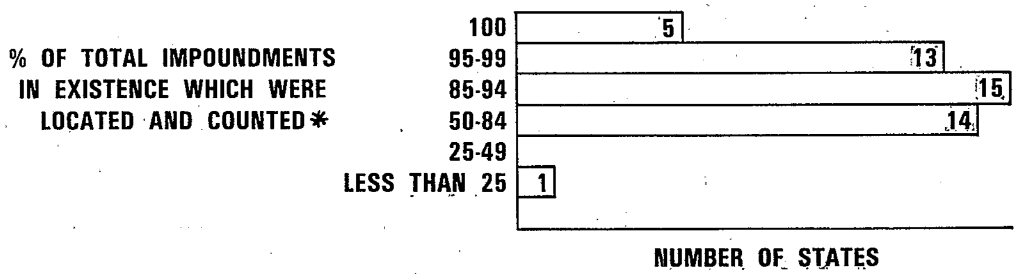


Figure 2.5



*Not all States estimated the % of total impoundments located

Figure 2.6

EVALUATION SCHEME

STEP 1: Rate the Unsaturated Zone

STEP 2: Rate the Ground Water Availability

STEP 3: Rate the Ground Water Quality

STEP 4: Rate the Waste Hazard Potential

STEP 5: Sum Up Overall Ground Water Comtamination Potential

Step 1 + Step 2 + Step 3 + Step 4

STEP 6: Rate the Potential Endangerment to Water Supplies

Figure 2.7

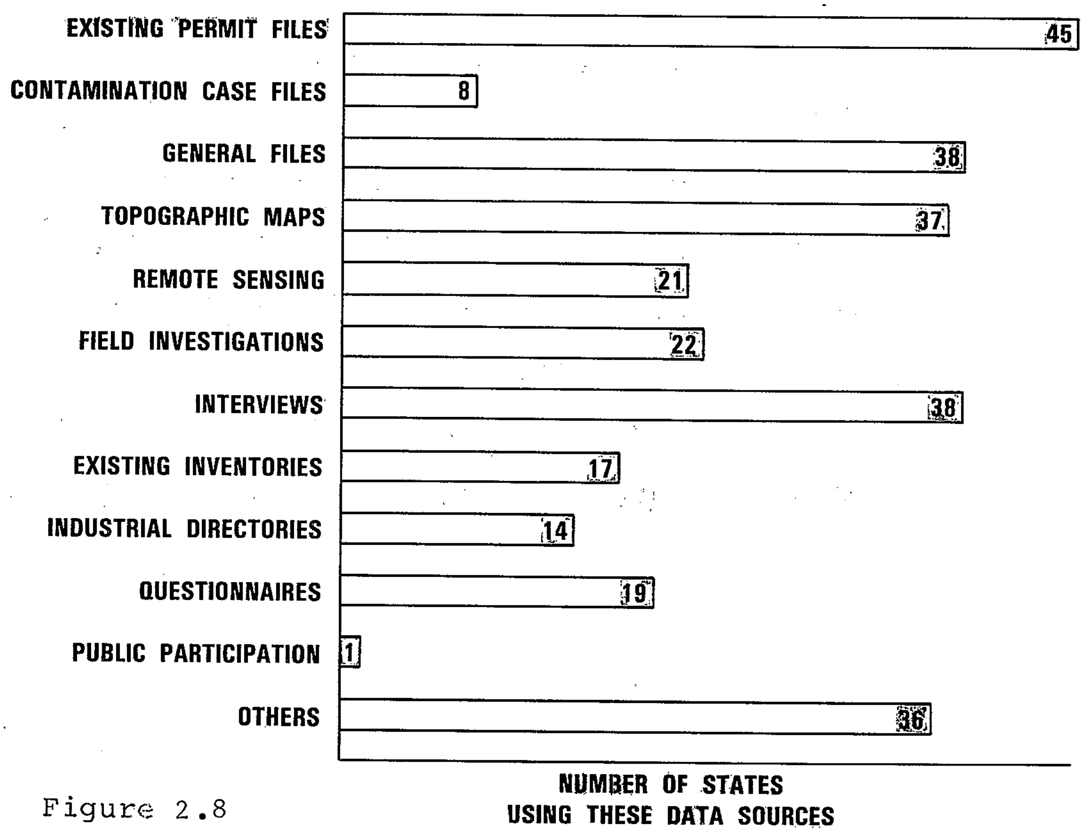


Figure 2.8

SOURCES OF DATA

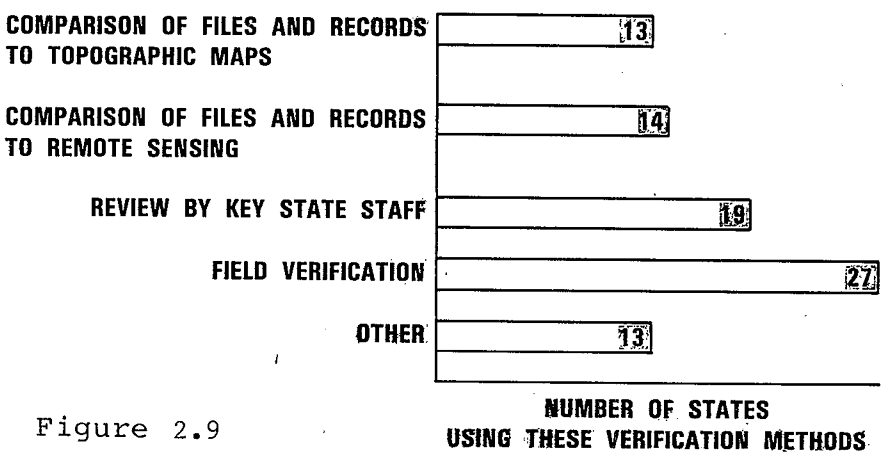


Figure 2.9

VERIFICATION METHODS

- U.S. Geological Survey Reports
- Soil Conservation Service Reports/Soil Surveys
- River Basin Plans
- Dairy Inspectors
- Chambers of Commerce
- "208" Reports and Surveys
- Consultant Reports

Since the data sources were largely "desk top," many States employed verification methods to confirm the data collected. Figure 2.9 illustrates the methods used.

DATA HANDLING

EPA made the decision to develop a centralized ADP system at Washington which could handle all of the States' data at no cost to them. EPA developed the Surface Impoundment Assessment Information System (SIAIS) on IBM System 2000 software.

Limitations of the Study

The SIA was designed to provide a first round approximation of the contamination potential of surface impoundments. The methodology, funding, and rating system were not designed to provide data that would prove valid on a site-specific basis. Nevertheless, the data, when used in sufficiently large aggregates, can establish the nature and extent of the potential impact on ground water from surface impoundments.

Funding limitations dictated that priorities be established for the inventory and assessments. Consequently, the comprehensiveness and accuracy of the data vary across categories.

Phase I, the Location and Count of Surface Impoundments, was given the highest priority. At a minimum, the State SIA Teams were to exhaust all reasonable possibilities to locate and count surface impoundments.

Phase II, the Hydrogeologic Evaluation of Surface Impoundments, was to be conducted after completion of Phase I with whatever funds remained. Under Phase II, if it was presumed that there would be more impoundments to evaluate than could be paid for with the remaining funds, then the State was to conduct hydrogeologic evaluations on one randomly selected impoundment at randomly selected sites. Funds were to be divided among the several categories of impoundments as follows:

(1) The evaluation of oil and gas sites should not receive more than 5 percent of the remaining funds;

(2) The evaluation of mining sites should receive not more than 5 percent of the remaining funds;

(3) The evaluation of industrial sites should receive at least 50 percent but not more than 80 percent of the remaining funds;

(4) The evaluation of municipal sites should receive a minimum of 10 percent of the remaining funds;

(5) The evaluation of agricultural sites should receive a minimum of 10 percent of the remaining funds.

The rating system emphasized existing data sources and is essentially a desk top study. Depending on the State, there was little or no field verification of the data collected. Accordingly, when viewed on an individual site basis, inconsistencies occur such as waste ratings which either underrate or overrate the waste hazard potential, or identification of sites as active that are closed or abandoned.

Although there was a training program developed and guidances issued on a continual basis, the States varied their approach to the study. To the degree that the rating system and training allowed for subjective interpretation, efforts between individual States were not consistent in their waste rating scores, in the priority they assigned to assessing the various categories of impoundments, or in the sources and interpretations used to conduct the hydrogeologic evaluation. Moreover, the quality of State ground water programs varies considerably, and the availability and comprehensiveness of the data vary accordingly. This limited the uses to which the data could be put.

The waste hazard score, as used in the SIA, is an approximation of the hazard potential that is based either on Standard Industrial Classification Codes (SIC) or a general waste identification. It is important to note that this method of classifying waste, while reliable for large numbers of sites viewed in aggregate, can result in errors on a site specific basis. For example, an impoundment at a facility with SIC code classification of 28 (chemical products) without further analysis would receive a relatively high hazard rating. However, it is conceivable that upon further investigation such an impoundment might be found to contain cooling water, not chemical wastes. Because the study was a first round approximation conducted without extensive field verification, it was not always possible to determine what waste an individual impoundment contained. The limited field verification that was performed suggests that while the extent may vary from State-to-State, such "misscores" are the exception, not the rule.

The term "hazardous," as used in the SIA, is not synonomous with "hazardous waste" as used in RCRA since that definition was developed after this study. In addition, wastes were assigned hazard values based on five parameters: toxicity, mobility, persistence, volume, and concentration. As a result, facilities which produce extremely high volumes of waste, such as mining operations, could receive a waste hazard rating equal to a site which produces relatively little waste of a higher toxicity.

CHAPTER III

STATE REGULATORY CONTROLS

AGENCY ORGANIZATION AND AUTHORITY

INTRODUCTION

One of the objectives of the SIA was to collect information on State programs dealing with surface impoundments in particular and ground water in general. Accordingly, EPA asked States to describe their laws, regulations, institutions, funding, and the general efficacy of their programs and regulatory activities that affect surface impoundments. This chapter is based on the results of these self-assessments. Although the information that follows represents the status of State programs as described by State personnel, there were often differences of opinion within individual State agencies concerning the effectiveness of programs. As a result, the characterizations of programs provided in this chapter may not reflect official State views.

In addition, many changes in State programs have resulted since the time of the study (1978-1979) due to the increased concern about ground water protection at the State level and the passage and implementation of Federal programs under RCRA, the Superfund and the Safe Drinking Water Act.

LEGISLATIVE BASIS

At the time of the study few States had laws relating specifically to ground-water contamination from surface impoundments. More often, States derive their statutory authority from broad mandates against polluting the "waters of the State." In the majority of instances, State laws were formulated primarily with surface water protection in mind. In some cases States had laws which specifically related to only one type of impoundment or laws that provided different levels of control for different types of impoundments.

For example, one State had six different agencies empowered under distinct acts which assigned authority over various types of operations. California, on the other hand, uses the Porter-Cologne Act as the primary basis for establishing specific standards for water quality control plans, waste discharge, and disposal of liquid waste. A single State agency, the State Water Resources Control Board (in conjunction with the 9 Regional Water Quality Control Boards) had the primary responsibility for administering this and other ground water-related legislation.

Several States indicated they were in the process of developing new, more stringent legislation that addressed ground water specifically. This was largely a result of recent Federal legislation and increased demand for good quality water. Hawaii, for example, was developing a State water code which requires the following: (1) review of all water quality programs, (2) establish agency responsibilities, (3) streamlined regulatory processes, (4) establish guidance on water rights.

Table 3.1 is an overview of State authorities at the time of the survey. With regard to enabling legislation, most State programs did not specifically address ground water pollution from surface impoundments. As discussed earlier, States derived their statutory authority from broad mandates against polluting the "waters of the State." Where legislation addressed surface impoundments, it generally focused on point source discharges to surface water rather than seepage and non-point pollution.

STATE REGULATORY PROGRAMS

A majority of the States surveyed had some sort of regulatory program involving a permitting system for waste impoundments under either State or Federal programs. In the States which practice permitting and licensing (see Table 3.1) of surface impoundments, the focus of the program was frequently directed on the treatment phase of the entire facility, or on the direct discharge of wastes to surface water through the NPDES program and not on ground water contamination. However, a few State programs (New Mexico, Connecticut, New Jersey, New York, Pennsylvania, and California) concerned themselves directly with the discharge of wastes to the ground water.

However, most State programs--whether they addressed facility standards and direct discharges or whether they were empowered to permit indirect dischargers--reported that they were not adequately staffed and funded to provide the comprehensive plan reviews, regular inspections, effective monitoring programs, and consistent, timely enforcement actions required to assure compliance with permit conditions.

Enforcement of permit requirements and pollution controls, for example, was subject to the effects of limited resources. Approximately half the States reviewed construction plans prior to issuing a permit, but only nine States regularly inspected facilities, and even these inspections were reported to be sporadic due to time and staff constraints.

Over 50% of the States could require a new operator to monitor his facility in some manner. However, again resource constraints limited both the number of sites at which monitoring was actually required and the efficiency of any State review of monitoring

TABLE 3.1

STATE AUTHORITIES

STATE	LEAD AGENCY(S)	Statutory Law	Rules/ Regulations	License/ Permit	Plan Review	Inspection	AGR	MUN	IND	OAG	MNG
Alabama	Alabama Geological Survey										X
	Water Improvement Comm.				X		X	X	X		
	Dept. of Public Health						X	X	X		
	State Oil & Gas Board									X	
Alaska	Dept. of Env. Conser.	X		X	X	X		X	X	X	
American Samoa	Dept. of Health, Dept. of Public Works							X			
Arizona	Dept. of Health Services (11 Other Agencies included)	X	X	X	X	X	X	X	X	X	X
Arkansas	Dept. of Pollution Control and Ecology	X	X	X	X		X	X	X	X	X
	State Health Dept.							X			
California	Resources Agency DWR, WRCB, RWQB	X	X	X	X	X	X	X	X	X	X
Colorado	Water Quality Control	X	X	X				X			X
	O&G Conservation Comm.	X	X							X	
	Div. of Mined Land Reclamation										
	Dept. of Natural Resources	X	X								X
Connecticut	Dept. of Environmental Protection	X	X	X			X	X	X		

TABLE 3.1 (Cont'd)

STATE AUTHORITIES

STATE	LEAD AGENCY(S)	Statutory Law	Rules/ Regulations	License/ Permit	Plan Review	Inspection	AGR	MUN	IND	OAG	MNG
Delaware	Div. of Env. Control· Dept. of Health & Social Services	X	X	X	X			X	X		
District of Columbia											
Florida	Dept. of Env. Regulation	X	X	X	X	X		X	X	X	X
Georgia	Dept. of Natural Resources, Environmental Prot. Div.	X	X		X		X	X	X		X
Hawaii	Dept. of Health	X	X	X	X		X	X	X		
Idaho	Dept. of Health & Welfare Div. of Environment	X			X		X	X	X		X
	Dist. Health Dept.			X			X	X			
	Dept. of Water Resources										
	Soil Conservation Com.						X			X	
	Dept. of Lands										
Illinois	Env. Protection Agency	X	X			X	X	X	X		
	Dept. of Mines & Minerals	X		X						X	X
Indiana	Board of Health										
	Stream Pollution Control Board	X		X							
	Water Pollution Control Div.		X		X	X	X	X	X		X
	Water Supply Section		X		X	X		X			
	General Sanitation section		X		X	X		X			
	Solid Waste Management Section		X		X	X					
	Dept. of Natural Resources	X		X							
	Reclamation Division		X		X	X					X
	Oil and Gas Division		X		X	X				X	

TABLE 3.1 (Cont'd)

STATE AUTHORITIES

STATE	LEAD AGENCY(S)	Statutory Law	Rules/ Regulations	License/ Permit	Plan Review	Inspection	AGR	MUN	IND	OAG	MNG
Kansas	Dept. of Health & Environment Div. of Environment	X	X	X	X	X	X	X	X	X	X
Kentucky	Dept. of Natural Resources & Environmental Protection	X	X	X	X		X	X	X	X	
Louisiana	Office of Env. Affairs	X	X	X		X		X	X		
	Dept. of Natural Resources	X								X	X
	Dept. of Agriculture	X					X				
Maine	Dept. of Env. Protection	X	X	X	X			X	X	X	
Maryland	State Water Res. Adm.	X		X			X	X	X		
	Env. Health Adm.	X						X			
	Maryland Bureau of Mines	X	X								X
Massachusetts	Water Resources Commission	X		X							
	Dept. of Env. Quality	X					X	X	X	X	X
Michigan	Dept. of Natural Resources	X	X	X	X	X		X	X	X	X
	Dept. of Public Health	X	X	X	X	X		X			
Minnesota	Pollution Control Agency	X		X		X	X	X	X		
	Dept. of Natural Resources	X			X						X
Mississippi	Dept. of Natural Resources	X	X	X			X	X	X		
	Oil and Gas Board	X								X	
	Board of Health	X							X		
Montana	Dept. of Health & Env. Sciences	X	X	X				X	X		X
	Oil & Gas Conservation Div.	X	X							X	
	Dept. of State Lands			X	X						X

TABLE 3.1 (Cont'd)

STATE AUTHORITIES

STATE	LEAD AGENCY(S)	Statutory Law	Rules/ Regulations	License/ Permit	Plan Review	Inspection	AGR	MUN	IND	OAG	MNG
Nebraska	Dept. of Env. Control	X	X	X	X		X	X	X		
	O&G Conservation Comm.	X	X	X						X	
Nevada	Dept. of Env. Protection	X		X			X	X	X		
New Hampshire	Water Supply & Pollution Control Commission	X		X	X		X	X	X		
	Dept. of Health & Welfare	X		X				X	X		
New Mexico	Env. Improvement Division		X	X	X		X	X	X	X	X
	Oil Conservation Division	X	X	X		X				X	
	Coal Surface Mining Bureau	X	X								X
New York	Dept. of Env. Conservation		X	X	X	X		X	X	X	
North Carolina	Dept. of Natural Resources & Community Development	X		X	X		X	X	X		X
	Dept. of Human Resources	X							X		
North Dakota	Dept. of Health	X	X	X	X	X	X	X	X		
	Geological Survey	X		X						X	X
	Public Service Commission		X		X						
Ohio	EPA	X	X	X	X		X	X	X		
	Dept. of Natural Resources,		X			X				X	X
Oklahoma	Corporation Commission	X	X							X	
	Dept. of Health	X	X			X	X		X		
	Water Resource Board	X	X	X			X	X	X		
	Dept. of Agriculture	X		X			X				
	Dept. of Mines	X								X	
New Jersey	Dept. of Env. Protection										
	Dept. of Water Resources	X	X		X			X	X		

TABLE 3.1 (Cont'd)

STATE AUTHORITIES

STATE	LEAD AGENCY(S)	Statutory Law	Rules/ Regulations	License/ Permit	Plan Review	Inspection	AGR	MUN	IND	OAG	MNG
Oregon	Dept. of Env. Quality	X	X	X	X		X	X			X
	Dept. of Geology & Mineral Ind.	X		X						X	
Pennsylvania	Bureau of Water Quality Management	X	X	X	X	X	X	X	X	X	X
	Bureau of Surface Mine Reclamation	X									X
	Bureau of Topographic & Geologic Survey	X								X	
Puerto Rico	Aqueduct & Sewer Auth	X						X			
	Env. Quality Board	X						X	X		
	Dept. of Health	X					X	X	X		
Rhode Island	Dept. of Env. Management	X	X	X	X				X		
South Carolina	Dept. of Health & Env. Control	X		X	X	X	X	X	X		
South Dakota	Office of Water Quality	X			X		X	X	X		X
Tennessee	Div. of Water Quality Control	X		X				X	X		
	Div. of Solid Waste Mgmt.	X	X						X		
Texas	Dept. of Water Resources	X	X	X	X	X	X	X	X		X
	Railroad Comm.		X			X				X	X
Utah	State Dept. of Health	X	X		X			X	X	X	X
Vermont	Agency of Env. Conservation	X		X	X			X	X		

TABLE 3.1 (Cont'd)

STATE AUTHORITIES

STATE	LEAD AGENCY(S)	Statutory Law	Rules/ Regulations	License/ Permit	Plan Review	Inspection	AGR	MUN	IND	OAG	MNG
Virginia	State Water Control Board	X	X	X				X	X	X	
	State Dept. of Health	X	X					X			
Washington	Dept. of Ecology	X		X		X		X	X		
West Virginia	Div. of Water Resources	X		X						X	
	Env. Health Division	X						X			
	Div. of Reclamation		X		X						X
Wisconsin	Dept. of Natural Resources	X		X	X			X	X		X
Wyoming	Dept. of Env. Quality	X		X	X		X	X	X		X
	O&G Conservation Comm.		X	X						X	
	Office of Ind. Siting Adm.		X		X				X		

data. Frequently, facilities which existed before regulations became effective were not subject to monitoring requirements and, in many States these laws and regulations are relatively recent. As a result, many older facilities are not subject to monitoring requirements even where such requirements exist.

A few States had developed computerized data bases that were sampled for selected parameters periodically. The ultimate aim of these programs was to establish background quality so that changes can be detected.

INSTITUTIONAL FRAMEWORK

The organization within States having responsibility for control of surface impoundments covers a broad spectrum of practices at the time of the study. In general, institutional approaches employed by the States may be characterized as single agency, lead agency with cooperating agencies, or multi-agency. Table 3.2 illustrates the percentage of States in these categories. It appears that the majority of States fall into the multi-agency category, i.e. have several agencies involved in regulating impoundments, with no specific agency taking the lead. It is difficult to make other conclusions on a nationwide basis from this table since some States did not include sufficient information to adequately characterize their program.

Many States indicated that having several agencies involved in water pollution control in general, and surface impoundment controls in particular, can cause problems. The surface impoundment survey revealed voids and overlaps in management authority, probably resulting from the involvement of several agencies. The State agencies often competed for limited resources to accomplish similar goals.

At the time the study was conducted the legislature in Maine had authorized a Ground Water Protection Commission, and regulations were being drafted for control of hazardous waste. In Colorado, a ground-water quality task force responded to the passage of the Safe Drinking Water Act by promulgating State rules which will serve to regulate surface impoundments. With increasing attention to the control of designated hazardous waste under RCRA, many additional States are currently considering actions to improve coordination among agencies involved in ground-water protection.

Impoundments in the Agricultural category were the most consistently unregulated facilities. Most States had no program pertaining to these, other than voluntary construction requirements established by the Soil Conservation Service (SCS). After agricultural impoundments, oil and gas sites were the least regulated, particularly in the producing States in the East and Midwest. Even in the West and Southwest, where regulations

INSTITUTIONAL APPROACHES

	NUMBER OF STATES	PERCENT
Single Agency	11	22%
Lead Agency-with Cooperating Agencies	9	18%
Multi-Agency	19	38%
No Data	11	22%

Table 3.2

either prohibit or severely limit the use of oil and gas impoundments, the large number of such sites in the inventory indicated that regulations were not strictly enforced.

PERSONNEL AND FUNDING

The issue most critical to the effectiveness of State programs and most frequently mentioned by the States was funding and, as a result, staffing. In general, the States found current funding and staffing inadequate. A few States indicated that funding and staffing were taxed just to maintain present programs. Several States noted unfilled positions due to lack of funding or hiring constraints, and lack of qualified candidates.

Staffing qualifications varied from State to State but most positions dealing with ground-water contamination in general, and surface impoundments in particular, require training in hydrology or geology. However, most States had difficulty finding candidates with adequate training.

Ohio was training existing staff in ground water science and policies and was hiring persons with some ground water background. In many States, the staff had training in sanitary engineering and water chemistry, but few had specific hydrogeologic expertise. This may reflect the bias towards surface water quality. States reported that the most critical issue to hiring qualified staff obtaining adequate funding and identifying competent candidates.

TECHNICAL DESIGN CRITERIA

Most States had established some type of technical design criteria for siting, constructing, or operating surface impoundments. Here again there was a wide disparity between States as to what was required, and often considerable difference in technical requirements between agencies of a single State. Most States applied design criteria on a case-by-case basis depending on hydrogeologic conditions, type of waste and category of impoundment, and aquifer quality and use. The technical requirements most commonly employed by the States included liners, buffer zones in the vicinity of production wells, and the use of water quality standards.

The most common technical requirement was the use of liners to prevent seepage. Liners were usually required to meet a certain maximum permeability. The use of liners as a requirement often depended on waste type. Many States also used buffer zones in the vicinity of production wells. Essentially this type of requirement is not designed to protect ground water, itself, but it does isolate areas of aquifers used as drinking water supplies from potential sources of contamination. Isolation zones prohibit siting of disposal facilities within a given distance from a well. In most cases, the distance is determined by the type of well and hydrogeologic conditions in the vicinity of the well. Distances varied considerably, with one State requiring as little as a 200 ft. buffer and another a buffer in excess of 2000 ft. While a number of States were moving towards ground-water standards, at the conclusion of the study only nine (California, Florida, Maryland, New Jersey, New York, New Mexico, Nebraska, Utah, Virginia) had done so.

Several more States were in the process of developing new regulations, or legislation which would authorize them. Still other States were developing aquifer classification schemes based on use patterns and ground water quality. Many States were developing minimum standards for impoundments which were part of a treatment chain, but since this focuses primarily on surface features, such an approach may not significantly affect ground water contamination.

STATE ASSESSMENTS OF FEDERAL PROGRAMS

The principal Federal programs which the States discussed were the ones implemented under the Resource Conservation and Recovery Act (RCRA); the Clean Water Act (CWA); Safe Drinking Water Act (SDWA) which authorized the Underground Injection Control Program, the SIA, and the Sole Source Aquifer Program; and the Toxic Substances Control Program. There were a variety of attitudes on these programs.

For example, California found that Federal legislation and programs have had little effect on State programs because Federal guidelines were no more stringent that those of the State programs. Delaware, on the other hand, noted improvement in the State program directly attributable to Federal initiatives. Arkansas suggested that a ground-water protection program be developed in each State. On the other hand, Indiana stated that while both State and Federal programs are weak, EPA oversight is excessive. Kentucky cited excessive reporting requirements. Vermont noted a need for Federal research into the long range effects of hazardous materials on the environment and the development of uses and markets for these wastes.

The most frequent comment made by the States was the need for Federal programs to be more flexible and to acknowledge local needs of the States. South Dakota expressed a desire to see Federal programs place greater emphasis on local governments and their part in controlling ground water pollution. Several States, including Nebraska and Louisiana, noted that Federal programs do not always apply from region to region and from State to State due to variations in geology, hydrology, climate and other geographical features. Arizona pointed out a need for programs under CWA, SDWA, and RCRA to be coordinated and integrated so that the programs support one another and avoid duplication of effort. Several States noted that control is best achieved through existing or modified State programs but most required Federal funding to staff adequately and operate some existing programs and any new ones. Idaho noted that improved auditing of Federally-funded State programs to assure proper management and implementation could be the Federal government's "most valuable contribution to ensuring strong and uniform State enforcement policy."

CHAPTER IV

LOCATION AND COUNT

As stated in Chapter II, a total of 80,263 active and abandoned sites has been located and inventoried in the course of the SIA. These sites contain a total of 180,973* impoundments.

The inventoried sites, both active and abandoned are distributed among six categories designated as:

Municipal
Agricultural
Mining
Oil & Gas
and Other

Table 4.1 shows the nationwide distribution of sites and impoundments among these categories. Of the 80,263 sites, 31,386 were randomly chosen to be assessed as shown in Table 4.2. A State-by-State distribution of assessed sites is shown in Appendices I-IV. The assessment is described in Appendix A; it consists generally of ratings based on characteristics of the unsaturated zone, the saturated zone, the transmissivity of the aquifer, and the waste.

LOCATION AND COUNT

Active Sites

To provide for nationwide consistency in presenting and analyzing the results of the SIA, we reorganized some of the data provided by some States to get a uniform categorization of the sites. We based the reorganization on Standard Industrial Classification (SIC) codes to sort the data according to the original SIA instructions or the prevalent interpretation by the States. This was necessary only where States did not assign a given industrial group to the proper SIC code and, in general, States did an adequate job in identifying the correct classification code.

The relative importance, in terms of numbers, for each category is shown in Figure 4.1. Thirty-one percent of all sites, and 37% of all impoundments belong to the oil and gas category, making it the most important, in terms of numbers, in the data base. The municipal and agricultural categories come next in terms of number of located sites. The number of assessed

*All numbers and percentages presented in this chapter reflect the numbers in the data base and represent only an approximation of the actual numbers of sites and impoundments in the various categories of data presented.

LOCATED SITES

	Active Sites	Active Impoundments	Abandoned Sites	Abandoned Impoundments
Agricultural	14,677	19,167	173	270
Municipal	19,116	36,179	630	1,006
Industrial	10,819	25,749	941	2,163
Mining	7,100	24,451	264	587
Oil & Gas	24,527	64,951	463	537
Other	1,500	5,745	53	168
TOTAL	77,739	176,242	2,524	4,731

Total Located Sites 80,263
Total Located Impoundments 180,973

Table 4.1

ASSESSED SITES

	Active Sites	Active Impoundments	Abandoned Sites	Abandoned Impoundments
Agricultural	6,597	7,133	49	49
Municipal	10,675	13,626	147	152
Industrial	8,193	10,664	469	578
Mining	1,448	2,045	104	105
Oil & Gas	3,304	3,330	50	54
Other	327	327	23	26
TOTAL	30,544	37,125	842	964

Total Assessed Sites 31,386
Total Assessed Impoundments 38,089

Table 4.2

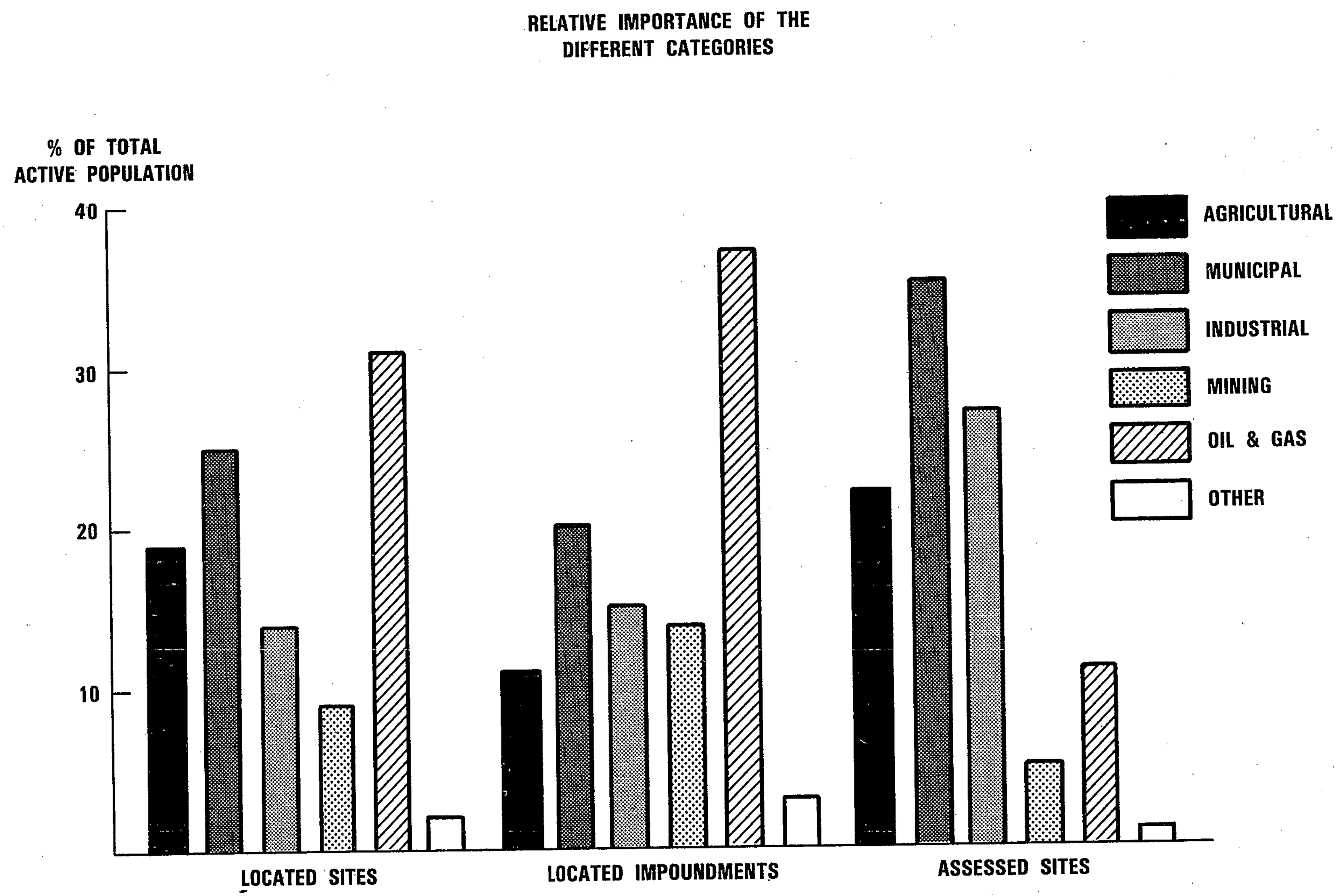

RELATIVE IMPORTANCE OF THE
DIFFERENT CATEGORIES
% OF TOTAL
ACTIVE POPULATION
40
30
20
10
AGRICULTURAL
MUNICIPAL
INDUSTRIAL
MINING
OIL & GAS
OTHER
LOCATED SITES
LOCATED IMPOUNDMENTS
ASSESSED SITES

Figure 4 .1

sites reflects the greater emphasis placed on municipal and industrial sites, while the mining and oil and gas category were given less consideration. The study specified this approach since mining, oil and gas sites, and agricultural sites are generally located in more remote areas and therefore have a lower potential for adverse impact on large numbers of people.

Agricultural Category

Included in the agricultural category are all impoundments associated with farming, crop production and animal husbandry. Specifically excluded are slaughterhouses and other animal processing facilities which belong in the industrial category.

The location of the agricultural sites, depicted in Figure 4.2, shows a high concentration of these sites in the Midwest and the central and southeastern United States. Heaviest concentrations are in Minnesota, Missouri, Kansas, Nebraska, South Carolina, Georgia, Michigan, and Illinois. The States of Louisiana and Nevada chose not to inventory agricultural sites.

A breakdown by SIC codes is contained in Table 4.3 and shows that general livestock and dairy farms comprise the greatest number of sites, followed by hog farms and cattle feedlots.

Municipal Category

Three types of facilities make up the municipal category.

1 - All domestic waste treatment facilities regardless of ownership, including municipal sewage treatment plants and privately owned facilities located at hotels, restaurants, mobile homes, parks and subdivisions (SIC code 4952).

2 - Impoundments associated with water treatment facilities (SIC code 4941).

3 - Impoundments used to collect seepage and run off at landfills (SIC code 4953).

The location of the municipal sites is depicted in Figure 4.3, and shows a higher concentration in the eastern half of the nation. The location of these sites is evidently tied to the population centers. The apparently higher concentration in Florida is deceptive since septic tank drainfields were included by this State in the inventory of municipal impoundments.

A breakdown by SIC codes is contained in Table 4.4, and shows that the majority of sites in this category are the sewage treatment plants and other domestic waste treatment facilities.

AGRICULTURAL SITES

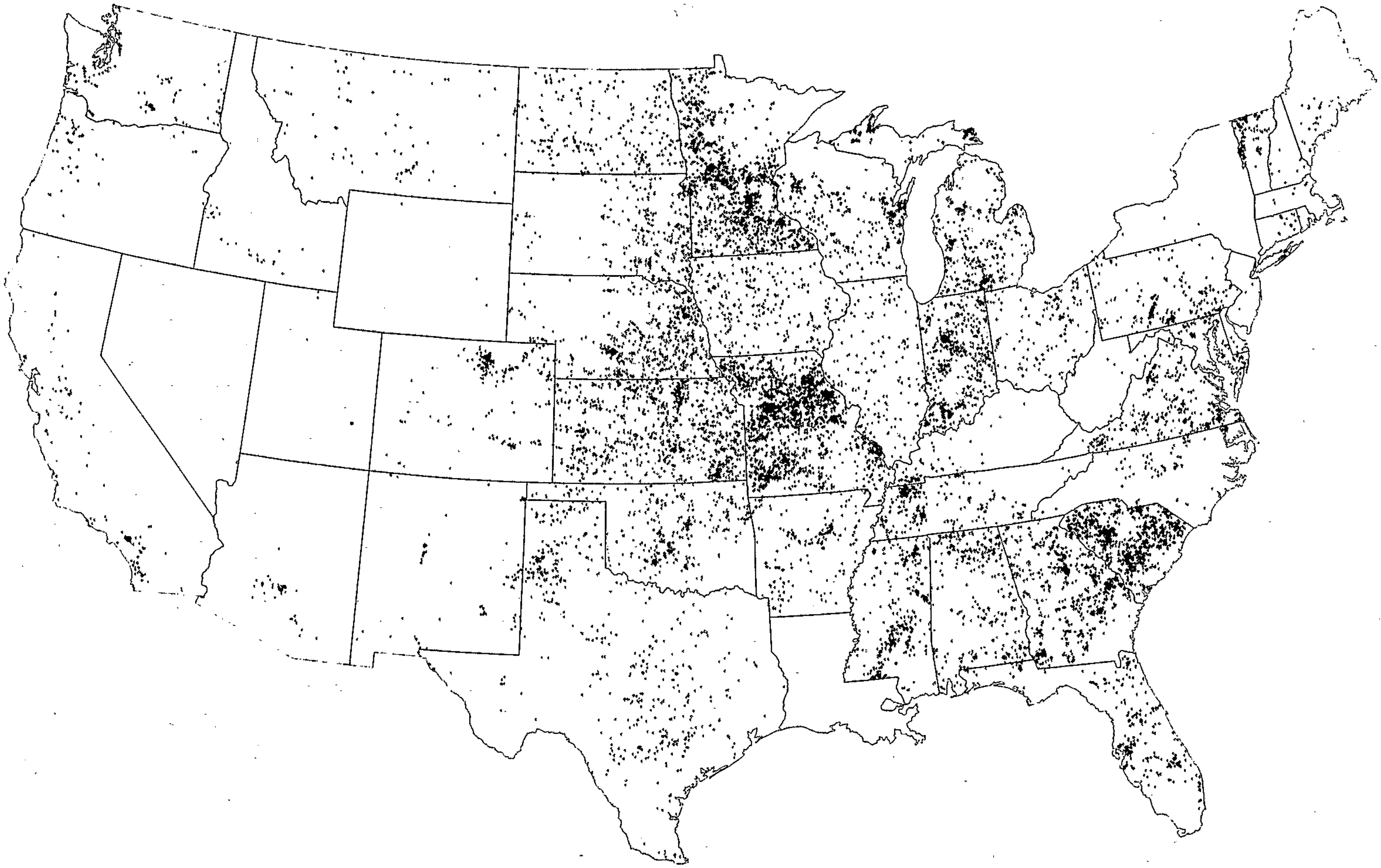


Figure 4.2

Note: Louisiana and Nevada did not
inventory agricultural sites

SIC CODE BREAKDOWN OF AGRICULTURAL SITES

SIC Code	Type Facility	Located Sites	Located Impoundments	Assessed Sites
01	Crop Production	90	190	81
0211	Cattle Feedlot	1,599	2,974	413
0213	Hogs	2,528	3,492	1,062
021, 0212, 0214, 0291	Livestock General	4,402	5,333	2,049
0241	Dairy Farms	4,141	4,732	2,058
025	Poultry Farms	515	717	284
027	Other Fur Bearing Animals	215	336	132
029	General farms	1,112	1,208	504
0921	Fish Hatcheries	18	95	14

Table 4.3

MUNICIPAL SITES

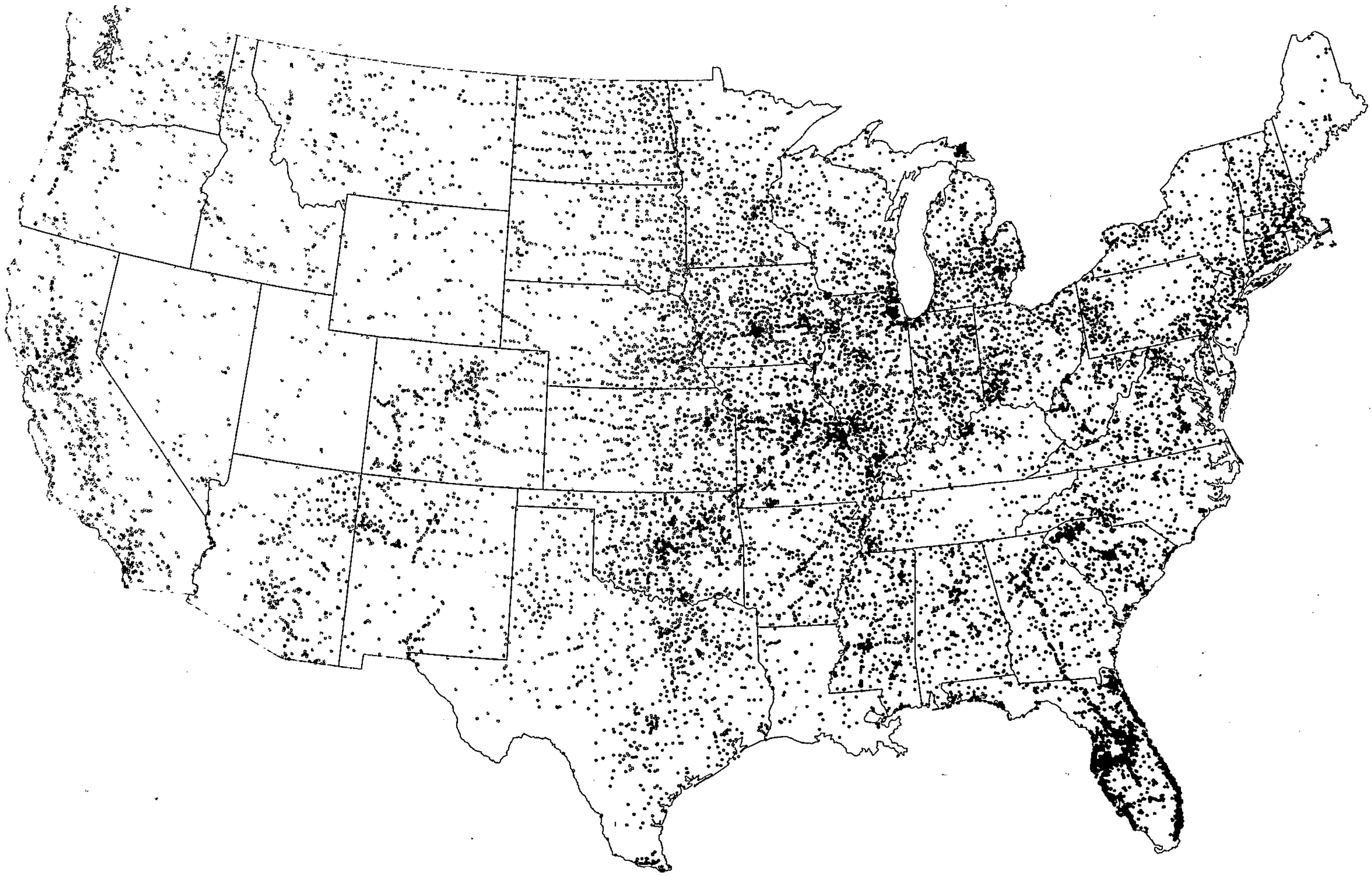


Figure 4.3

SIC CODE BREAKDOWN OF MUNICIPAL SITES

SIC Code	Type Facility	Located Sites	Located Impoundments	Assessed Sites
4941	Water Treatment Plant	768	1,307	483
	Sewage Treatment Plant	17,467	32,856	9,740
	Municipal Sanitary Landfill	179	446	149

Table 4.4

The small number of sites in the sanitary landfill category is probably due to general lack of knowledge about these sites and may not be a true representation for this type of impoundment.

Industrial Category

The industrial category includes all impoundments used in the processing, storage or disposal of industrial waste but excludes impoundments used for raw or processed material storage or in the manufacturing process. The location of the industrial sites is depicted in Figure 4.4, and shows a higher concentration in the eastern part of the nation and along the West Coast.

A breakdown by SIC codes is contained in Table 4.5 and shows that impoundments are widely used throughout industry. The most important users of impoundments are the food processing industry (2,087 sites and 4,960 impoundments) and the chemical industry (1,414 sites and 4,377 impoundments). Other industries accounting for more than 1,000 impoundments each are the petroleum refineries; power plants; paper and allied products; stone, clay and glass products; primary metals; and fabricated metals.

Oil and Gas Category

The oil and gas category is comprised strictly of impoundments associated with oil and gas extraction, commonly known as brine pits. Two types of brine pits are found in the oil fields--disposal pits, which most States discourage except where they do not endanger ground water, and emergency pits, where generally the brine should not be held for more than 24 to 72 hours. Because they are used extensively and sometimes on a continuous basis, emergency pits, normally excluded from the SIA, were included by most States for this category. Well drilling mud pits were excluded and refinery wastes are included in the industrial category.

There are 24,527 oil and gas sites in the data base with a total of 64,951 impoundments, and 3,302 sites which have been assessed. A geographic breakdown of the sites is provided in Figure 4.5. Because of the high concentration of these brine pits in very localized areas, these sites are most often not representative of ownership or of single facilities as in the other categories. In Arkansas each oil field was considered a site; in the small fields, each impoundment was counted, but in the larger fields, the total count was extrapolated from the count in one portion of the field. New York assumed one impoundment per lease and used well coordinates for the impoundment location. Pennsylvania assumed one impoundment per well. In Texas the impoundments were grouped by oil field or by 5 minute quadrant. Coordinates for the center of the oil field or of the 5 minute quadrant were used as site coordinates. In New Mexico, all impoundments within a given

INDUSTRIAL SITES

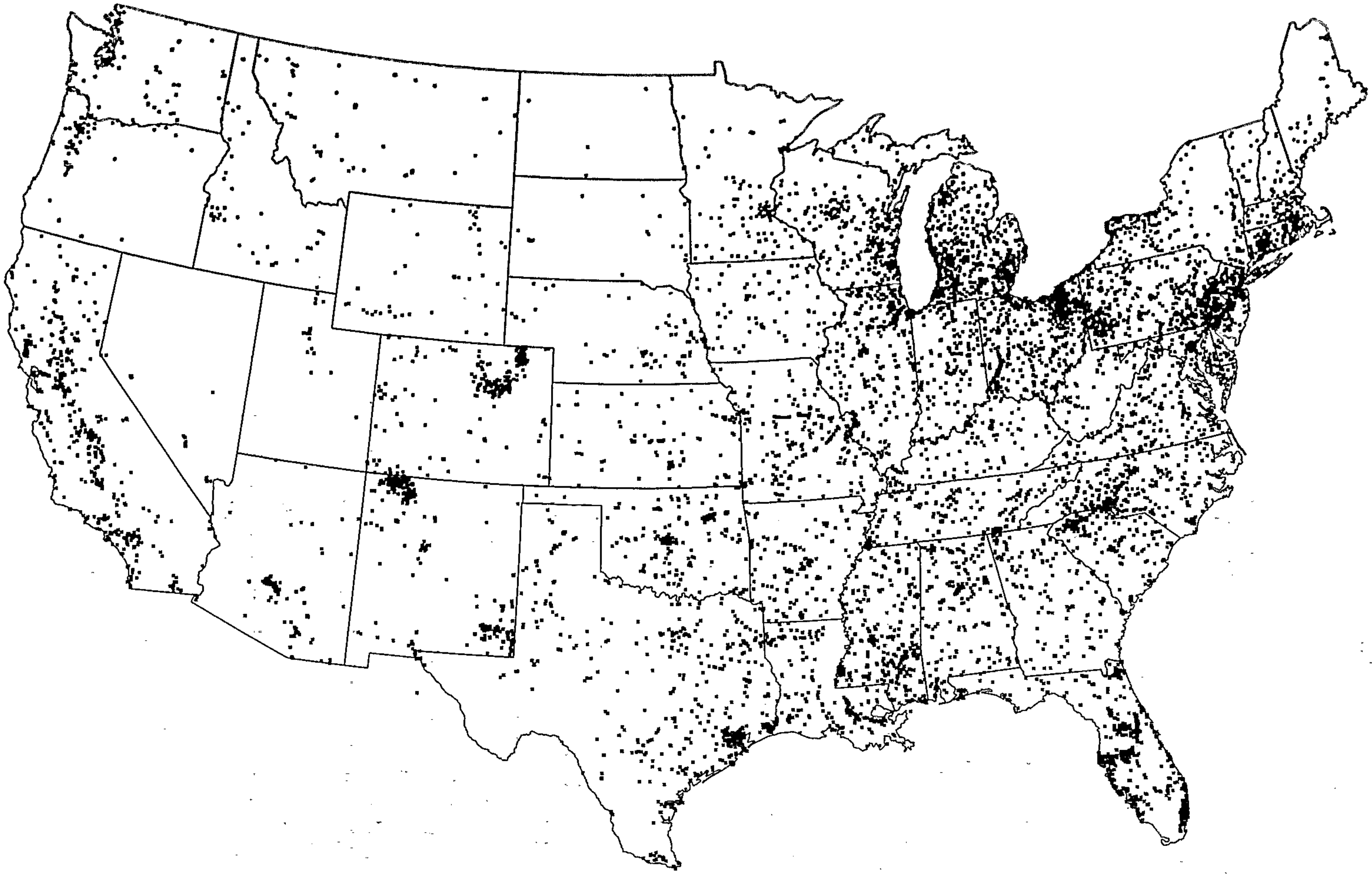


Figure 4.4

INDUSTRIAL SITES

SIC Code	Type Facility	Located Sites	Located Impoundments	Assessed Sites
1389	Oil Field Services	266	764	97
07	Agric. Services	93	167	83
20	Food	2,087	4,960	1,608
21	Tobacco	6	11	5
22	Textile Mills	258	536	210
23	Apparel	10	13	10
24	Lumber and wood	348	781	294
25	Furniture & Fixtures	23	35	20
26	Paper & Allied	371	1,249	288
27	Printing & Publishing	18	24	15
28	Chemical & Allied	1,414	4,377	1,176
29	Petroleum & Allied	671	1,884	537
30	Rubber & Misc. Plastics	156	252	129
31	Leather Products	34	104	31
32	Stone, Clay & Glass Products	698	1,243	580
33	Primary Metals	574	1,380	444
34	Fabricated Metals	661	1,316	513
35	Machinery	174	294	141
36	Electric & Electronic	200	391	177
37	Transportation Equip.	217	487	152
38	Instruments	47	92	36
39	Misc. Manufacturing	235	359	120
40-47	Transportation	310	516	239
491	Power Plants	543	1,671	442
492	Gas Production & Dist.	240	543	63
493	Combination Elec/Gas	39	81	37
496	Steam Suply	17	35	14
4953	Industrial Refuse Sites	199	602	162
517	Petroleum Bulk Terminal	65	141	47
554	Service Stations	50	65	45
721	Cleaning Establishments	251	381	130
7542	Car washes	59	72	49

Table 4.5

OIL AND GAS SITES

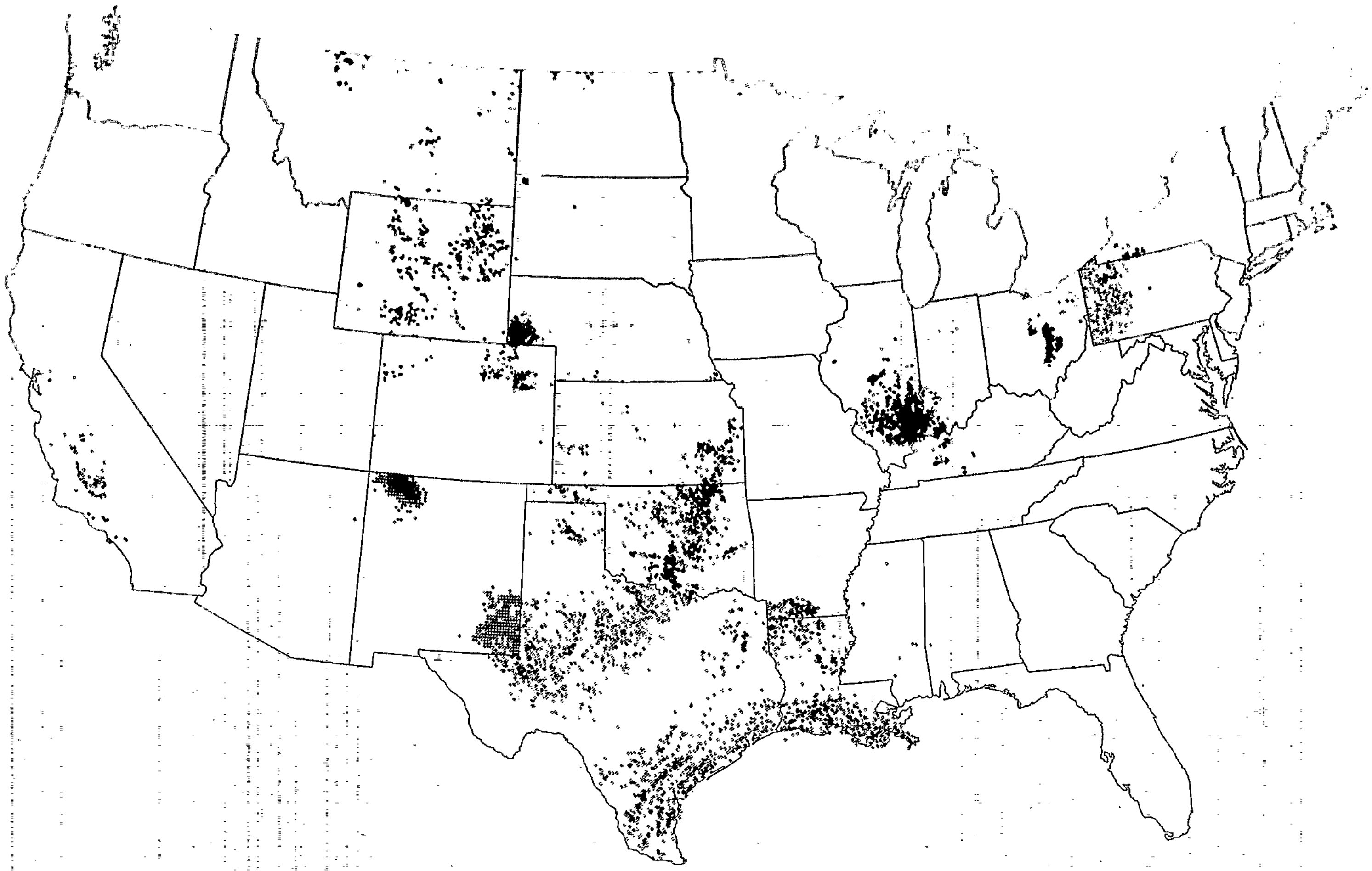


Figure 4.5

36 square mile township range were given the coordinate of the center of the range, which explains the regular pattern observed in that State.

Mining Sites

The mining category includes impoundments associated with ore extraction and on site activities such as washing, crushing and sorting of ore, as well as treatment of mine wastewater. It does not include milling and processing wastes which are included in the industrial category.

The geographic distribution of mining sites is illustrated of Figure 4.6 and shows a higher concentration of sites in Pennsylvania, Ohio and West Virginia, associated mostly with coal mining. Some ore mining activity takes place in almost every State except Maine, New Hampshire, Rhode Island, Massachusetts and Delaware.

The type of mining activities going on in each State is illustrated in Figure 4.7. Table 4.6 which is a breakdown of mining sites by SIC code, shows that the majority of sites and impoundments are associated with bituminous coal and lignite mining.

As in the oil and gas category, the sites do not necessarily represent ownership or facilities. For example, in Ohio, the count includes "strip pits" grouped by 7.5 mn quadrangle with each quarter of the quadrangle counted as a site.

In Pennsylvania, the State assumed each deep mine permitted after January 1, 1966 had at least one impoundment located near the mine portal, and each surface mine permitted after January 1, 1972 was also assumed to have one impoundment. This method did not distinguish between active and abandoned sites.

Abandoned Sites

Most States only recorded data on abandoned sites as they were found during the inventory of active sites. Some States did not inventory them at all; therefore, the data on abandoned sites are not complete and cannot be used to draw any conclusions on a nationwide basis since there are not enough facilities to provide a statistically valid data set.

The inventory of abandoned sites is presented in Appendix B.11. Abandoned sites account for 6 percent of all located sites in the data base. A distribution by category is shown in Figure 4.8 and is a reflection of the emphasis placed by the States on diverse categories rather than a true representation of the abandoned sites population. Most abandoned sites inventoried and most of the ones assessed fall in the industrial category.

MINING SITES

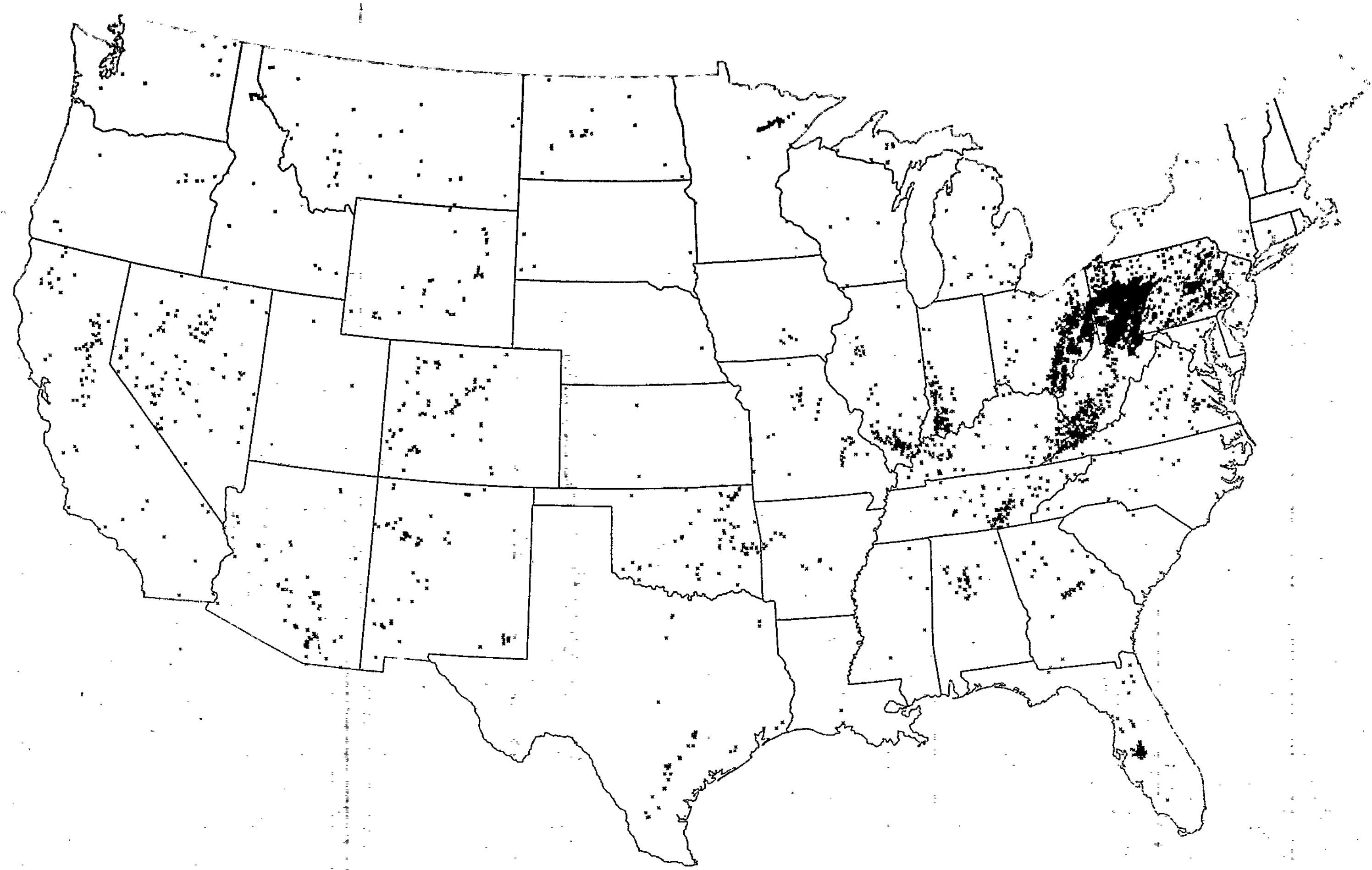


Figure 4.6

TYPE OF MINING ACTIVITY

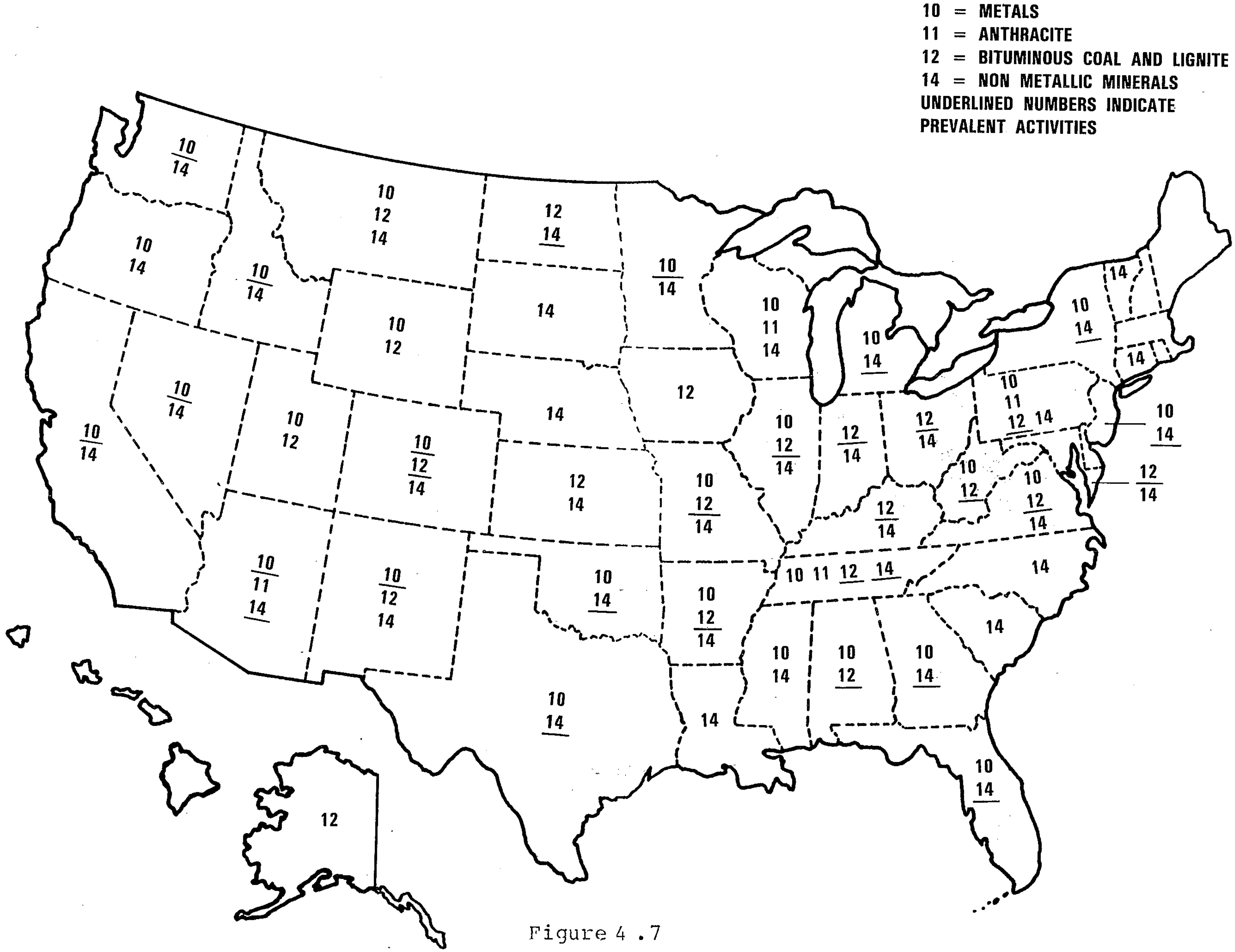
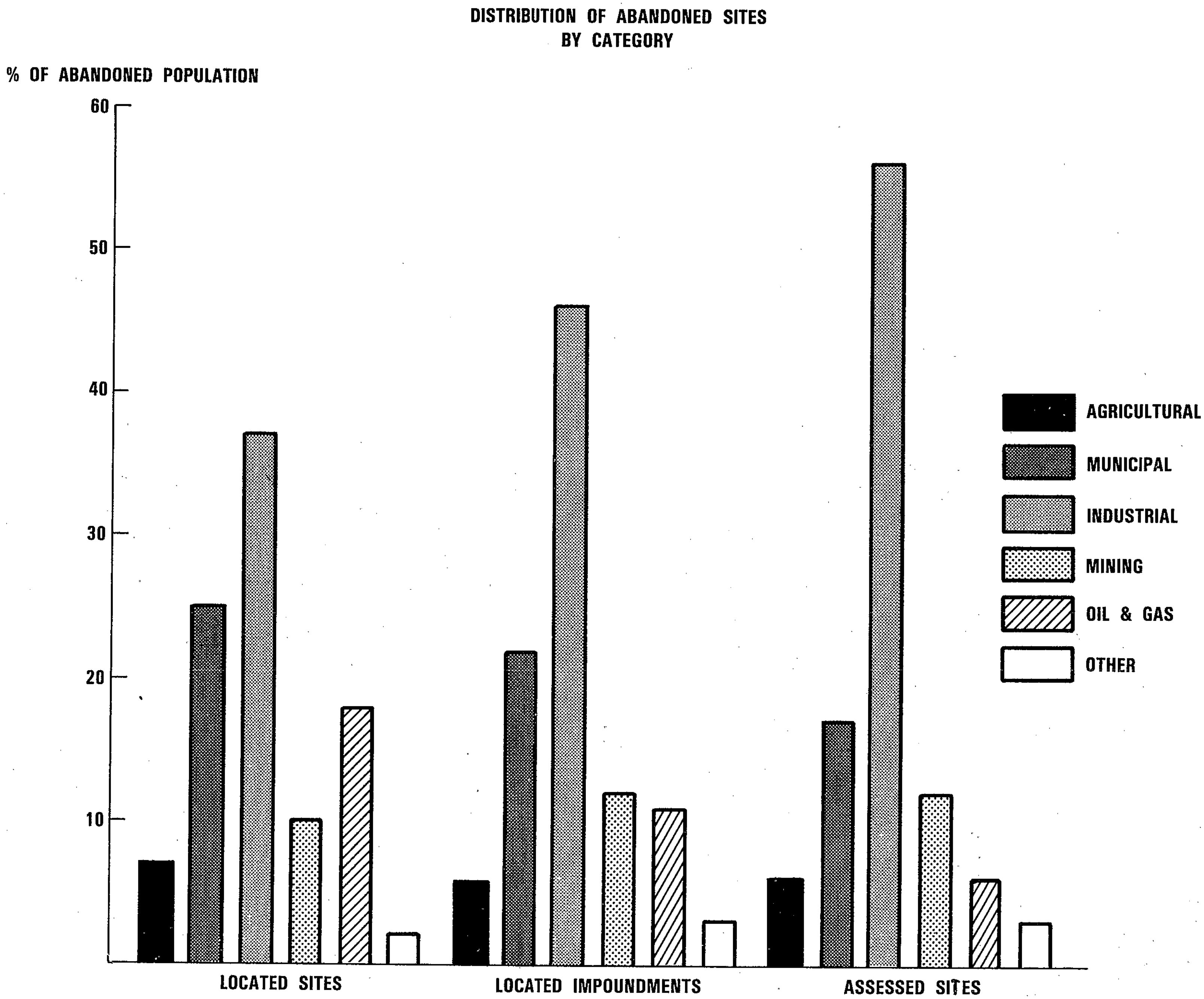


Figure 4 .7

SIC CODE BREAKDOWN
FOR
MINING SITES

SIC Code	Type Facility	Located Sites	Located Impoundments	Assessed Sites
10	Metals	501	1,754	247
11	Anthracite	350	459	7
12	Bituminous Coal and Lignite	5,038	19,891	830
14	Non-Metallic Minerals	1,187	2,272	369

Table 4.6



DISTRIBUTION OF ABANDONED SITES
BY CATEGORY
% OF ABANDONED POPULATION
60
50
40
30
20
10
AGRICULTURAL
MUNICIPAL
INDUSTRIAL
MINING
OIL & GAS
OTHER
LOCATED SITES
LOCATED IMPOUNDMENTS
ASSESSED SITES

Figure 4.8

CHARACTERISTICS OF IMPOUNDMENTS

The data collected on the randomly chosen "assessed sites" consist of two parts, data on the characteristics of the impoundments (purpose, age, size, construction features) and the hydrogeologic assessment of the site. The impoundment characteristics will be discussed here, with the hydrogeologic assessment discussed in the following chapter.

A distribution of the assessed sites is shown in Figure 4.9. A majority of the located industrial sites (75 percent) were assessed, representing 41 percent of the impoundments in this category. Approximately half of the agricultural and municipal sites (45 percent and 56 percent respectively) were assessed, representing 37 percent of the agricultural impoundments and 38 percent of the municipal impoundments.

In contrast only 20 percent of the located mining sites and 13 percent of the located oil and gas sites were assessed. This represents 8 percent of the mining impoundments and 5 percent of the oil and gas impoundments, making detailed analysis of the data in these two categories less meaningful.

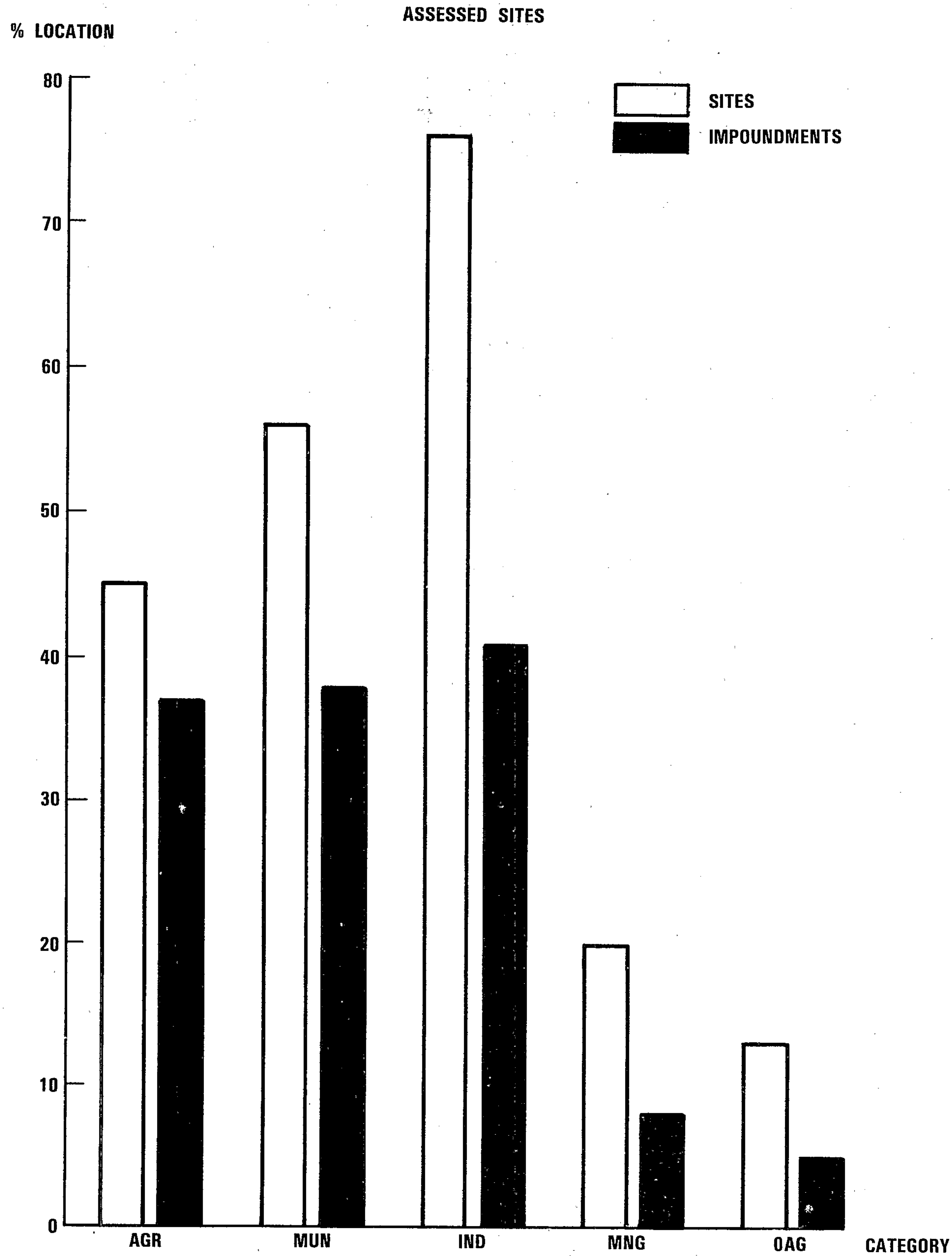
Purpose of Impoundments

A summary of the primary purposes of the impoundments is contained in Table 4.7. In the municipal category, the primary purpose is treatment. Impoundments associated with water treatment plants are most often used for settling of sludges. At sewage treatment plants, the most common uses are settling of raw and treated sewage, and oxidation and stabilization of primary and secondary effluent.

Impoundments in the industrial category serve a multitude of purposes; 52 percent of the impoundments are used for treatment of the waste: settling, anaerobic or aerobic digestion, pH adjustment, equalization, polishing, etc. Fifty-five percent of the impoundments in the agricultural category are used for waste storage, usually prior to land application. In the mining category, the primary use is treatment which generally consists of settling prior to discharge into streams. In the oil and gas category the primary use (67 percent) is disposal; 29 percent of the oil and gas impoundments in the data base are storage, (i.e. emergency pits), and 4 percent are used for treatment prior to discharge, (usually oil skimming).

Size of Impoundments

The size distribution of the impoundments in the various categories is shown in Table 4.8. In the agricultural category, most of the impoundments (87 percent) cover less than one acre in surface area with the largest reported agricultural impoundment 665 acres.



ASSESSED SITES
% LOCATION
80
70
60
50
40
30
20
10
0
SITES
IMPOUNDMENTS
AGR
MUN
IND
MNG
OAG
CATEGORY

Figure 4.9

PURPOSE OF IMPOUNDMENTS
(By Percent)

	Storage	Disposal	Treatment
Agricultural	55	26	19
Municipal	5	31	64
Industrial	17	31	52
Mining	18	27	56
Oil & Gas	29	67	4

Table 4.7

IMPOUNDMENT SIZE

(Acres)

% Sites	<.1	0.1-<1	1-<5	5-<10	10-<100	>100
Agricultural	20	67	10	1	2	<1
Municipal	20	37	30	6	7	<1
Industrial	29	40	20	5	5	1
Mining-Metals	10	26	22	6	29	7
Mining-Coal & Lignite	24	60	6	4	5	1
Mining-Other Non-Metals	5	21	22	11	21	20
Oil & Gas	46	29	23	<1	<1	--

Table 4.8

In the municipal category, most of the impoundments are less than five acres (87 percent), with a slight predominance of impoundments in the 0.1 and 1 acre range. The larger municipal impoundments (largest reported is 850 acres) are usually oxidation ponds and sludge disposal lagoons.

The picture is similar in the industrial category where 89 percent of the impoundments are less than five acres. However, some 20 industrial impoundments have been reported which exceed 1,000 acres with the largest impoundment reported covering 5,300 acres. Most of these larger impoundments are located at power plants (cooling lakes), paper mills and copper refineries.

Because the practices included in the mining category vary widely in their use of impoundments, this category has been divided according to the SIC codes. Impoundments associated with coal mining are generally small; 84 percent are less than one acre.

They are larger in the other two categories. In the non-metal mining 52 percent of the impoundments are greater than five acres. Largest reported sizes are 299 acres in the coal mining category, 1,990 acres in the metals mining and 1,229 acres in the non-metal mining category.

Finally oil and gas impoundments are usually very small; 46 percent are less than 0.1 acres and 98 percent are less than five acres. The largest reported size is 79 acres.

Characteristics of Impoundments - Liners

The data show that 16 percent of agricultural impoundments are lined. This number increases to 23 percent in the municipal category and 28 percent in the industrial category. For the mining and oil and gas categories, the percentage of lined impoundments is 17 percent and 10 percent respectively. It should be noted that for the purpose of the national report, impoundments which used soil amendments (such as bentonite mixed with native soil) or compacted soils to reach a low permeability were considered to be lined. In some instances, States did not count such as lined. A complete discussion of the liner categories is provided in Appendix A.

The distribution of lined impoundments varies from State to State as shown in Figures 4.10, 4.11 and 4.12 for the agricultural, municipal and industrial categories. Some States are consistently higher than the national average (Idaho, Nevada, Oregon, Illinois, Pennsylvania, and Kentucky). While this is indicative of a generally stronger water protection program, it is in some cases a result of the hydrogeologic settings or specific industrial practices in the State. In some States certain categories are given more emphasis than others. In addition

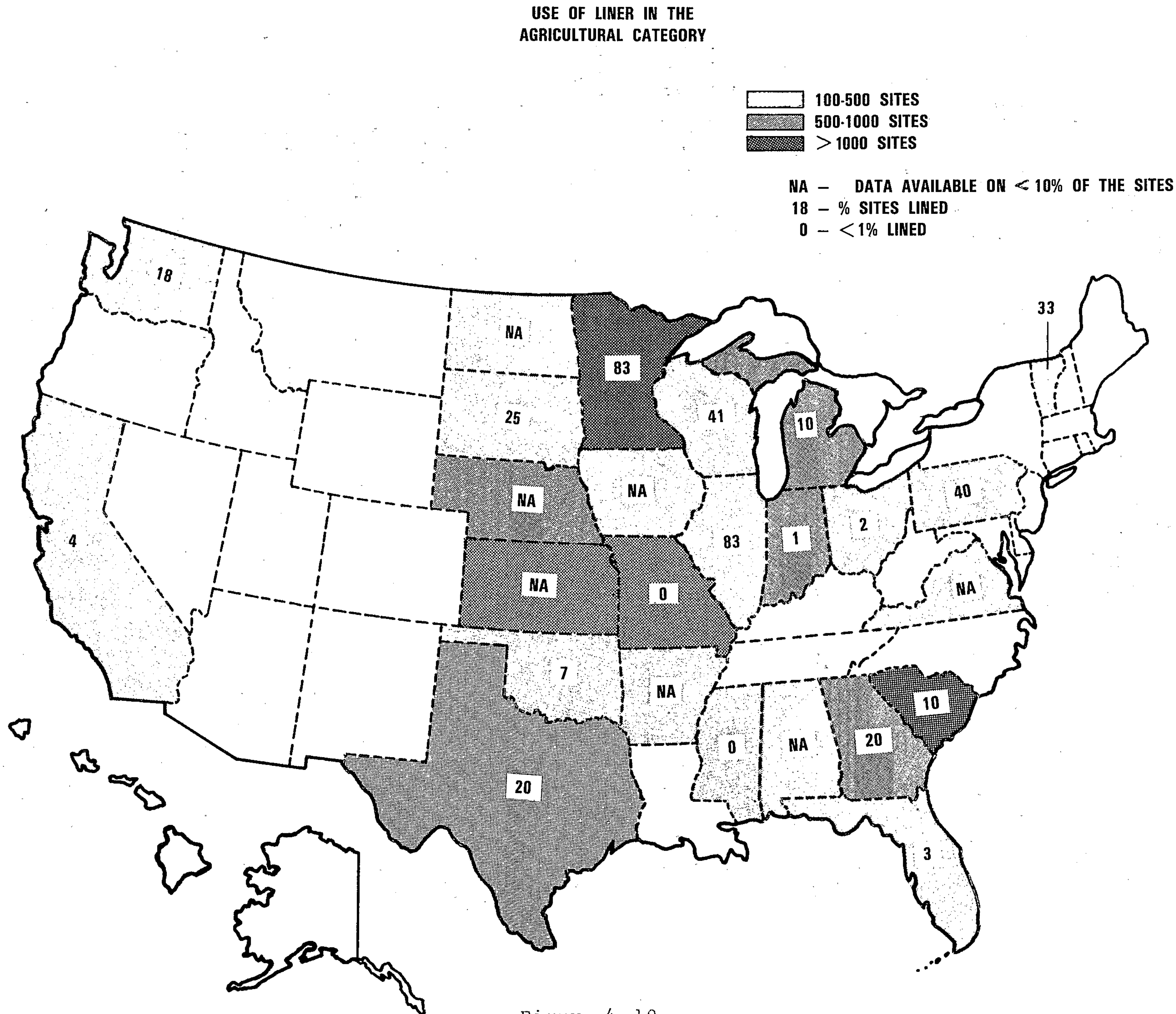

USE OF LINER IN THE
AGRICULTURAL CATEGORY
100-500 SITES
500-1000 SITES
>1000 SITES
NA – DATA AVAILABLE ON < 10% OF THE SITES
18 – % SITES LINED
0 – <1% LINED
18
NA
83
25
33
41
10
NA
NA
40
4
83
1
2
NA
0
NA
7
NA
10
0
NA
20
20
3

Figure 4.10

USE OF LINER IN THE
MUNICIPAL CATEGORY

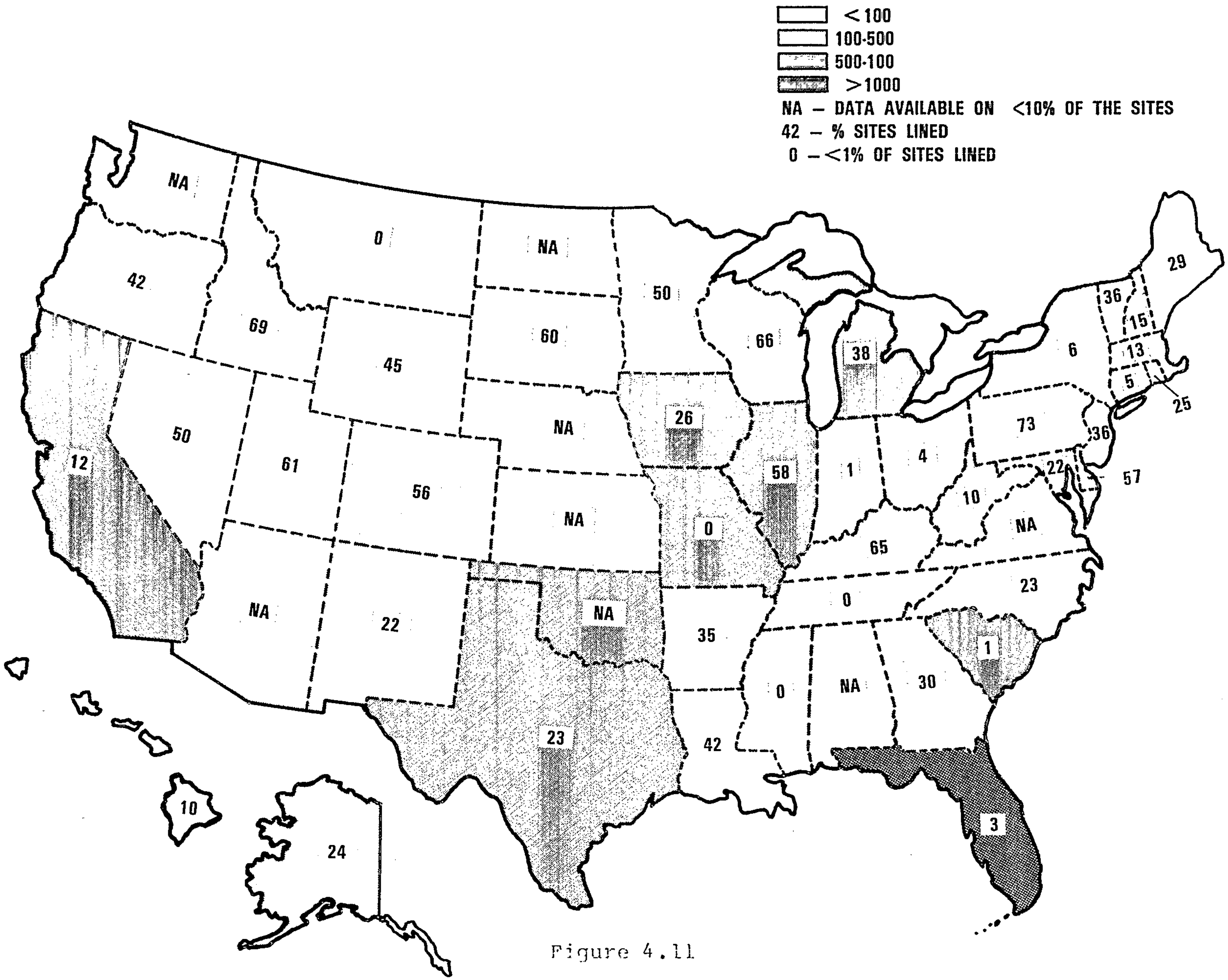


Figure 4.11

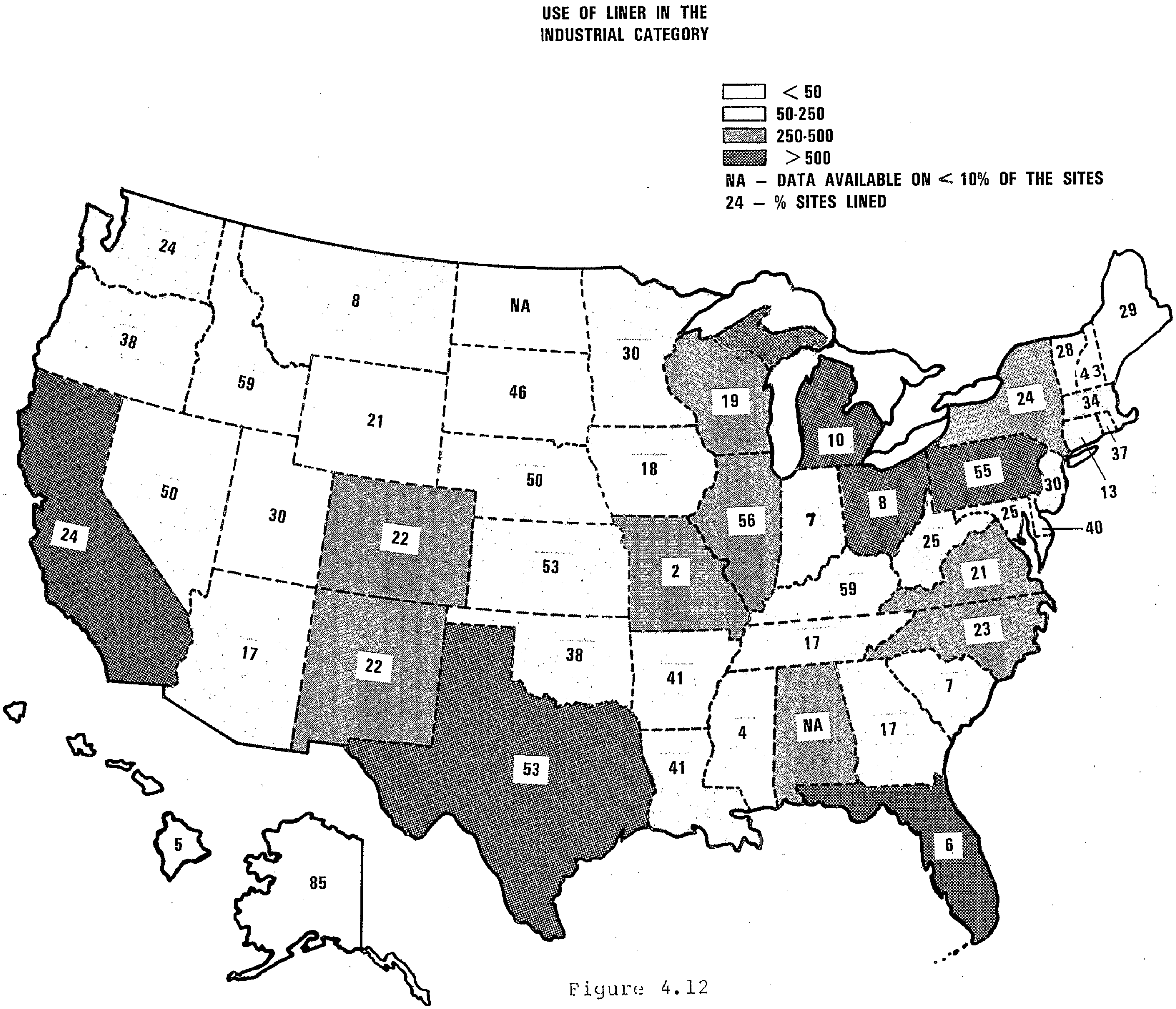

USE OF LINER IN THE
INDUSTRIAL CATEGORY
< 50
50-250
250-500
>500
NA – DATA AVAILABLE ON < 10% OF THE SITES
24 – % SITES LINED
24
38
59
8
NA
30
46
21
19
10
29
28
43
24
34
37
13
50
30
22
50
18
56
7
8
55
30
25
40
25
24
53
2
21
59
17
22
38
41
17
23
7
4
NA
17
53
41
6
5
85

Figure 4.12

to the States listed above, 50 percent or more of the industrial impoundments are lined in Texas, Nebraska, Kansas, and Alaska. In Minnesota 50 percent or more of the agricultural impoundments are lined, and more than 50 percent of municipal impoundments are lined in Wisconsin. In contrast, less than 10 percent of impoundments are lined in every category in Indiana, Ohio, South Carolina, Florida, Mississippi and Montana.

Because a small percentage of impoundments were assessed in the mining and oil and gas categories, the data in these categories do not lend themselves to State by State breakdowns. However, there was a sufficient amount of data to establish that in the oil and gas category, only 3 percent of the disposal pits are lined while 18 percent of the storage, i.e. emergency pits are.

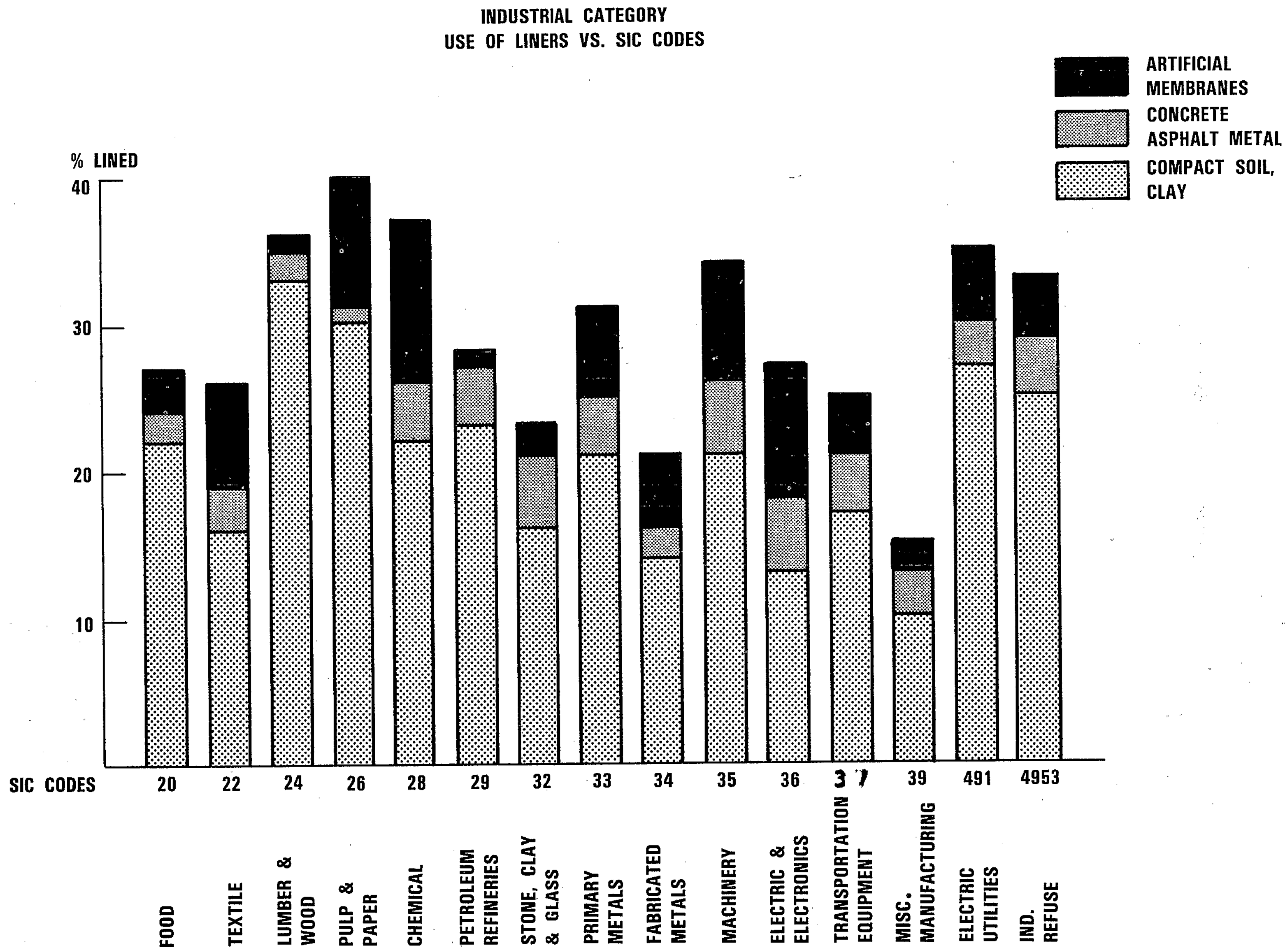
In the municipal category, impoundments located at landfill sites are lined more often than the other types of impoundments (30 percent to 21 percent). Figure 4.13 shows that in the industrial category there is a slight relationship between the use of liners and the SIC codes (e.g., SIC codes that are associated with potentially hazardous waste have a slightly higher percentage of lined impoundments) and more particularly between the type of liner used and the SIC code. For example, in SIC code 36--electric and electronic, which includes battery manufacturing --more than half the liners are synthetic, while in SIC code 24--lumber and wood products--most liners are naturally occurring soil materials. There is also a relationship between the age of the impoundments and the use of liners (Table 4.9). Generally the younger impoundments are lined more often than the older ones, reflecting an increased awareness of the need to protect ground water.

Impoundment Surveillance - Monitoring Wells

When the data on monitoring wells were entered in the computer, the difference between "unknown" and "no monitoring wells" was lost and the only hard data now retrievable are the number of sites with monitoring wells. A total of 1,564 sites are monitored: 725 of these fall in the industrial category and 634 in the municipal category.

The distribution of known monitoring wells, by State, for the municipal and industrial categories is shown in Figure 4.14 and 4.15. Monitoring, like lining, is more prevalent in some States than others. Florida, Pennsylvania, Texas and California account for 44 percent of the sites known to be monitored in the industrial category, and Florida and California account for 64 percent of the sites known to be monitored in the municipal category. In the industrial category monitoring is more prevalent in certain SIC codes. The distribution of monitoring by SIC codes is shown in Figure 4.16. These data show that 32 percent of the industrial refuse sites and 20 percent of the sites in the

Figure 4.13



INDUSTRIAL CATEGORY
USE OF LINERS VS. SIC CODES
ARTIFICIAL MEMBRANES
CONCRETE ASPHALT METAL
COMPACT SOIL, CLAY
% LINED
40
30
20
10
SIC CODES
20
22
24
26
28
29
32
33
34
35
36
37
39
491
4953
FOOD
TEXTILE
LUMBER & WOOD
PULP & PAPER
CHEMICAL
PETROLEUM REFINERIES
STONE, CLAY & GLASS
PRIMARY METALS
FABRICATED METALS
MACHINERY
ELECTRIC & ELECTRONICS
TRANSPORTATION EQUIPMENT
MISC. MANUFACTURING
ELECTRIC UTILITIES
IND. REFUSE

COMPARISON OF

INDUSTRIAL IMPOUNDMENTS

Age vs. Liner

AGE	% LINED
1 - 5	36
6 - 10	30
11 - 15	23
16 - 20	25
21 - 30	17
>30	18

Table 4.9

MONITORING WELLS
MUNICIPAL CATEGORY

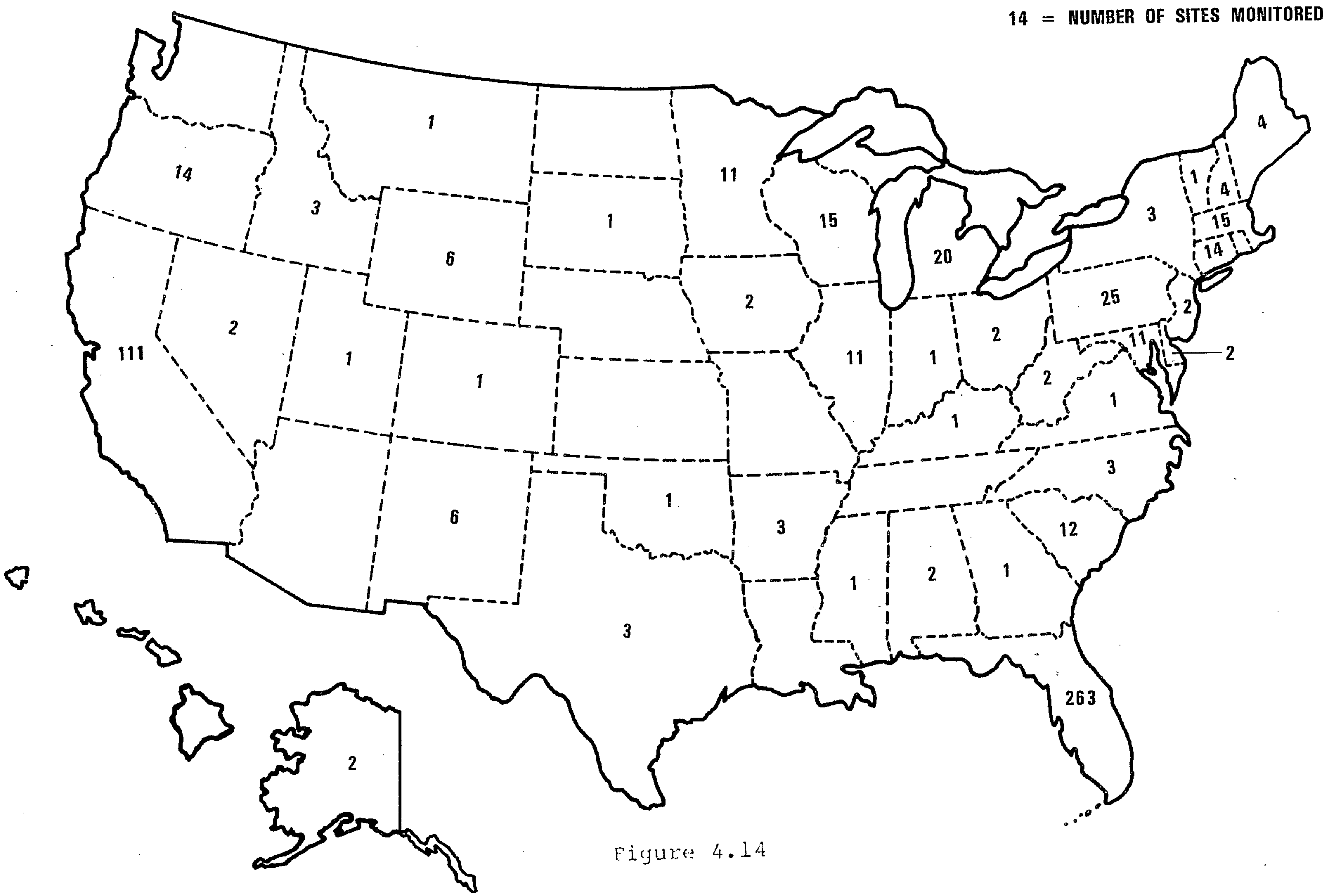


Figure 4.14

MONITORING WELLS
INDUSTRIAL CATEGORY

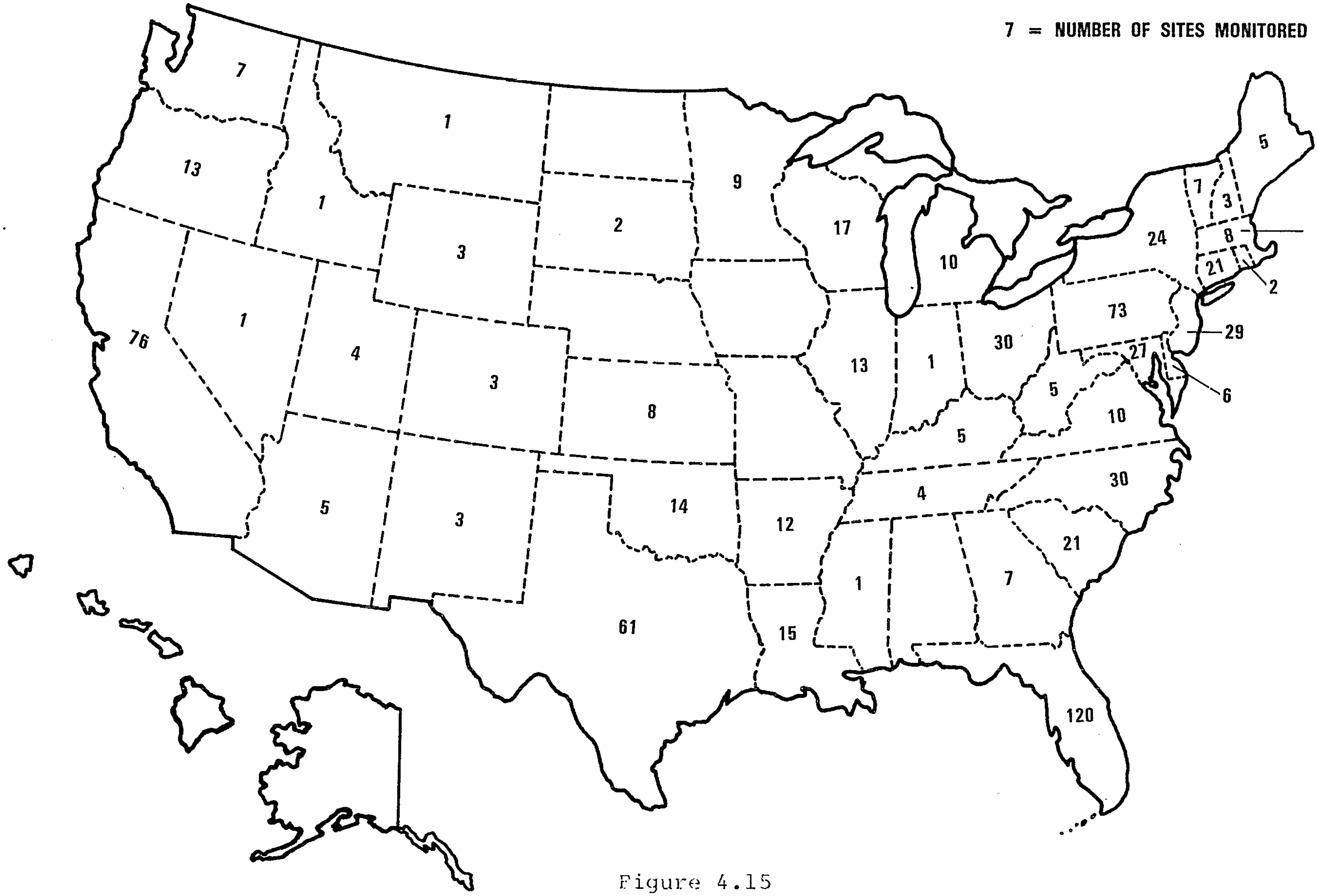


Figure 4.15

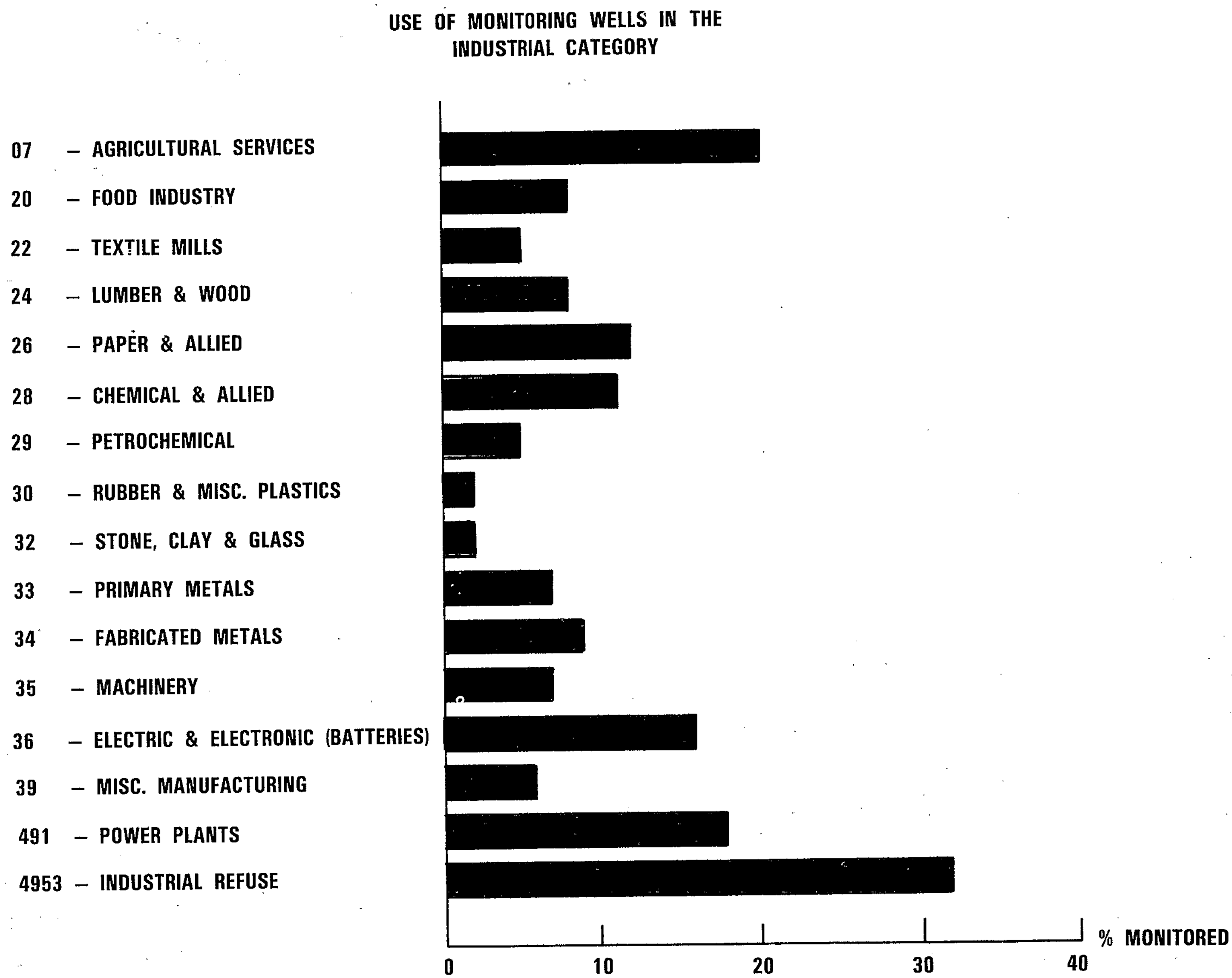

USE OF MONITORING WELLS IN THE INDUSTRIAL CATEGORY
07 – AGRICULTURAL SERVICES
20 – FOOD INDUSTRY
22 – TEXTILE MILLS
24 – LUMBER & WOOD
26 – PAPER & ALLIED
28 – CHEMICAL & ALLIED
29 – PETROCHEMICAL
30 – RUBBER & MISC. PLASTICS
32 – STONE, CLAY & GLASS
33 – PRIMARY METALS
34 – FABRICATED METALS
35 – MACHINERY
36 – ELECTRIC & ELECTRONIC (BATTERIES)
39 – MISC. MANUFACTURING
491 – POWER PLANTS
4953 – INDUSTRIAL REFUSE
% MONITORED
0
10
20
30
40

Figure 4.16

agricultural services category are being monitored; more than 10 percent of the sites are monitored in the Paper and Allied, Chemical and Allied and Electric and Electronic categories; and nearly 20 percent of the impoundments located at power plants are monitored.

CHAPTER V

ANALYSIS OF DATA

In this chapter, we will examine the results of the assessment and attempt to use the data to draw correlations that provide an insight on the potential impact of surface impoundments on ground water. Only the categories where the data can be considered valid on a nationwide basis will be used; these are data in the agricultural, municipal, industrial, mining and oil and gas categories. Excluded are the "abandoned" categories which are too incomplete, and the "other" category, which some States used to store data not directly related to the SIA, such as industrial septic systems and impoundments which were excluded by definition from the SIA. As in the preceding chapter, the numbers and percentages reflect the data base and are an approximation of the actual numbers.

RESULTS OF THE ASSESSMENT

Step 1, The Unsaturated Zone

Step 1 is intended as a measure of the ability of the unsaturated zone to impede or retard the downward movement of the waste contained in the impoundments. The score is based both on the thickness and lithology of the unsaturated zone.

A summary of the ratings for the unsaturated zone is shown in Table 5.1. This table shows a fairly even distribution of sites among the different types of earth materials, except for the very impermeable materials ($k = 10^{-7}$ cm/sec) where only 7 percent of the sites are located.

The numerical component of Step 1, which ranges from 1 to 9 can be used to divide the sites in three broad groups representing varying degrees of contamination potential.

Group I - A score of less than 3 represents sites located in thick and relatively impermeable unsaturated zones which would provide good protection to underlying aquifers.

Group II - A score of 3 to 6 represents sites where moderate protection to underlying aquifers is provided by a fairly impermeable or fairly thick unsaturated zone.

Group III - A score of greater than 6 indicates sites with a very thin or very permeable unsaturated zone affording little protection to underlying aquifers.

STEP 1 - RATING OF THE UNSATURATED ZONE

EARTH MATERIAL	Gravel, Medium to Coarse Sand Cavernous or Fractured Limestone, Evaporites, Basalt Lava Fault Zones		Fine to Very Fine Sand Fractured Igneous and Metamorphic (Except Lava) Sandstone (Poorly Cemented)		Sand with <15% clay, silt Sandstone (Moderately Cemented) Fractured Shale		Sand with >15% but ≤50% clay Sandstone (Well Cemented)		Clay with <50% Sand Siltstone		Clay Unfractured Shale, Igneous and Metamorphic Rocks	
Permeability cm/sec	$>10^{-2}$		10^{-4}–10^{-2}		10^{-5}–10^{-4}		$>10^{-5}$		$>10^{-6}$		$>10^{-7}$	
No. (%) Sites	6,236 (20)		5,675 (18)		6,623(21)		4,720 (15)		6,148 (19)		2,093 (7)	
Thickness (m)	Score	No.	Score	No.	Score	No.	Score	No.	Score	No.	Score	No.
>30	9	1,017	6	843	4	775	2	544	0	693	0	384
>10 ≤30	9	892	7	760	5	1,053	3	959	1	1,635	0	422
>10 ≤30	9	1,398	8	833	6	2,039	4	2,118	2	2,239	0	648
>1 ≤ 3	9	1,386	9	1,002	7	1,864	5	778	3	1,319	1	385
>0 ≤1	9	1,543	9	2,237	9	892	9	321	9	262	9	254

Table 5.1

An analysis of Figure 5.1 shows that nearly 50 percent of the sites fall in Group III. This percentage is highest in the municipal and industrial categories where 56 percent and 50 percent of sites respectively are located in areas where they threaten underlying aquifers. Thirty percent of the sites fall in Group II. The percentage of agricultural sites found in this group is significantly higher (43 percent) than for sites in the other categories.

Finally, 22 percent of all sites are located in areas where the unsaturated zones afford good protection to underlying aquifers. This percentage is highest in the oil and gas category (47 percent) and lowest in the municipal category (16 percent).

Step 2, The Saturated Zone

The Step 2 score is based on the saturated thickness and lithology, or the permeability of the saturated zone, and is a measure of the transmissivity of the aquifer. Table 5.2 shows that a majority of the sites (55 percent) are located over highly permeable aquifers, with only ten percent located over fairly impermeable formations ($k > 10^{-6}$ cm/sec). Using the same rationale as in Step 1, the sites can be divided in three groups:

Group I - A score of less than 3 indicates aquifers with very low transmissivity where contaminants would move slowly.

Group II - Sites where Step 2 = 3 are located over thin or moderately permeable aquifers.

Group III - A step 2 score greater than 3 indicates sites located in ares where thick and very permeable aquifers would allow a widely dispersed contaminant plume.

An analysis of Figure 5.2 shows that the data are definitely skewed towards Group III. Seventy-one percent of all sites fall in this group. The industrial category has the greatest percentage (78 percent), while the mining category has the lowest (47 percent).

Approximately 20 percent of all sites fall in Group II, with the mining category leading the ranks in this group (32 percent).

Only 11 percent of all sites fall in Group I. Mining and oil and gas sites appear more frequently in this group (21 percent and 18 percent respectively) than the other categories.

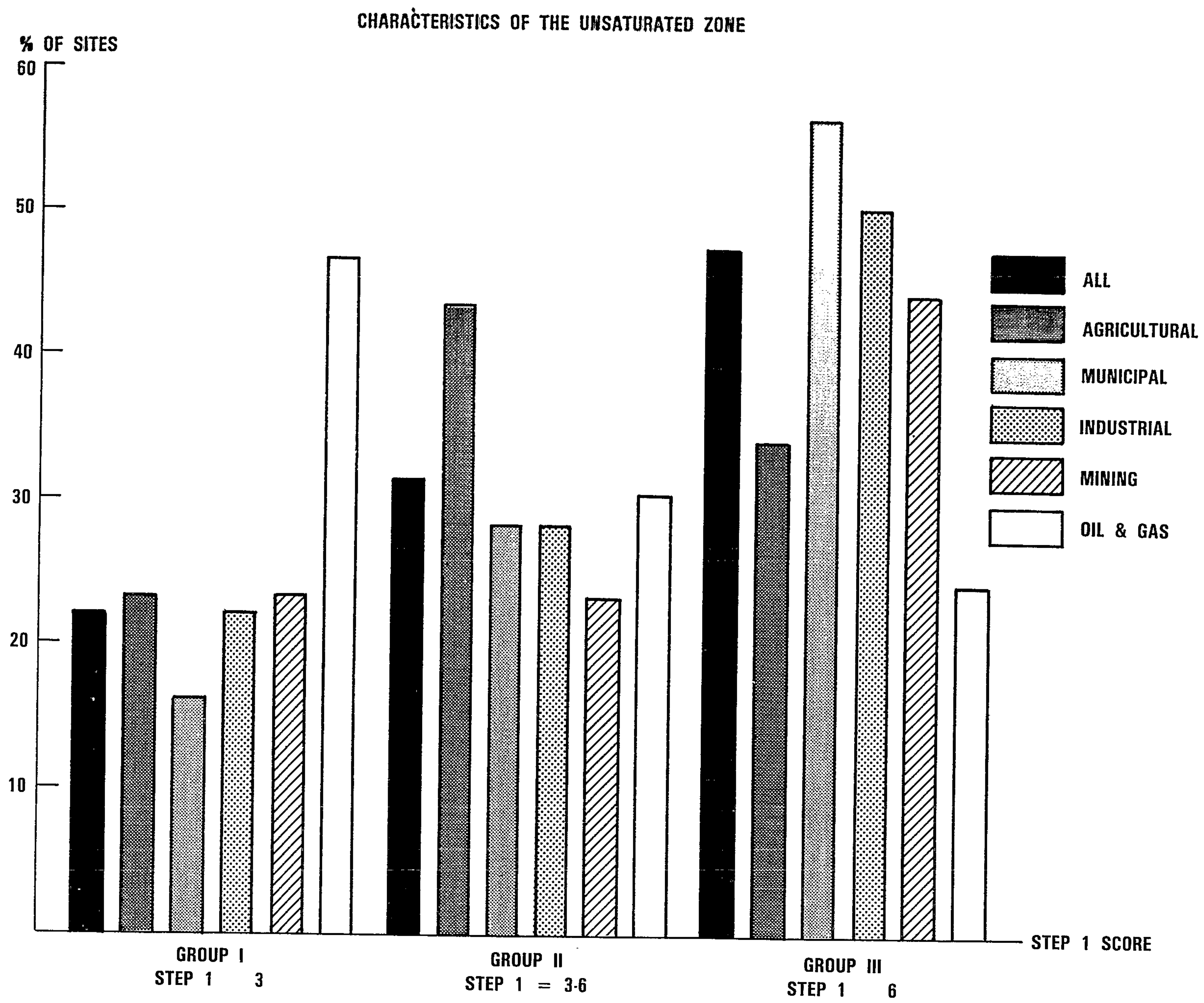

CHARACTERISTICS OF THE UNSATURATED ZONE
% OF SITES
60
50
40
30
20
10
GROUP I
STEP 1 3
GROUP II
STEP 1 = 3-6
GROUP III
STEP 1 6
STEP 1 SCORE
ALL
AGRICULTURAL
MUNICIPAL
INDUSTRIAL
MINING
OIL & GAS

Figure 5.1

STEP 2 - RATING OF THE SATURATED ZONE

EARTH MATERIAL	Gravel or sand Cavernous or Fractured Rock, Poorly Cemented Sandstone, Fault Zones		Sand with >50% clay Moderately Well Cemented Sandstone, Fractured Shale		Clay with $\geq$50% sand Siltstone, Unfractured Shale and other Impervious Rock	
Permeability (cm/sec)	$>10^{-4}$		10^{-4}-10^{-6}		$<10^{-6}$	
No. (%) Sites	17,298 (55)		11,069 (35)		3,087 (10)	
Thickness (m)	Score	No.	Score	No.	Score	No.
>30	6	9,653	4	6,235	2	1,402
3-30	5	6,535	3	4,408	1	1,261
$\leq$3	3	1,110	1	426	0	424

Table 5.2

CHARACTERISTICS OF THE SATURATED ZONE

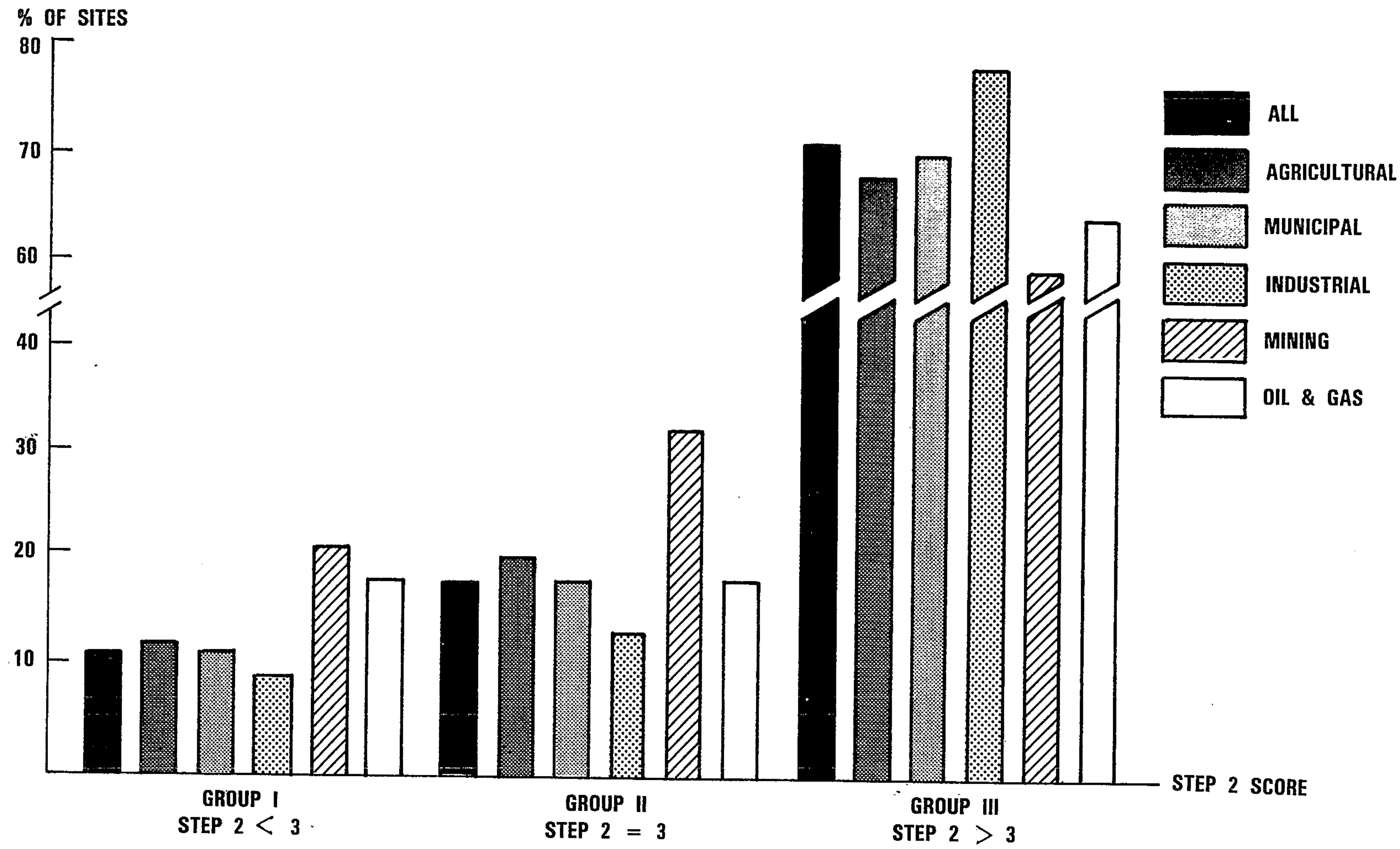


Figure 5.2

Step 3, Ground Water Quality

Step 3 is a rating of Ground Water Quality based on current usage and total dissolved solids (TDS). Table 5.3 shows that almost 87 percent of the sites are located over aquifers currently used as a source of drinking water, while less than 2 percent are located in areas where there is no ground water or where it is extremely saline (>10,000 mg/l TDS). These proportions are constant throughout the different categories, as shown in Table 5.4, with the mining and oil and gas sites having a slightly lower percentage of sites located on drinking water aquifers (80 percent) and the industrial category having the highest percentage (89 percent).

The Hydrogeologic Setting

Another way to look at the data provided in the first three steps of the assessment is to combine the scores to obtain a general picture of the hydrogeologic characteristics of the sites assessed. Two groups clearly emerge: sites with a low potential to contaminate an aquifer (Group I) and sites with a high potential to contaminate ground water (Group III). Between these two extremes are all other sites (Group II).

Group I - Low Endangerment Potential.

This group is comprised of sites which fall in Group I for Steps I and II (i.e. are located in areas where the unsaturated zone is very thick or very impermeable and the aquifer has low transmissivity) and where the ground water is not currently used and of poor quality (>3,000 mg/l TDS) or where there is no ground water.

Group II - Moderate Endangerment Potential

This group contains sites where a good aquifer is protected by a thick unsaturated zone, or sites where the ground water is not currently used but is of good quality: in other words, sites where potential endangerment is moderate, since seepage is somewhat mitigated by natural conditions.

Group III - High Endangerment Potential

This group is comprised of sites which fall in Group III for Step I and II (i.e. located in areas where highly transmissive aquifers are poorly protected by thin or very permeable unsaturated zones) and where the ground water is currently used or of high quality 1,000 mg/l TDS).

RATING OF THE GROUND WATER QUALITY

Ground Water Quality TDS mg/l	No. of Sites (%) Located Over Aquifers Used As a Supply
≤500 or current drinking water	37,464 (86.7)
>500 - ≤1,000	1,629 (5.1)
>1,000 - ≤30,000	1,347 (4.2)
>3,000 - ≤10,000	629 (2.0)
>10,000	289 (0.9)
No ground water	276 (0.9)

Table 5.3

GROUND WATER QUALITY RATINGS

by CATEGORY

Ground Water Quality (TDS mg/l)	AGR %Sites	MUN %Sites	IND %Sites	MNG %Sites	OAG %Sites
≤500 or drinking water source	88.1	88.4	88.7	80	80.1
>500 - ≤1,000	3.6	4.4	5.8	7.9	7.5
>1,000 - ≤3,000	2.2	4.2	3.0	8.5	10.3
>3,000 - ≤10,000	4.0	1.9	1.2	2.4	0.6
>10,000	0.8	1.1	1.2	0.5	0.1
No ground water present	1.6	0.5	0.7	1.7	1.1

Table 5.4

Figure 5.3 is a graph of the data grouped in this manner and shows that the majority of sites fall in Group II. Very few sites, 7 percent in all, can be discounted as presenting no threat to ground-water users based on their hydrogeologic characteristics. This proportion is slightly higher in the mining category (11 percent).

In the municipal and industrial categories, 41 percent and 39 percent of the sites respectively are in Group III, i.e. they have a higher potential to contaminate ground water, while only 8 percent or the oil and gas sites fall in that group.

Step 4, Waste Hazard Potential

In Step 4, the waste contained in the impoundments is assessed to determine its "hazard potential" and given a score of 1 to 9. Table 5.5 shows the results of step 4 in all but the oil and gas category where the uniform nature of the waste--brine--resulted in a score of 7 in 87 percent of the assessments.

The guidance for the SIA suggested a scoring range in the agricultural category of 1 - 2 for crops and 2 - 5 for livestock. Table 5.5 shows that the score is heavily skewed towards the upper end of the range, probably because in most instances, livestock operations are more frequently associated with impoundments. Pits used to dispose of pesticides or herbicides, and impoundments, such as dipping vats, account for the sites which scored higher than five in this category.

In the municipal category, the suggested range for rating the waste hazard was 2 to 5 and the scores are fairly evenly distributed within that range. The sites scoring higher than 5 are probably associated with facilities where there is a heavy contribution of industrial waste.

Scores in the industrial category are fairly evenly distributed between 2 and 9, while in the mining category, most sites fall within the range of 2 to 7, with the emphasis towards the upper end of the scale.

Figure 5.4 shows that overall, 25 percent of the sites contain wastes which, while they can degrade water quality, appeared at the low end of the rating (score <4), while 15 percent contain waste which may be considered hazardous (score >7). Mining and industrial sites are predominant in the potentially hazardous category. The reason that mining wastes rank so high is not so much because of their toxicity but because of the high volumes involved. Since volume was a consideration in the waste hazard rating, mining sites received a high score.

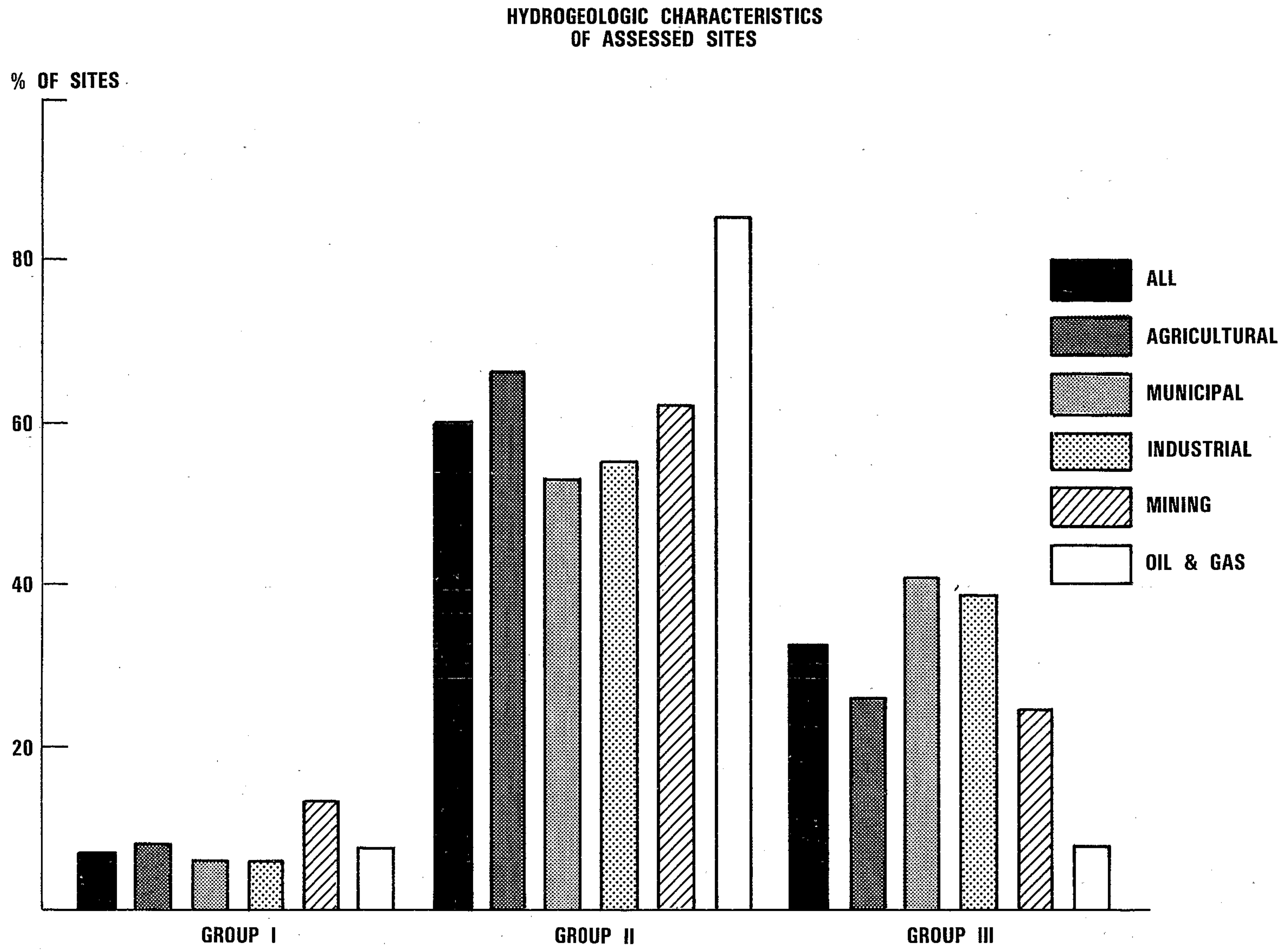

HYDROGEOLOGIC CHARACTERISTICS
OF ASSESSED SITES
% OF SITES
80
60
40
20
GROUP I
GROUP II
GROUP III
ALL
AGRICULTURAL
MUNICIPAL
INDUSTRIAL
MINING
OIL & GAS

Figure 5.3

WASTE HAZARD POTENTIAL RATING

Score	AGR	MNN	IND	MNG
1	14	24	19	3
2	97	1,236	913	210
3	301	2,997	1,251	51
4	2,333	2,278	993	55
5	3,625	3,035	935	112
6	15	809	1,277	348
7	28	163	927	659
8	10	230	1,141	8
9	91	38	767	11

Table 5.5

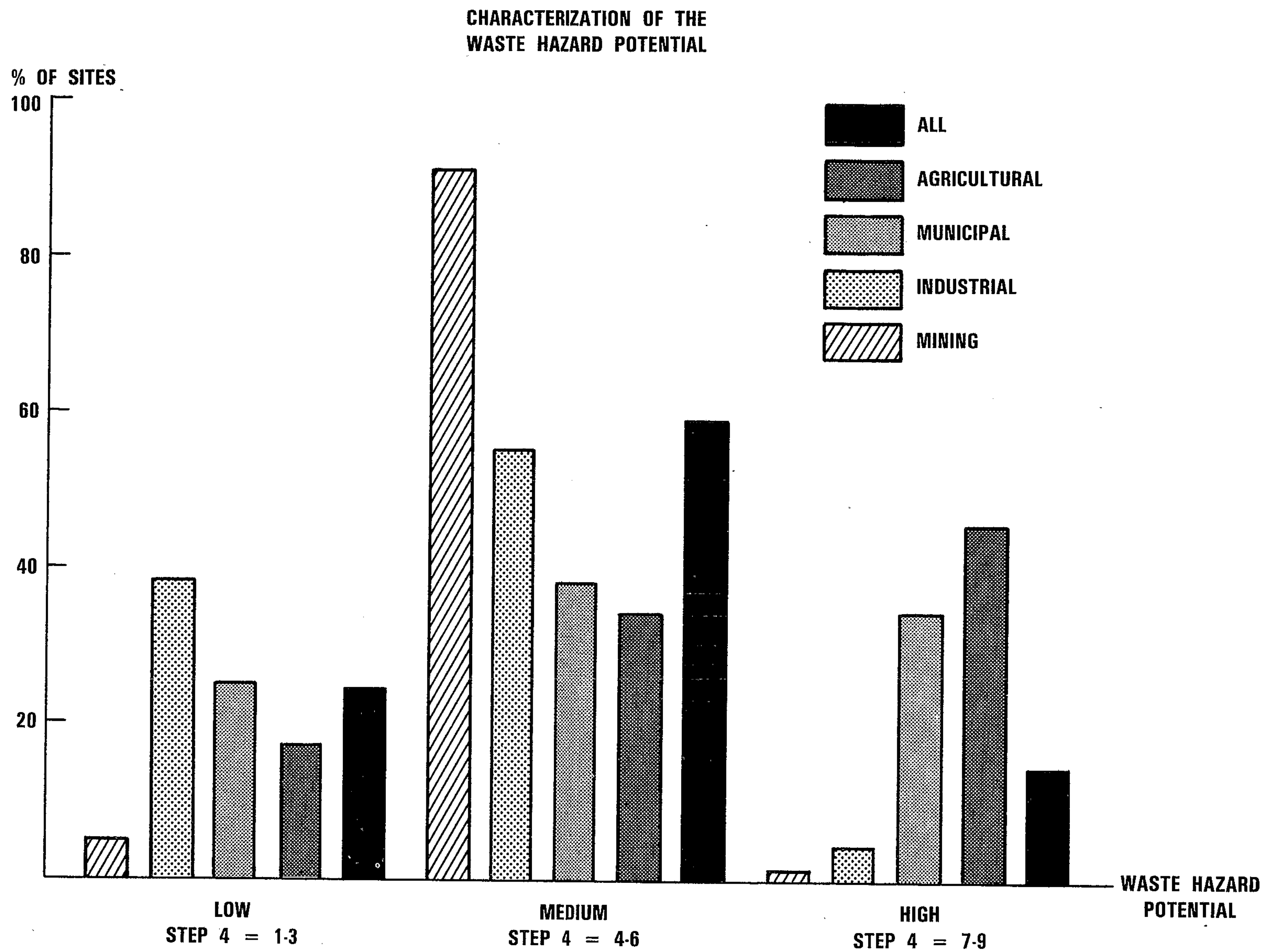

CHARACTERIZATION OF THE
WASTE HAZARD POTENTIAL
% OF SITES
100
80
60
40
20
ALL
AGRICULTURAL
MUNICIPAL
INDUSTRIAL
MINING
WASTE HAZARD
POTENTIAL
LOW
STEP 4 = 1-3
MEDIUM
STEP 4 = 4-6
HIGH
STEP 4 = 7-9

Figure 5.4

The waste rating was based either on the SIC code of the facility or the nature of the waste. In the agricultural, municipal, mining and oil and gas categories, the nature of the waste is almost always clearly related to the SIC code and little variation except for degree of treatment can be expected within each SIC code.

Within the industrial category, there is greater variation in the waste streams for industrial sites, and the scores may misrepresent the true hazard potential when SIC codes are used to determine the rating. However, in 44 percent of the cases, the assessments are based on the waste identification, not the SIC code, and thus any potential for misrepresentation is somewhat mitigated.

Figure 5.5 shows how the various SIC codes differ in degree of hazard. In the chemical and petroleum refining categories, as well as fabricated metals manufacturers and industrial refuse sites, more than 60 percent of the sites contain potentially hazardous waste. At the other end of the spectrum are the food processors and stone, clay, glass and concrete products industry, where less than 10 percent of the waste is hazardous.

Step 5

The step 5 score is the sum of the scores obtained in steps 1, 2, 3 and 4. Figure 5.6 shows the range, mean and mode of step 5 for each category. The step 5 score is most meaningful at each end of the range. If a site ranks lower than 14, it is probably not posing a threat to ground water, while a site that ranks higher than 26 must contain potentially hazardous waste and be located above a vulnerable aquifer. Between these two extremes, the scores can represent a variety of conditions and they should not be considered alone. For example, a score of 23 can represent an impoundment located on a very vulnerable aquifer but containing fairly innocuous waste (Step 1 = 9, Step 2 = 6, Step 3 = 6, Step 4 = 2) or an impoundment containing potentially hazardous waste (Step 4 = 7) located on a good aquifer (Step 2 = 6, Step 3 = 5) protected by less than 3 meters of clayey sand (Step 1 = 5D). For this reason, the step 5 score is most meaningful when the individual steps are considered in evaluating the total score.

Step 6, Potential Endangerment to Human Health

Step 6 looks at the potential for a site to endanger human health by assessing its proximity, and therefore its potential impact, on a water supply.

By using 7.5' topographic maps or other available information, a determination was made of:

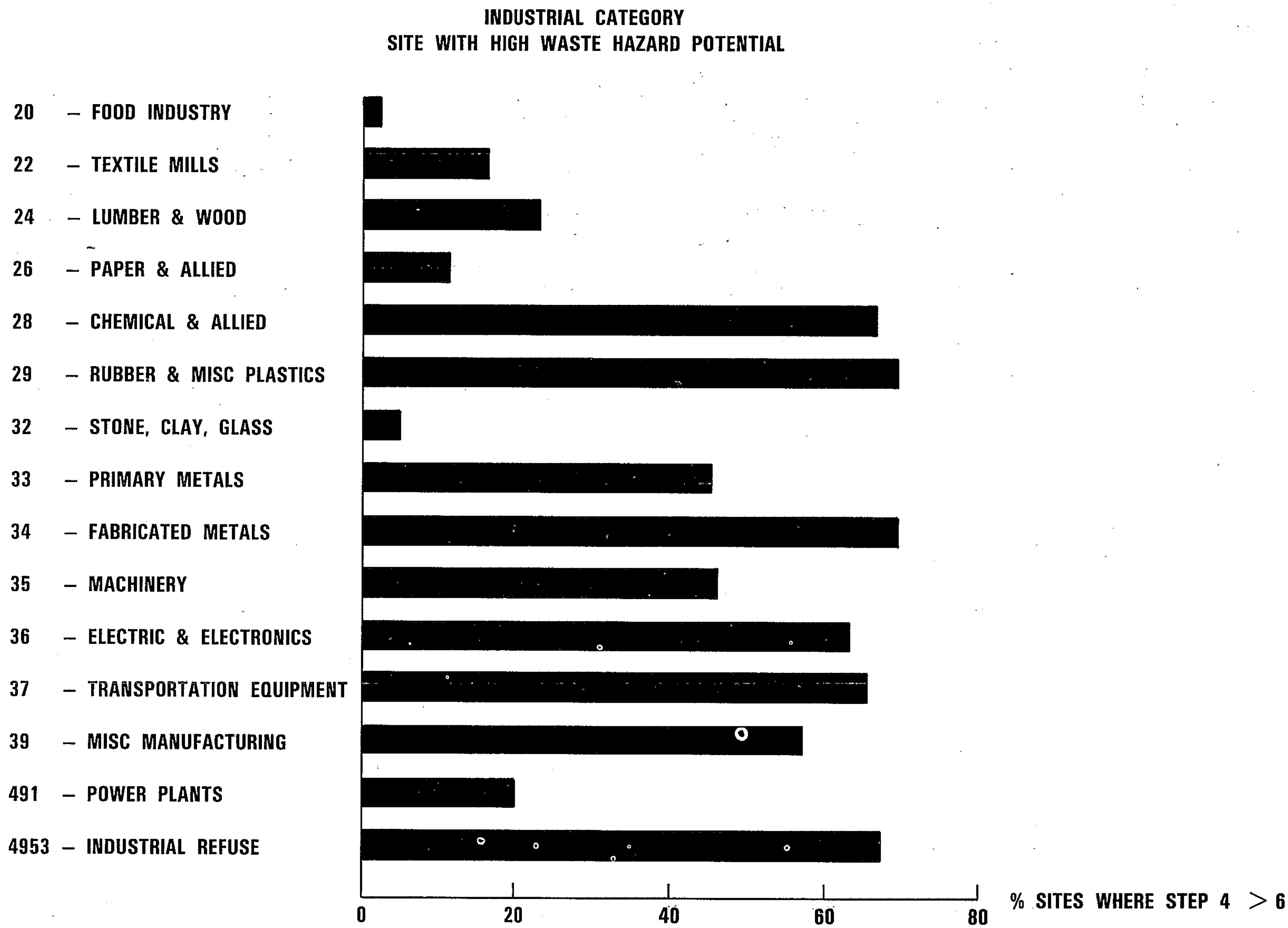

INDUSTRIAL CATEGORY
SITE WITH HIGH WASTE HAZARD POTENTIAL
20 – FOOD INDUSTRY
22 – TEXTILE MILLS
24 – LUMBER & WOOD
26 – PAPER & ALLIED
28 – CHEMICAL & ALLIED
29 – RUBBER & MISC PLASTICS
32 – STONE, CLAY, GLASS
33 – PRIMARY METALS
34 – FABRICATED METALS
35 – MACHINERY
36 – ELECTRIC & ELECTRONICS
37 – TRANSPORTATION EQUIPMENT
39 – MISC MANUFACTURING
491 – POWER PLANTS
4953 – INDUSTRIAL REFUSE
0
20
40
60
80
% SITES WHERE STEP 4 > 6

Figure 5.5

STEP 5 SCORE

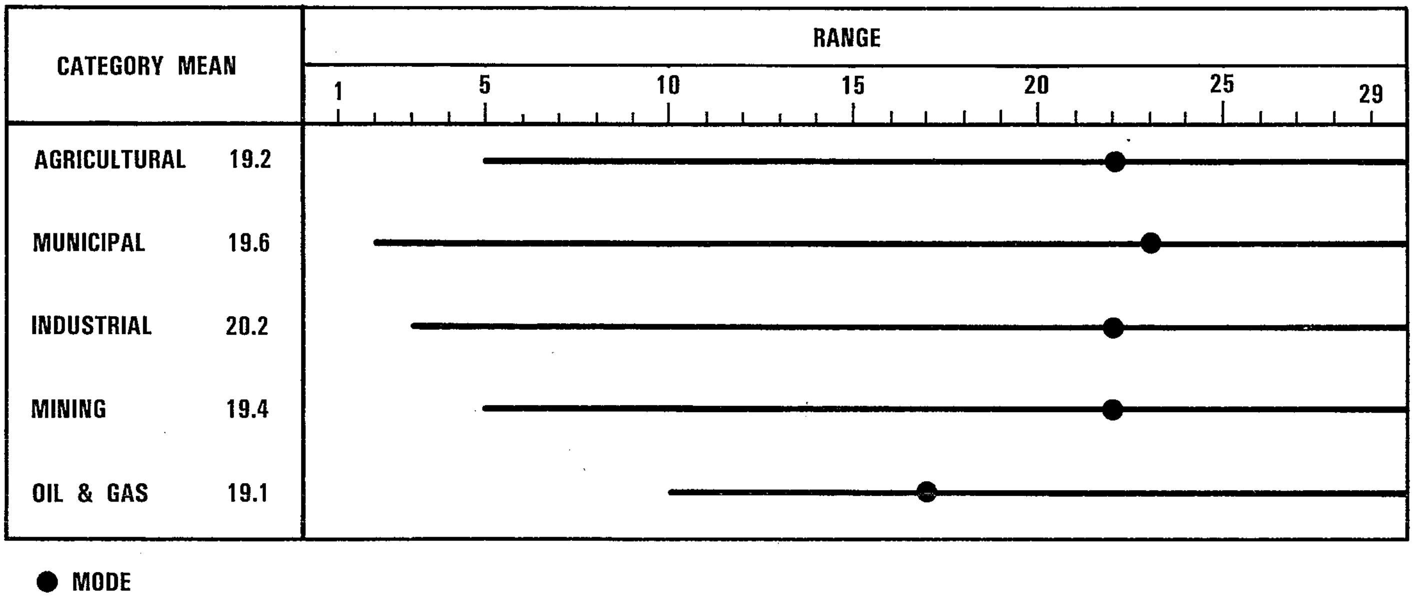


Figure 5.6

(1) the anticipated flow direction of seepage from the site

(2) whether a potential plume of contamination would first intersect a water well supply or a surface water supply, and the distance of this water supply from the site.

Where no hard data were available, the States were to assume that any stream other than intermittent was a potential water supply and that any well shown on the topographic maps was a drinking water well. Furthermore, in rural areas any house was assumed to use a water well.

Table 5.6 shows that 26 percent of all sites assessed would have a potential impact, primarily on ground-water supplies, while in the majority of cases (60 percent), the impact of any seepage would affect primarily a surface water supply via ground-water discharge into that surface water.

These percentages are fairly constant in each category, as illustrated in Table 5.7, with the proportion of surface water supply to ground-water supply slightly higher in the mining and oil and gas category, and lowest in the industrial category. These proportions vary from State to State as illustrated in Figure 5.7 which shows areas of the country where surface water supply would be the primary affected entity (>60 percent of the site potentially affect a surface water supplier) and those areas in which ground water supplies would be the primary affected entity (>60 percent of the sites potentially affect a ground water supply).

As discussed above, sites in the "Group III" hydrogeologic setting are the ones most likely to contaminate ground water. Table 5.8 shows that 31 percent of these sites are likely to impact primarily a ground-water supply while 57 percent are likely to impact a surface water supply. The proportion in each category is similar to those of the population as a whole, except in the municipal and industrial categories where the ratio of ground water supply to surface water supply is slightly higher for the "Group III" sites.

GROUND-WATER PROTECTION

The Use of Liners

The determining factors in whether or not a site is lined should be the nature of the unsaturated zone (Step 1) and/or the nature of the waste (Step 4). This last factor is particularly important in the industrial category.

RATING OF THE ENDANGERMENT TO

POTENTIAL WATER SUPPLIES

Distance from potentially affected water supply (m).	# Sites with Water well down dip	# Sites with Surface water down dip	# Sites with well water up dip	# Sites with no nearby water source
<200	3,508	10,529	717	
200 - 400	1,956	4,750	421	
400 - 800	1,572	2,186	695	
800 - 1,600	1,070	1,416	539	
TOTAL	8,106 26%	18,881 60%	2,372 8%	1,942 6%

Table 5.6

CHARACTERISTICS OF THE POTENTIAL ENDANGERMENT

TO WATER SUPPLIES (ALL SITES)

% Sites	AGR	MUN	IND	MNG	OAG
A. Potentially affecting a water well	28	27	29	17	17
B. Potentially affecting a Surface water	61	58	56	64	68
C. No water source down dip	7	10	8	8	5
D. No water source within 1 mile	4	5	7	11	10

Table 5.7

CHARACTERIZATION OF THE POTENTIAL ENDANGERMENT TO WATER SUPPLIES

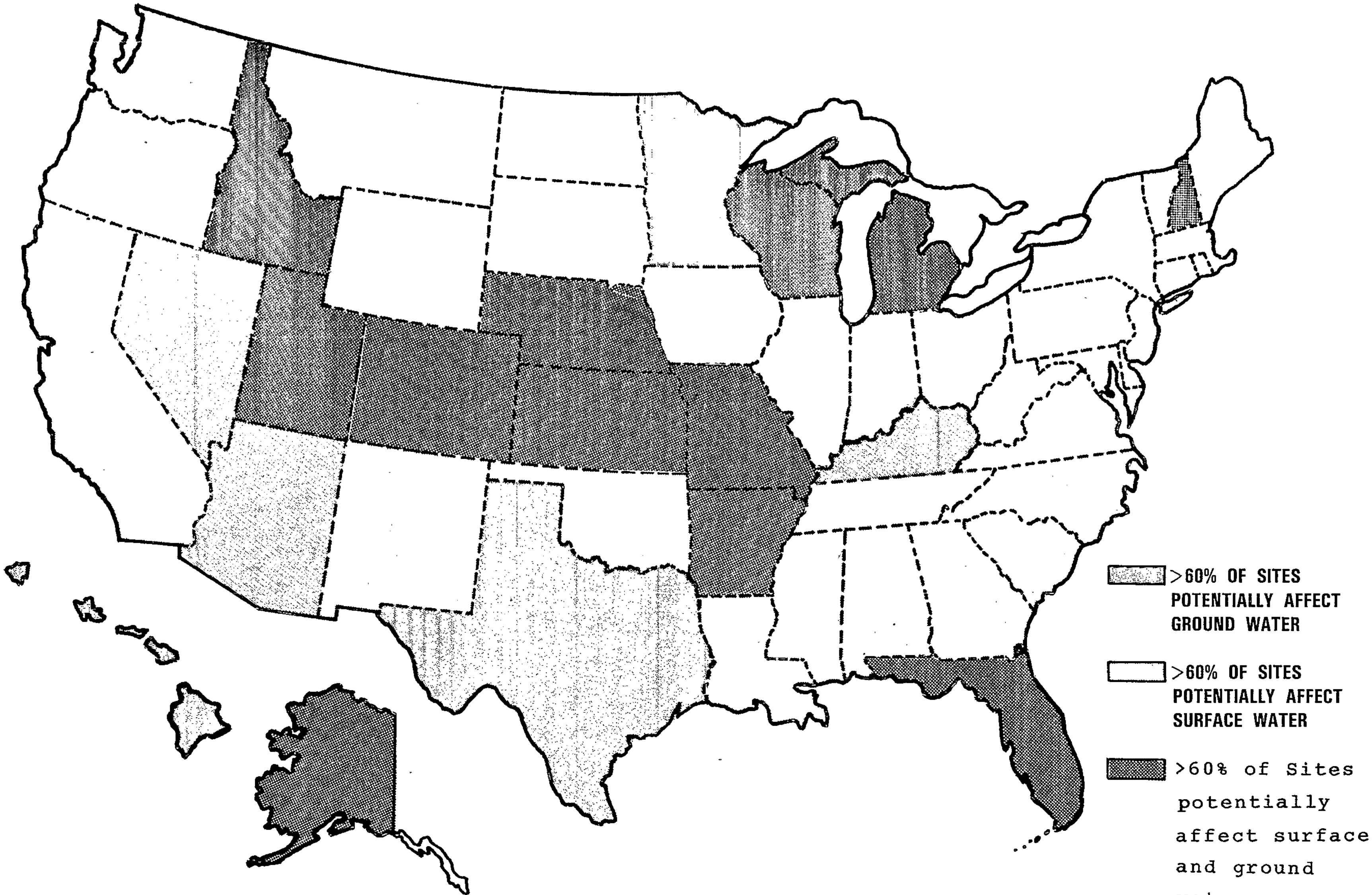


Figure 5.7

CHARACTERISTICS OF THE POTENTIAL ENDANGERMENT TO WATER SUPPLIES

(SITES IN "GROUP III" HYDROGEOLOGIC SETTING)

Category % Sites	AGR	MUN	IND	MNG	OAG	ALL
A. Potentially affecting a water well	29	32	33	23	16	31
B. Potentially affecting a surface water *	61	55	57	63	64	57
C. No water source down dip	6	10	7	7	8	9
D. No water source within one mile	4	3	3	7	12	3

*Although surface water is the primary supply that may be affected in B, ground water between the waste source and surface water supply would also be adversely affected.

Table 5.8

An attempt to establish a correlation between liners and Step 1 rating is shown in Figure 5.8. The figure indicates that no correlation exists.

Approximately 30 percent of the industrial sites, 22 percent of the municipal sites and 16 percent of the agricultural sites are lined, regardless of the nature of the unsaturated zone. Furthermore, the type of liner does not seem to be influenced by the siting. Clay and compacted soil liners are as prevalent in sand and gravel areas as in the tighter formations.

Similarly, Figure 5.9 shows very little correlation between the presence of a liner and the hazard potential estimated for the waste. In the mining, industrial and municipal categories, the hazard potentials of the waste cover a broad range and should have some influence over frequency of liner use. Only in the municipal category is there a significant difference between the percentage of sites lined when the waste rating is >7 (22 percent) or >7 (35 percent lined). The types of liner used do not vary however, and clay or compacted soil from the majority of liners.

The industrial category shows a slight increase in the use of artificial liners in impoundments containing wastes with a higher hazard potential, but little difference in the percentage of impoundments lined.

Finally, a comparison of lined and unlined sites in the different hydrogeologic groups shown in Figure 5.10, illustrates that there is no correlation between the natural setting and the use of liners.

Use of Monitoring Wells

The limited amount of data available on monitoring wells and the problems with the validity of the data explained in Chapter IV, make it difficult to derive any correlations. However, none could be found between the hydrogeology of the sites and the use of monitoring wells. In other words, the sensitivity of the aquifer to contamination appears to have little to do with whether it is monitored.

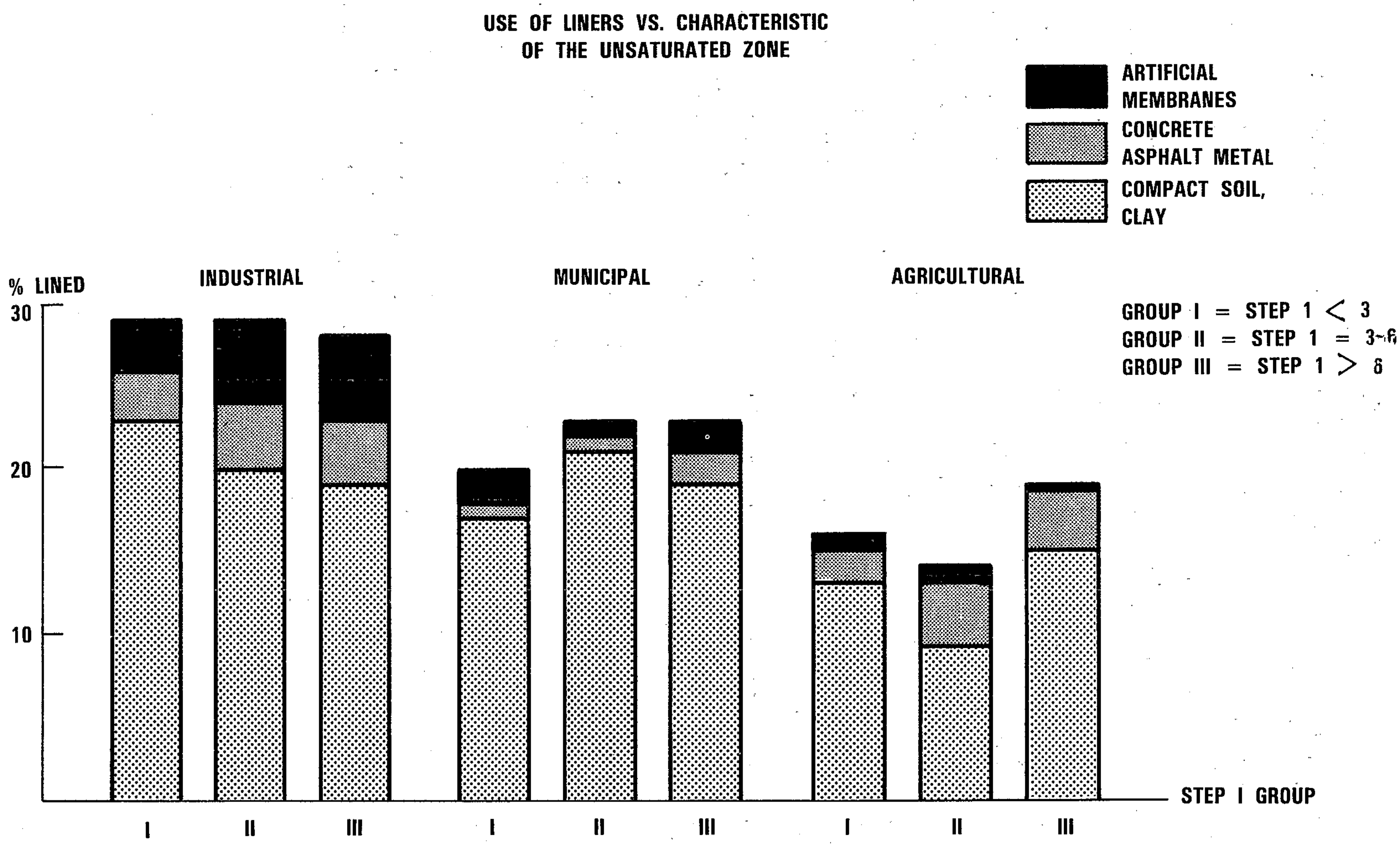

USE OF LINERS VS. CHARACTERISTIC
OF THE UNSATURATED ZONE
ARTIFICIAL MEMBRANES
CONCRETE ASPHALT METAL
COMPACT SOIL, CLAY
% LINED
30
20
10
INDUSTRIAL
MUNICIPAL
AGRICULTURAL
GROUP I = STEP 1 < 3
GROUP II = STEP 1 = 3-6
GROUP III = STEP 1 > 6
STEP I GROUP
I
II
III
I
II
III
I
II
III

Figure 5.8

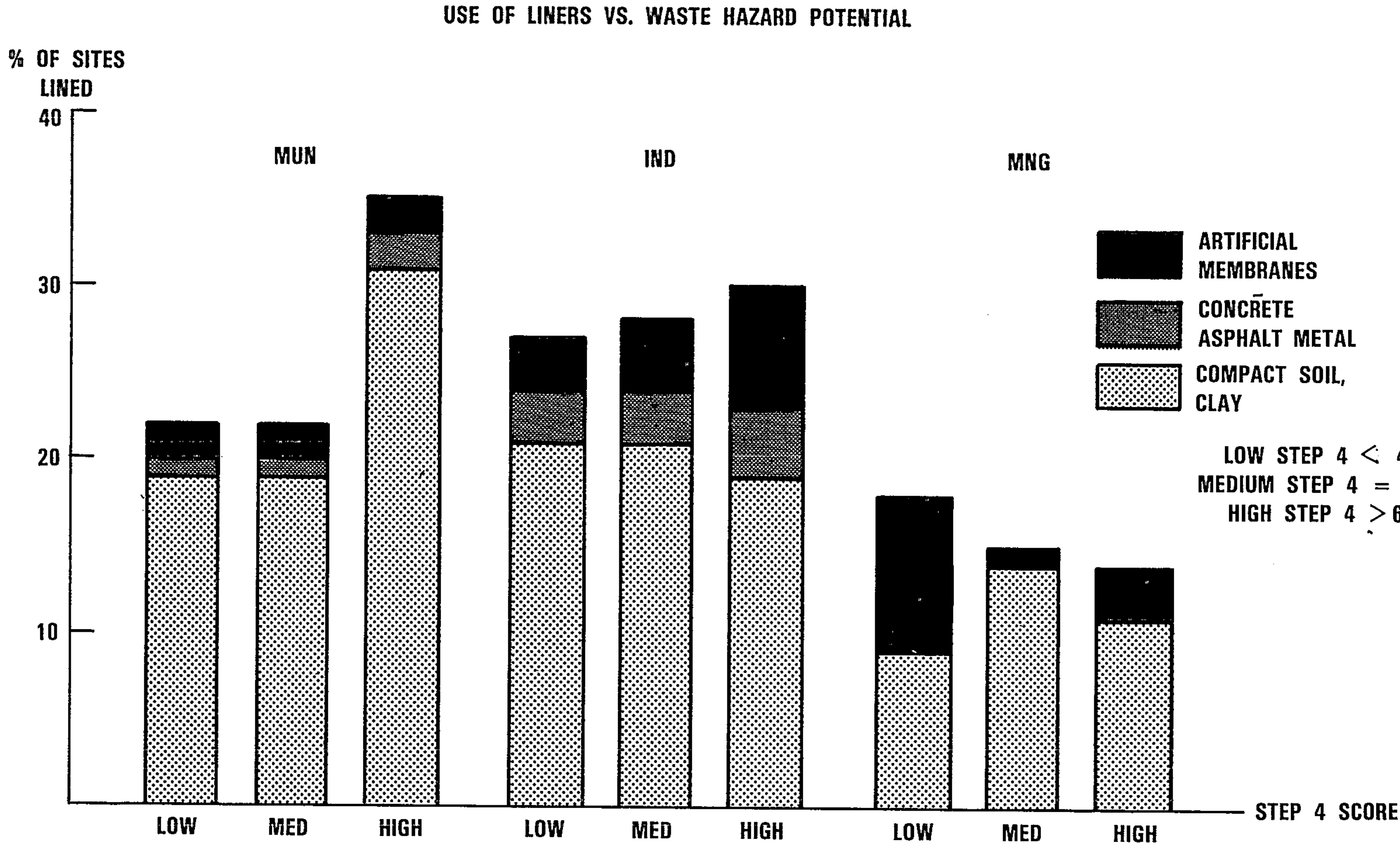

USE OF LINERS VS. WASTE HAZARD POTENTIAL
% OF SITES LINED
40
30
20
10
MUN
IND
MNG
ARTIFICIAL MEMBRANES
CONCRETE ASPHALT METAL
COMPACT SOIL, CLAY
LOW STEP 4 < 4
MEDIUM STEP 4 = 4-6
HIGH STEP 4 > 6
LOW
MED
HIGH
LOW
MED
HIGH
LOW
MED
HIGH
STEP 4 SCORE

Figure 5.9

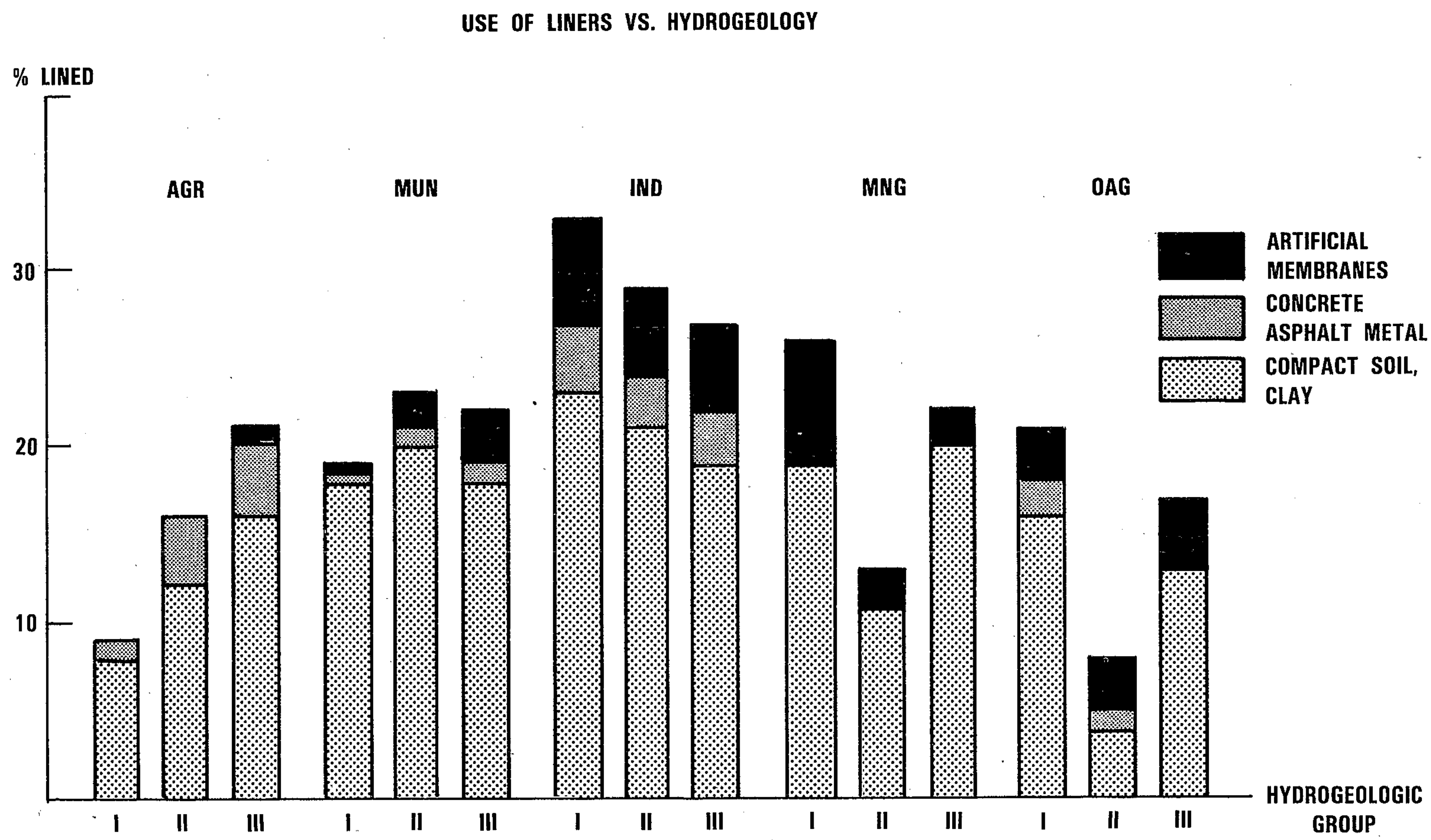

USE OF LINERS VS. HYDROGEOLOGY
% LINED
30
20
10
AGR
MUN
IND
MNG
OAG
ARTIFICIAL MEMBRANES
CONCRETE ASPHALT METAL
COMPACT SOIL, CLAY
I
II
III
I
II
III
I
II
III
I
II
III
I
II
III
HYDROGEOLOGIC GROUP

Figure 5.10

CHAPTER VI

CASE STUDIES OF GROUND WATER CONTAMINATION FROM SURFACE IMPOUNDMENTS

INTRODUCTION

This chapter presents summary information on incidences of ground water contamination from surface impoundments. The data on which this summary is based were provided by the States as part of their final SIA Report. The nature of the information provided showed considerable disparity in both quality and detail, since the level of investigation performed by the States in gathering the data varied. However, in nearly all instances, States were careful to include only documented case studies that could clearly be attributed to surface impoundments. In the few instances where this was not the case, they carefully indicated the situation.

The data here are illustrative rather than comprehensive. Indeed, the case studies cited by the States are merely representative and in most cases include only a small number of the known cases of ground water contamination from surface impoundments, and do not consider contamination from other sources.

SUMMARY OF INFORMATION PROVIDED

A total of 416 case studies were discussed in some detail in the State Reports. Several States reported an additional 143 cases but these are not included in the analysis that follows since they did not contain sufficient information. Within the data base, there are an additional 115 sites that have not been developed as case studies, since sufficient detail is not available to characterize them. However, the information is discussed briefly at the end of the chapter. Seven States provided no case studies at all. Figure 6.1 shows the geographic distribution of the 416 sites as reported by the States.

In general, States included information on four major areas: cause of contamination, method of detection, affected supplies and remedial action taken. These topics are discussed in the sections that follow.

Figure 6.2 provides a breakdown of the sites by category, with the industrial category further delineated by SIC codes. Over 60 percent of the sites fall into the industrial category and within this, over 30 percent are in "Chemical and Allied Products." This trend may not necessarily reflect poor design and siting

LOCATION OF CASE STUDIES

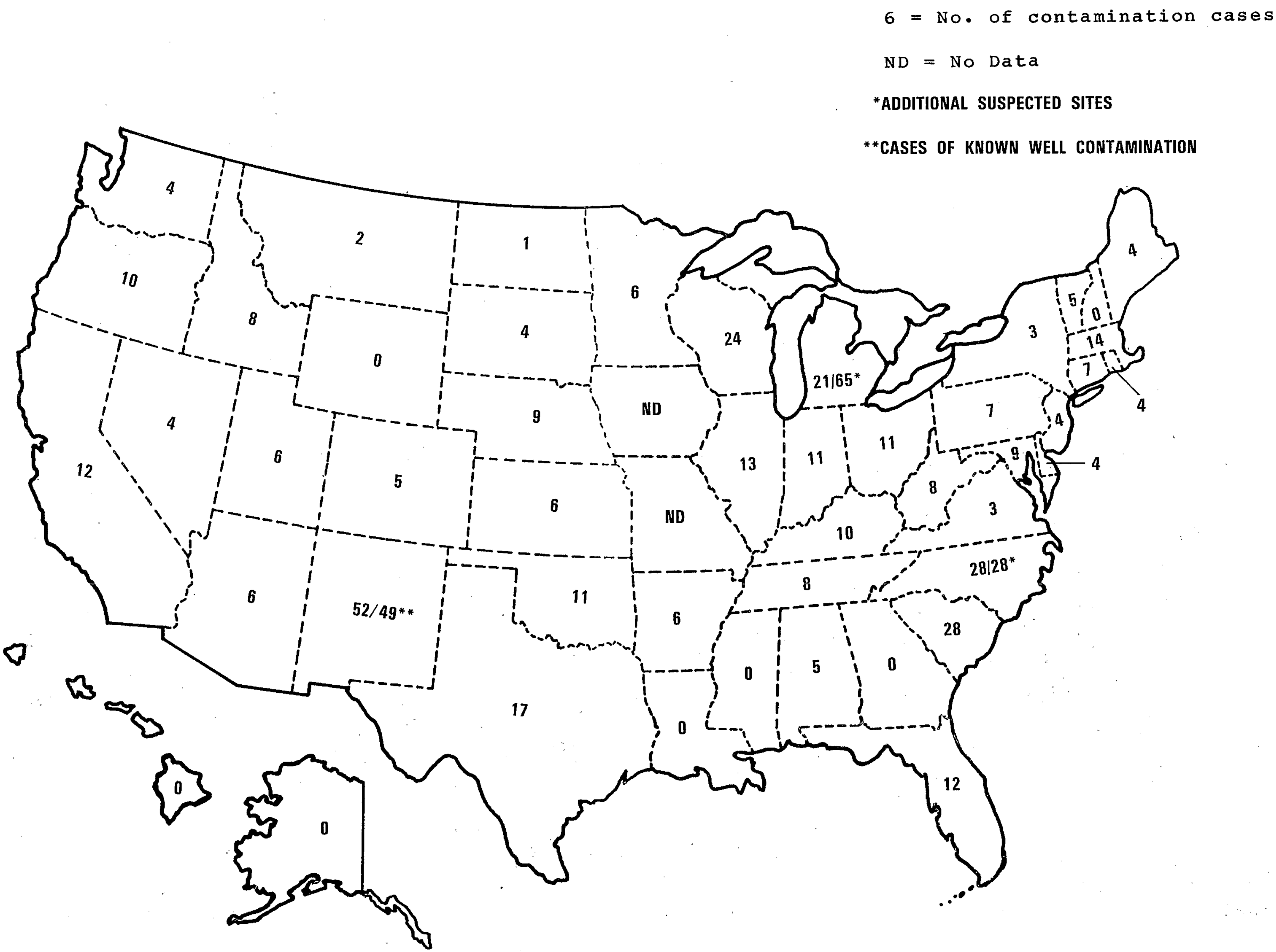


Figure 6.1

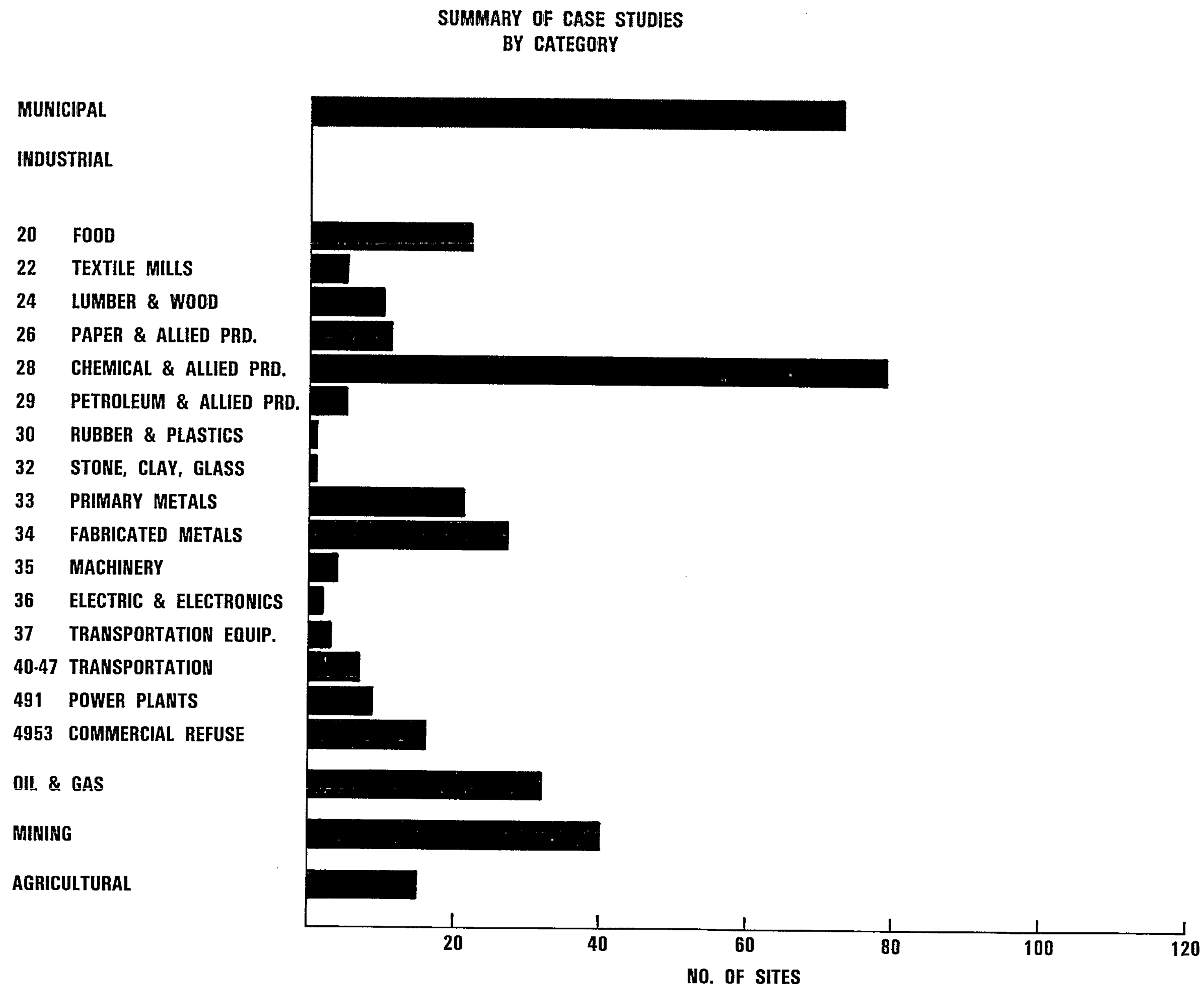

SUMMARY OF CASE STUDIES
BY CATEGORY
MUNICIPAL
INDUSTRIAL
20 FOOD
22 TEXTILE MILLS
24 LUMBER & WOOD
26 PAPER & ALLIED PRD.
28 CHEMICAL & ALLIED PRD.
29 PETROLEUM & ALLIED PRD.
30 RUBBER & PLASTICS
32 STONE, CLAY, GLASS
33 PRIMARY METALS
34 FABRICATED METALS
35 MACHINERY
36 ELECTRIC & ELECTRONICS
37 TRANSPORTATION EQUIP.
40-47 TRANSPORTATION
491 POWER PLANTS
4953 COMMERCIAL REFUSE
OIL & GAS
MINING
AGRICULTURAL
20
40
60
80
100
120
NO. OF SITES

Figure 6.2

on the part of the industrial sector; rather it may result from the fact that State programs tend to focus on industrial facilities. Of the remaining sites, just over 17 percent of the case studies are in the municipal category, 10 percent are in mining, 7 percent in oil and gas and just under 4 percent are in the agricultural category.

ASSESSMENTS OF CASE STUDIES

Of the 416 case studies reported, 208 were assessed using the SIA rating scheme. A comparison of their Step 5 (ground-water contamination potential, see Figure 6.3) score shows that the average score for case studies was 24.4, while the average score for the entire industrial sector was 20.2. In ranking sites for further study, a Step 5 score of 22 was considered to indicate a high potential for contamination. In view of the scores for the case studies evaluated, it would appear that the case studies indicate that the rating system does discriminate potentially dangerous sites from relatively safer sites, but the system may not be sensitive enough to provide more detailed analysis.

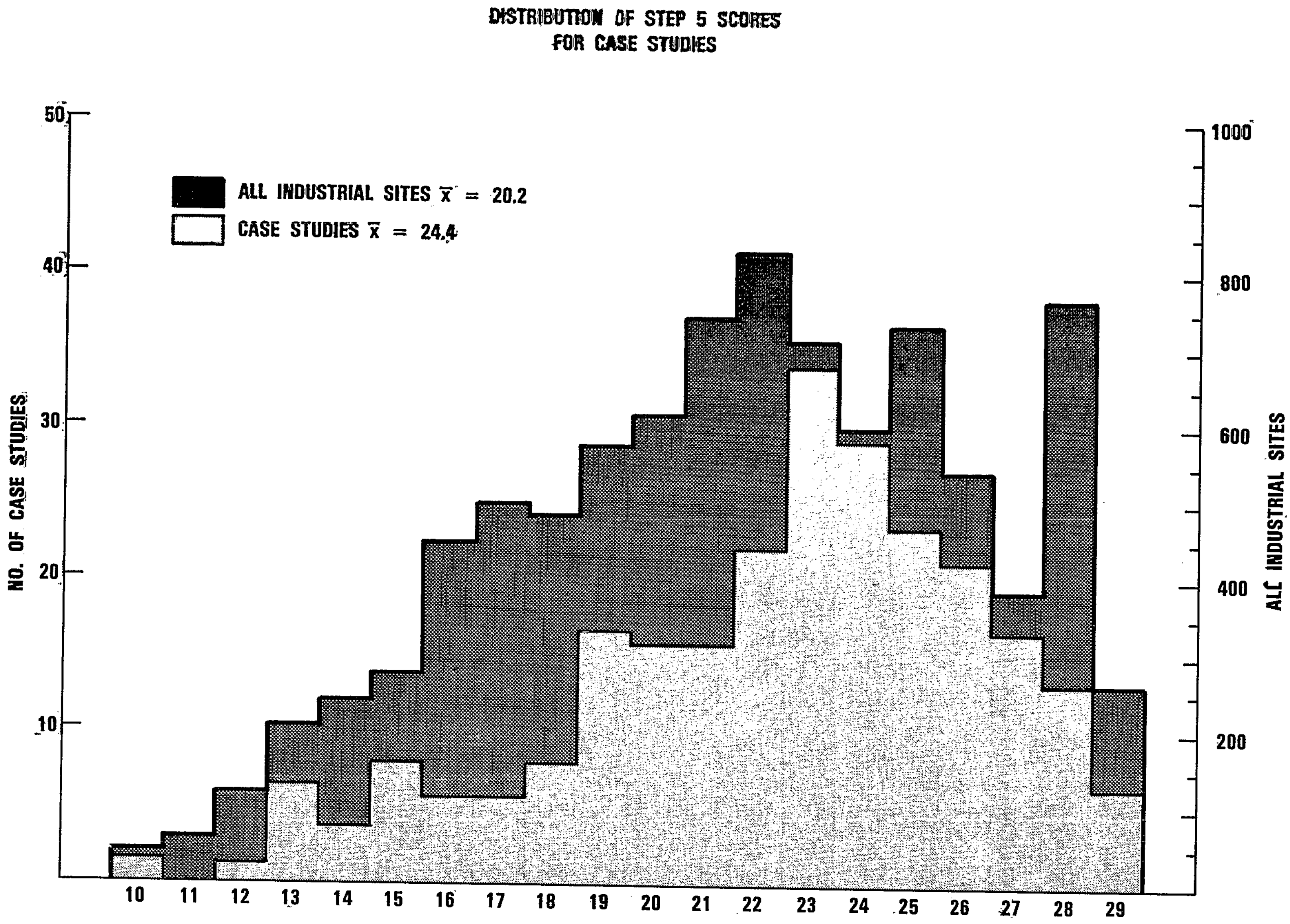
While this is to some extent true, there are some important limitations in such an assumption. In many instances, the investigations which led to these sites being identified as case studies were prompted by the SIA score itself. Thus, it is possible that the investigation and discovery of contamination in cases was not random and it favored sites with high scores.

Second, the variation in enforcement procedures and efficacy found from State to State was frequently accompanied by concommitant variations in the conduct of the SIA. Necessarily, the rating system allows some subjectivity in site evaluations. As a result, a State that conducted an aggressive inventory and assessment program frequently assigned relatively higher scores and at the same time identified more case studies than other States. This could have the effect of tipping the results in favor of higher scores for case study sites. Nevertheless, the average Step 5 score for case studies evaluated is sufficiently greater than the same score for the system as a whole that it is supportive of the rating system.

CAUSES OF CONTAMINATION

Information provided in the State reports pointed to four primary causes of contamination. Table 6.1 outlines the frequency with which a particular cause was cited as contributing to contamination.

Of course, defining the cause of contamination is a complex task that often involves extensive investigations conducted over a long time throughout large areas. In some cases, the



DISTRIBUTION OF STEP 5 SCORES
FOR CASE STUDIES
ALL INDUSTRIAL SITES $\bar{x}$ = 20.2
CASE STUDIES $\bar{x}$ = 24.4
NO. OF CASE STUDIES
10
20
30
40
50
ALL INDUSTRIAL SITES
200
400
600
800
1000
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

Figure 6.3

CAUSES OF CONTAMINATION

Cause	Frequency (Percent)
Seepage	78.7
Dike Failure/Overflow	10.1
Liner Failure	7.6
Catastrophic Collapse	1.6
Other	2.0

Table 6.1

State reports reflected investigations of this depth; in others, either the level of detail provided or the depth of the initial study was not as comprehensive. Furthermore, just 277 of the 416 sites had data on causes of contamination. Thus, this table is valid for a general overview of causes contributing to ground water contamination but should not be viewed as definitive.

Seepage, as used in this table, refers to the direct percolation of liquids to the water table from the impoundment itself. Overflow and liner failure, which also involve seepage, are viewed separately for the purpose of this analysis. Catastrophic collapse refers here to situations where the contents contributed to enlarging solution channels or to furthering sink hole development.

A variety of causes that did not fit a particular category have been termed "Other." This category included sites in which the contents were in direct contact with ground water (and thus did not involve seepage), sites which were located over boreholes which acted as a conduit for contaminants, and other miscellaneous causes.

Of particular significanc in Table 6.1 is the incidence of liner failure. The total number of case study sites which are lined is not known, but just under 8 percent of the case studies involved liners. Leaks due to loss of liner integrity was the primary cause of liner failure. Other problems included improper installation (allowing seepage through the dikes or liner seams) displacement of membrane liners (presumably due to hydrostatic pressure), and inadequate design standards for clay liners which allowed seepage of contents through the liner (despite apparent liner integrity). This clearly indicates the need for careful design, inspection, and other quality control measures when relying on liners.

METHOD OF DETECTION

The reported means of detecting contamination reveal a pattern of inadequate monitoring and surveillance. Figure 6.4 illustrates the means which led to discovery of ground water contamination. Just under 45 percent of the cases were not discovered until they had adversely affected water quality in supply wells and often more than one well was affected from a single instance. One case caused more than 50 domestic wells to be closed. Twelve percent of the cases either caused injury to crops, wildlife, or livestock, or contaminated surface water.

Although about 30 percent of the cases were detected by monitoring wells, many were not monitored until percolation was suspected. Moreover, less than 16 percent of the sites in

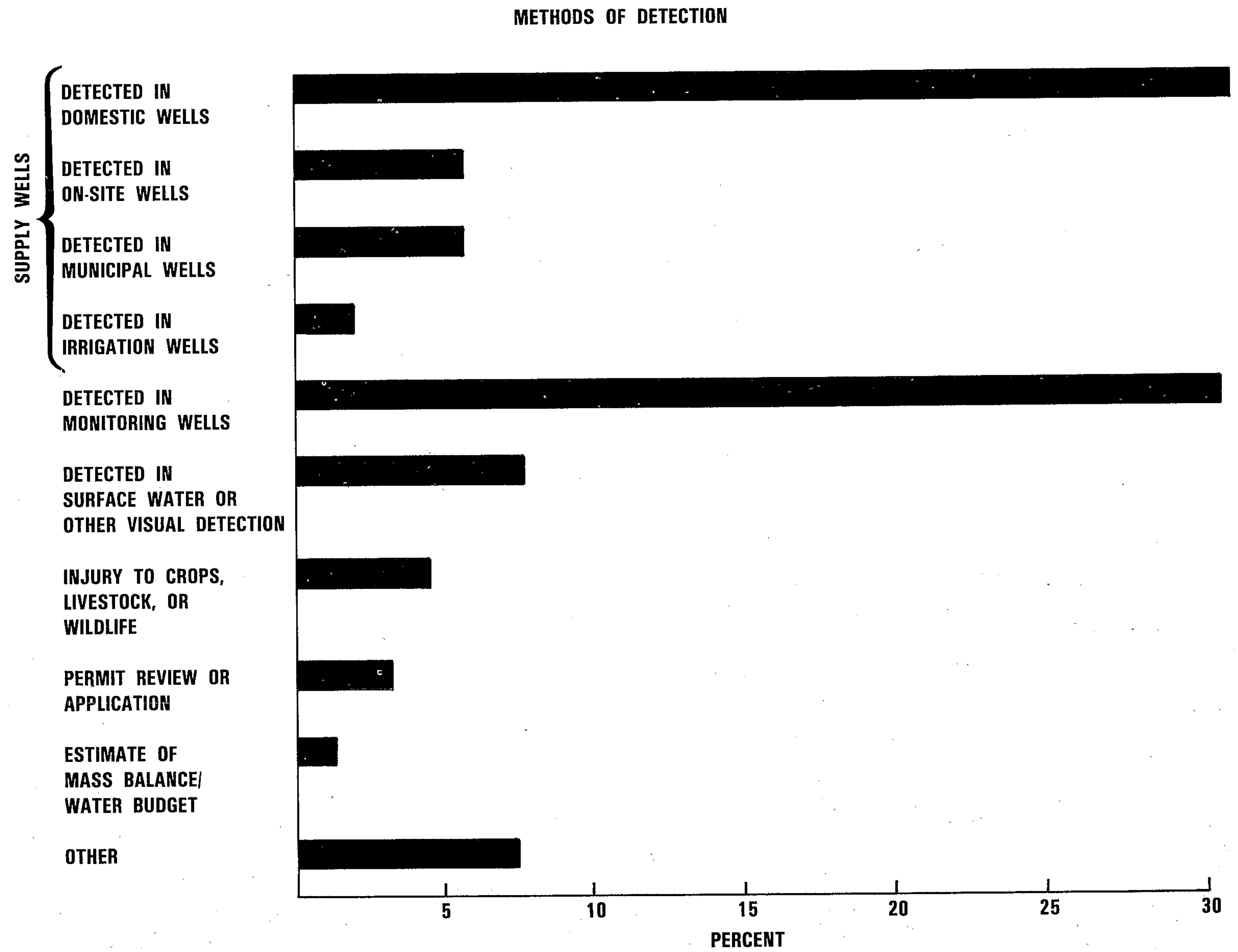

METHODS OF DETECTION
SUPPLY WELLS
DETECTED IN DOMESTIC WELLS
DETECTED IN ON-SITE WELLS
DETECTED IN MUNICIPAL WELLS
DETECTED IN IRRIGATION WELLS
DETECTED IN MONITORING WELLS
DETECTED IN SURFACE WATER OR OTHER VISUAL DETECTION
INJURY TO CROPS, LIVESTOCK, OR WILDLIFE
PERMIT REVIEW OR APPLICATION
ESTIMATE OF MASS BALANCE/ WATER BUDGET
OTHER
5
10
15
20
25
30
PERCENT

Figure 6.4

the data base as a whole are known to be monitored, and the efficacy of many monitoring programs (particularly those located in aquifers composed of crystalline or soluble rock) is open to question. Nevertheless, these figures indicate site monitoring is effective in identifying pollution at an early stage.

Review of existing permits and new applications together with rough estimates of water budgets based on available data were used as a method of detection in just 4.6 percent of the cases. Thus, contamination from unmonitored sites was identified by active intervention by authorities preceding obvious damage in less than 5 percent of the cases.

REMEDIAL ACTION

The following options were used most frequently in sites which practiced remedial action:

- Closing the impoundment or the facility
- Monitoring the problem with further actions studied
- Improved design or engineering (such as lining or relining)
- Containing or intercepting the plume
- Treating or replacing ground water
- Pretreating the waste
- Reuse/Recycle

Only about one third of the 416 case studies contained data on remedial action. The remaining sites either have done nothing or have no data. Operators seldom used only one measure for remedial action, but more often used a combination of actions such as closure, counter pumping, and replacement of the affected water supply. Table 6.2 illustrates the frequency with which the given methods were used.

Closure, which was employed at 28 percent of the sites, for the purposes of this study includes a variety of measures ranging from simple abandonment to detailed engineering plans that incorporate waste removal and treatment, filling, grading, capping, seeding and fencing.

Of the 17 percent of the sites that lined or relined impoundments, clay was used most frequently, followed by membrane liners and finally asphalt or cement liners. In some instances, facilities attempted to seal the impoundment while full,

SUMMARY OF REMEDIAL ACTION

EMPLOYED AT CASE STUDY SITES

Remedial Action	Frequency of Use (%)
Closure*	28%
Line or Reline Impoundment(s)	17%
Interceptor Wells, Counter Pumping Well Points, Slurry Trench etc.	15%
Treat or Replace Affected Supply	13%
Monitor and/or Ongoing Study	9%
Treat or Pretreat Waste	8%
Construct New Impoundments	6%
Litigation	2%
Recycle/Reuse	2%
	100%**

*Refers to closure of impoundment(s), not necessarily company or facility.

**Only one third of the sites contained information on remedial action.

Table 6.2

using bentonite or other fine-grained admixtures; however, the majority of the sites had to interrupt operations and install the liners using conventional measures.

A surprisingly large percentage, 15 percent of the sites, used some means of intercepting or containing the plume. These can be viewed essentially as active or passive management approaches. Counter pumping, interceptor wells, barrier wells etc., represent active measures that require significant expenditures for operating and maintenance. Passive approaches include cutoff walls, french drains and intercept trenches that rely primarily on gravity and that may involve significant initial capital expenditures, but usually do not require extensive costs for operating and maintenance. With both systems, some provision is necessary for treating or disposing of the affected ground water.

Treating or replacing the affected water supply was used by 13 percent of the sites. Treatment included Granulated Activated Carbon (GAC), chlorination, and other techniques and alternative water supplies included deeper wells, increased pumping from remaining wells in municipal systems, and connection to city supplies for affected domestic supply wells.

In 9 percent of the cases, although remedial action was either planned or required, no specific course of action was possible without further study and increased monitoring. The reason for this was frequently the possibility of litigation, or the presence of complex hydrogeologic conditions that precluded obvious assessments of damage and simple remedial solutions.

Waste treatment or pretreatment, used in 8 percent of the remedial actions, consisted of lime treatment, activated carbon and granulated activated carbon, reverse osmosis, ion exchange and other treatment methods. Closely related to treatment/pretreatment were alterations in the manufacturing process designed to reuse what had been waste and/or to recover and market waste products (used for upgrading at 2 percent of the sites).

Of the remaining 8 percent, 6 percent constructed new, usually lined, impoundments and closed existing impoundments; 2% were in some stage of litigation. The later figure may be somewhat misleading, however, since two-thirds of the case studies contained no data on remedial action and these sites may be involved in some form of litigation.

OTHER INSTANCES OF CONTAMINATION

As part of the assessment, States identified 183 instances where monitoring wells showed evidence of contamination. There is some overlap of the data presented here and the information extracted from the case studies provided in the

State reports which formed the basis for the analyses presented earlier in this chapter. Specifically, 68 listings, or just over 37 percent of these sites, were included in the preceding analyses.

Figure 6.5 presents the range, mean, and mode of the overall contamination scores (Step 5) for these sites by category. Industrial sites, which comprised 65 percent of this subset of data, had the highest mean score (24) while agricultural sites, comprising 7 percent of the data subset, had the lowest (18.4). Since these sites represent actual cases of contamination, it appears that the rating scheme emphasizes more the potential for adverse health effects than simply loss of ground water as a resource due to contamination. While this is valid for rating the hazard strictly from a health perspective, it tends to minimize the energy, economic, and resource impacts of damage to water supplies. The result may be that ratings which constitute a high potential for contaminating water supplies may not be consistent across categories. The primary problem appears to be the waste hazard rating.

MODE, MEAN AND RANGE:
STEP 5 SCORES OF CONTAMINATION CASES

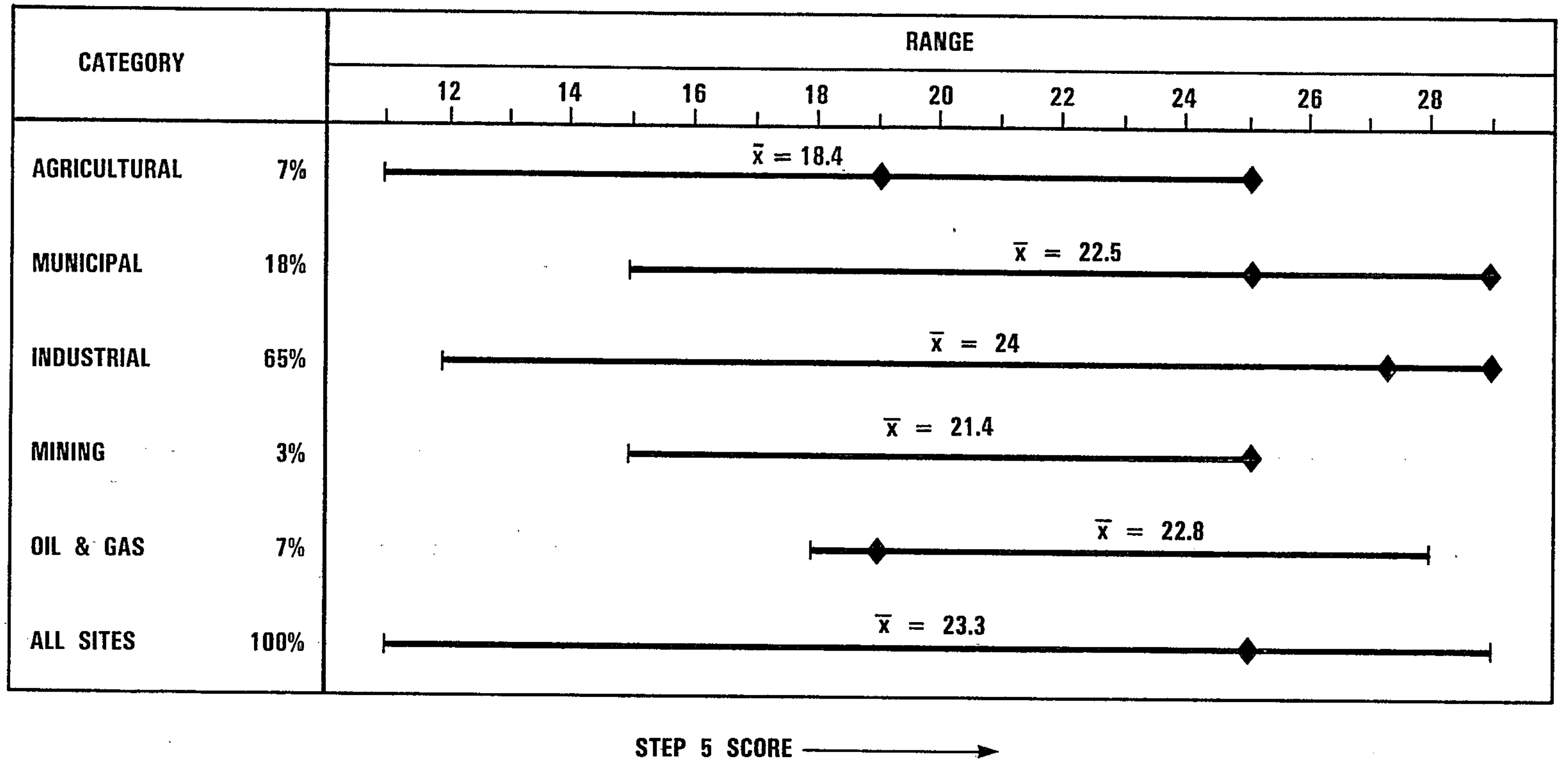


Figure 6.5

CHAPTER VII

STATE FINDINGS

States presented conclusions and recommendations in addition to the data on active and abandoned surface impoundments. In some cases the conclusions and recommendations address a wide range of issues related to ground water quality and are not directly related to the findings of the SIA. The conclusions and recommendations presented in this chapter represent the views (written in 1979-80) of the individuals responsible for conducting the SIA and not necessarily the policy of the State.

The State-identified issues generally predate the passage and implementation of Federal initiatives such as RCRA, Superfund and the UIC program. Since these programs have been initiated, the most threatening segment of impoundments (those containing designated hazardous wastes) are beginning to be addressed. Moreover, as mentioned in Chapter 3, State programs were changing at the time the SIA was conducted, and today the problems related to ground water contamination are more widely recognized.

In this chapter, the major and often-recurring conclusions and recommendations are summarized. Not all States addressed all issues and in some cases the responses were indirect. Thus, some interpretation was necessary. Nevertheless this report attempts to reflect State positions accurately.

Ground Water Contamination From Surface Impoundments

Ground water contamination has occurred from surface impoundments.

# of States Addressing Issue	% in Agreement	% Disagreeing
44	93	7

There is a high potential for ground water contamination from surface impoundments.

# of States Addressing Issue	% in Agreement	% Disagreeing
43	93	7

Surface impoundments are often poorly sited.

# of States Addressing Issue	% in Agreement	% Disagreeing
39	90	10

Design and construction practices are inadequate.

# of States Addressing Issue	% in Agreement	% Disagreeing
30	90	10

Operation, maintenance and monitoring practices are inadequate.

# of States Addressing Issue	% in Agreement	% Disagreeing
33	89	11

The vast majority of States indicated that surface impoundments have already polluted ground water, and that the potential for further contamination is high. In those States indicating that contamination had not occurred or that the potential for contamination was not high, none practiced extensive monitoring of impoundments.

The problems identified by the States covered every phase--from site selection, to monitoring. Again, the majority of States indicated that current practices were not adequate, while a small percentage stated that impoundment practices were, in general, sound, although most of the latter acknowledge individual abuses.

<u>Effectiveness of State Laws and Regulations</u>

Legislative authority is adequate.

# of States Addressing Issue	% in Agreement	% Disagreeing
36	81	19

Rules and Regulations are adequate.

# of States Addressing Issue	% in Agreement	% Disagreeing
40	35	65

Monitoring and Enforcement are adequate.

# of States Addressing Issue	% in Agreement	% Disagreeing
40	28	72

Programs suffer from jurisdictional fragmentation and/or inadequate resources.

# of States Addressing Issue	% in Agreement	% Disagreeing
30	70	30

The majority of the States believed that existing legislation was sufficiently comprehensive to establish effective programs. However, most of the States indicated that lack of adequate funds and a patchwork organization severely limited the effectiveness of existing programs. They cited other problems such as a bias towards surface water quality in regulations and a lack of inspection capabilities.

In those States citing jurisdictional fragmentation as a problem, the most common complaints were that agencies frequently competed for resources, that voids and duplication were often present in regulatory programs, and that communication between agencies was sparce when it occurred at all.

Impoundments in the agricultural and oil and gas category were the least regulated facilities.

Effectiveness of Federal Programs

Federal funding is necessary to existing programs and necessary for any improvements in programs.

# of States Addressing Issue	% in Agreement	% Disagreeing
26	96	4

Federal legislation is fragmented and/or does not adequately address groundwater contamination.

# of States Addressing Issue	% in Agreement	% Disagreeing
23	70	30

State criticism of federal programs reflected many of the same issues as their evaluation of their own programs. They cited fragmentation, strong bias towards surface water quality, and the presence of voids in certain types of impoundments (non-hazardous) as major problems. They also cited the inflexible approach of the Federal programs and described the administrative requirements as burdensome. Several States indicated that excessive reporting and public participation requirements were counter productive, often siphoning off resources that could be applied to ground water protection. Some also believed that the relative inflexibility of many of the Federal programs did not enable the States adequately to address problems that were unique to their own circumstance, problems that emanated from specific localized hydrogeologic conditions, for example.

The most frequently mentioned programs in their critique of the Federal role were those funded under RCRA, the Clean Water Act (especially the 208 program) and the Safe Drinking

Water Act. While they were critical of the Federal role, most did not favor additional Federal legislation, and nearly all the States indicated that programs could not be run without Federal funds.

Recommendations Regarding State Programs

New programs should be developed or existing programs improved.

# of States Addressing Issue	% in Agreement	% Disagreeing
40	70	30

Site Selection Criteria or standards should be developed for surface impoundments.

# of States Addressing Issue	% in Agreement	% Disagreeing
31	90	10

Design Criteria should be developed or improved for surface impoundments.

# of States Addressing Issue	% in Agreement	% Disagreeing
32	91	9

Routine monitoring should be required either for all impoundments or at least for the high risk impoundments.

# of States Addressing Issue	% in Agreement	% Disagreeing
32	97	3

More resources and/or better trained personnel are required to conduct an effective program.

# of States Addressing Issue	% in Agreement	% Disagreeing
31	93	7

A permanent data base should be established for the SIA data and made available to the States.

# of States Addressing Issue	% in Agreement	% Disagreeing
28	100	0

The majority of the States felt that new or revised programs were needed to adequately regulate surface impoundments. The specific actions needed were the establishment of criteria and standards for siting, designing, operating, maintaining and monitoring impoundments, and the reorganization of institutions to streamline regulatory efforts. However, in order to effect these changes, the States felt that additional staff and funds were necessary.

Conclusions Regarding the SIA

The SIA assessment methodology yielded an accurate first round approximation of the ground water contamination potential of surface impoundments.

# of States Addressing Issue	% in Agreement	% Disagreeing
37	78	22

The assessment can be used to prioritize sites for further study.

# of States Addressing Issue	% in Agreement	% Disagreeing
37	95	5

The assessment methodology contained elements that distorted the accuracy of the rating.

# of States Addressing Issue	% in Agreement	% Disagreeing
38	53	47

The majority of the States commenting felt that there were some problems with the rating system; however, most felt that the rating system was adequate to develop a first-round cut at defining the contamination potential of surface impoundments. The specific areas in which many States felt that the rating system needed improvement was the waste rating scheme (step 4) which was characterized by some as not sensitive enough, and as inaccurate by others. Other States noted that scores for the overall contamination potential (step 5) were consistently at the higher end of the scale, which they interpreted as being insufficiently sensitive to discriminate accurately between extremely hazardous sites and relatively safe sites. Many States felt, for example, that the system did not allow for discrimination between sites which posed a threat to health, and those that threatened the ground water quality, but had only minimal or no health impacts.

Nevertheless, most of the States felt that the methodology was sufficiently accurate to be useful in ranking sites and determining roughly the first round approximation of the contamination potential of surface impoundments. It was recommended that the assessment be field verified and the methodology refined if necessary.

In summary, it is evident that the majority of States believe that existing State laws are adequate to develop an effective program.

However, in general the States characterized regulations, funding and staffing as major problem areas. Specifically, design criteria and monitoring were the features mentioned most frequently as areas that required improvement.

While most States clearly wanted Federal involvement, there was no consensus on what form it should take. However, most favored a role that accented funding, technical assistance and research assistance, rather than additional mandatory requirements.

CHAPTER VIII

CONCLUSIONS

CONCLUSIONS: STATE PROGRAMS

With a very few exceptions, State laws have not historically addressed the specific problem of ground water contamination from surface impoundments; however, they do in general provide adequate authority. In most cases, enabling legislation is general in nature and focuses primarily on surface water contamination. Such authority as does exist is derived by interpreting "waters of the State" to include ground water.

Regulations governing surface impoundments at the time of this study reflect this bias towards surface water protection. Although the majority of States require some sort of permit for most surface impoundments, the focus of the permit historically was primarily on direct discharges or on the surface impoundment as part of a treatment chain and not on seepage. A few States have established ground-water quality standards, monitoring requirements, specific siting standards, and other technical requirements, such as liner use, but even in these cases application of these requirements has often been sporadic or applicable only to new facilities.

Based on the data provided, in most cases the institutional framework for administering regulations is shared by several agencies, often without a formal coordinating mechanism. State reports said that this often resulted in interagency competition for resources, duplication of effort, and voids in responsibility and coverage.

One of the primary limitations to effective regulation of impoundments, even in cases where effective regulations and institutions are present, is the low priority and lack of qualified personnel in this area. States were nearly unanimous in citing this as a problem. They mentioned both lack of funds and lack of available qualified ground-water experts as problems in hiring adequate staff. However, increases in Federal grants related to the hazardous waste program under RCRA and other ground water protection programs such as the UIC program under the SDWA and the Superfund should help with this problem.

It is interesting to note the characteristics of State programs that had high incidences of lined sites at the time of data collection. While there are a number of other variables which may influence the incidence of lined sites (i.e. local geology, type of industry, age of impoundments, etc.) the efficacy of the State programs probably played a role in the frequency of lined sites. Pennsylvania, California, and Texas showed the highest percentage of lined industrial impoundments for States having data on more than 500 sites (See Chapter IV, Figure 4.12). The key elements of their programs are outlined in Table 8.1.

These three States exhibit clearly defined areas of responsibility for the institutions that are charged with regulating impoundments. They are developing and have established technical requirements (such as siting requirements, ground water quality standards, monitoring requirements, and maximum permeabilities). They may permit both direct discharges and indirect discharges, and they have established some form of waste classification (See Table 8.1). The latter may be an important component of their programs because it allows these States to rank sites and use limited resources more efficiently. Although the majority of States indicated that Federal funding was required to run effective, adequately staffed programs, there was no consensus on how constructive Federal legislation, regulations, and programs have been. Three common themes were expressed in State assessments of Federal programs:

- Most States rely heavily on Federal funds to administer programs.
- Federal programs are characterized by many States as inflexible and sometimes burdensome.
- The existing Federal programs must be integrated and a more coordinated approach between programs is desirable.

The States mentioned RCRA, the SDWA, and the CWA as the Federal programs having the greatest impact on regulation of surface impoundments. As a result of these Acts and an increased awareness of the importance of ground water as a supply source, many States are considering further legislation or are upgrading existing regulations to better address the problem of ground water contamination.

CONCLUSIONS: LOCATION AND COUNT

Inventory

The data from the location and count phase of the SIA indicate that oil and gas sites are the most numerous category, followed by municipal, agricultural, industrial and mining. Municipal and industrial sites tend to be in close proximity to population centers and also have more impoundments per site on the average. Accordingly, their potential impact, in terms of the number of people who could be affected by any contamination that occurs, may be greater than other categories.

ELEMENTS OF SELECTED STATE PROGRAMS

California -	Lead Agency: WQCB with Regional Boards. Areas of Responsibility are clearly defined.	Empowered to protect "Waters of the State"; includes by definition groundwater. Permits both direct and indirect discharges.	Ground water quality standards; waste classification; siting (maximum permeability); may require lining and monitoring.	Annual Inspection of Permitted Facilities.
Texas -	Two: Texas Division of Water Resources (TDWA) and Texas Railroad Commission (TRRC). Distinct areas of responsibility.	Empowered to protect "Waters of the State" includes by definition Groundwater. Permits both direct and non-discharging impoundments	Distinct requirements based on waste type; siting requirements 10-7 cm/s; may require monitoring or lining; extensive statewide monitoring network.	Field Inspection for Selected Facilities.
Pennsylvania -	Lead Agency: Bureau Water Quality Management with Oil and Gas under a second Agency.	Empowered to protect "Waters of the State" includes by definition Groundwater. Permits all facilities above a minimum capacity.	Currently developing Ground water quality standards; distinct requirements based on waste type; siting standards, (maximum permeability)	Semi-Annual Inspection

Table 8.1

Data on the quality and quantity of the influent and effluent fluids were sometimes unavailable and States generally indicated a low confidence rating on the validity of such information. They thought data on impoundment size was somewhat more valid, and on the average, mining and industrial impoundments tended to be larger.

Ground Water Protection

Less than 30 percent of the industrial impoundments are lined and fewer are lined in other categories. Similarly, monitoring is conducted at very few sites on a national level, although a few States require monitoring more frequently.

The study indicated that the main correlation that existed between increased use of liners and monitoring reflected variations of requirements in State programs, rather than the relative danger of the practice. For example, liner use should increase in sites that are located over usable aquifers within thin or permeable unsaturated zones. Similarly, more liners should be used when the waste is relatively more hazardous. However, the data showed no correlation between the hydrogeology of a site and the frequency of liner use and only a slight correlation between the waste hazard rating and liner use.

One factor that influenced the frequency of liner use was the relative age of the impoundment. Newer impoundments were more likely to be lined than older ones. Presumably this reflects the impact of recent legislation, as well as an increasing reliance on ground water as a water supply. In general, States which had a relatively higher percentage of impoundments lined also had more monitoring at sites. (Florida is an exception, with relatively few sites lined, but a high number of sites monitored.)

CONCLUSIONS: ANALYSES OF DATA

The analyses indicate that surface impoundments are often sited in a way that allows percolation of wastes to the ground water. In addition, they often are lacking in design safeguards and monitoring, and are located in close proximity to water supplies. The use of siting and design safeguards shows little or no correlation with waste hazard potential or sensitive hydrogeologic settings. Indeed, patterns for both liner use and frequency of monitoring showed a greater correlation to State boundaries than to technical criteria which indicates little past attention to potential impacts on ground water.

Viewed from the perspective of specific categories, the industrial category shows the greatest contamination potential, with a mean Step 5 score of 20.4. Municipal sites followed with a mean score of 19.6. Moreover, municipal and industrial sites are generally located in proximity to both population centers and water supply systems. Beyond this, about 35 percent of the industrial sites contain waste which scored greater than 6 on the hazard potential rating. This rating is indicative of potentially hazardous waste. Summarizing these analyses, the data reveal the following:

<u>Site Selection</u>

- Nearly 50 percent of all sites are located on unsaturated zones that are either very thin or very permeable. For industrial categories, more than 50 percent are so sited.
- Approximately 70 percent of all sites are located over thick and very permeable aquifers that allow rapid movement of plumes. For the industrial category the percentage rises to nearly 80 percent.
- Over 30 percent of all sites are located in areas that have thin or permeable unsaturated zones, overlie highly transmissive aquifers containing water that is currently used or of high quality. For the municipal and industrial category, the percentages rise to approximately 40 percent. Less than 10 percent of all sites are located in a manner that poses little threat of ground water contamination.

<u>Waste Characteristics</u>

- Over 15 percent of all sites (excluding oil and gas) contain waste which received waste rating scores that indicate a high potential for noxious or toxic waste. In the industrial category, about a third of the sites contain potentially toxic waste.

<u>Proximity to Water Supplies</u>

- Approximately 85 percent of all sites are located within one mile of a potential surface or ground water source.

<u>Gound Water Protection</u>

- Approximately 30 percent of the industrial sites are lined, 20 percent of the municipal sites are lined, and 15 percent of the agricultural sites are lined. There is little or no correlation between the waste hazard, the siting characteristics and the use of liners.

- Data on monitoring also show little correlation between the sensitivity of the aquifer to contamination and the use of monitoring wells.

CONCLUSIONS: CASE STUDIES

Analysis of the case studies points to the following: surface impoundments--whether they are termed evaporation ponds, holding ponds, etc.--have contaminated ground water when careful siting, design and operation were not practiced. Analysis of the causes of contamination shows, further, that liners and other design measures, by themselves, are no assurance that an impoundment will perform satisfactorily. There should be a well planned program of inspections, maintenance, and monitoring in order to assure satisfactory performance and adequate protection.

Use of monitoring practices seems to be inadequate, with detection occuring only as a result of contamination of the water supply in 45 percent of the cases. Moreover, in some cases when monitoring wells are employed, there is no assurance that detection will be adequate to prevent contamination of supply wells. Beyond this, the case studies indicate that remedial approaches, while practiced, require extensive study and often involve difficult legal determinations.

Finally, the Step 5 scores indicate that the rating system used in the SIA may be generally valid for its stated purpose: a first-round approximation of the contamination potential that can be useful in large aggregates but that cannot be applied to site-specific situations. It appears, however, that the rating system could be improved by increasing its sensitivity. The difference in overall contamination sources between industrial sites known to contaminate ground water and the mean score for all sites was only 3.8 out of a possible 29.

CONCLUSIONS: STATE FINDINGS

It is evident that the majority of States believe that existing State laws are adequate to develop an effective program.

However, in general the States characterized regulations, funding and staffing as major problem areas. Specifically, design criteria and monitoring were the features mentioned most frequently as areas that required improvement.

While most States clearly wanted Federal involvement, there was no consensus on what form it should take. However, most favored a role that accented funding, technical assistance and research assistance rather than additional mandatory requirements.

APPENDIX A

PREFACE

The Manual for Evaluating Contamination Potential of Surface Impoundments was prepared specifically for implementing a standardized evaluation system for the EPA Office of Drinking Water Surface Impoundment Assessment (SIA) and serves as the training manual for that assessment. The SIA evaluation system set forth in the manual is based upon the previous work by Harry E. LeGrand who began over 15 years ago to develop a standardized, consistent approach to the selection of proper waste disposal sites. This system departs from the LeGrand system in order to accommodate certain philosophical differences concerning ground-water protection and specific technical aspects related to surface impoundments. In no way does this detract from the importance of the LeGrand system in serving as the basis for the SIA evaluation system.

This manual also was prepared with the assistance of the SIA work group who made many valuable suggestions. The work group members are:

Jack Keeley
Ground Water Research Branch
Kerr Environmental Research Laboratory/EPA
Ada, Oklahoma

Charles Kleeman
Ground Water Protection Section
EPA/Region III

Richard Bartelt
Ground Water Protection Section
EPA/Region V

James K. Channell
Hazardous Materials Branch
EPA/Region IX

George Garland,
Toby Goodrich
Office of Solid Waste
EPA/Headquarters

Jane Ephremides,
Larry Graham,
Ted Swearingen,
Lyle Silka
Office of Drinking Water
EPA/Headquarters

The Office of Drinking Water also extends its appreciation to the following for their assistance in reviewing early drafts of this manual:

Bruce F. Latta
Oil Field and Environmental Geology Section
Kansas State Department of Health & Environment

John Dudley
Water Quality Division
New Mexico Environmental Improvement Agency

Robert M. Sterrett
Virginia Water Control Board

Donald G. Williams
Water Quality Bureau
Montana Department of Health and Environment

Ronald G. Hansen
Water Pollution Control
Alaska Department of Environmental Conservation

Paul Beam
Bureau of Water Resources Management
Florida Department of Environmental Regulation

Robert Wall
Division of Water Pollution Control
Nebraska Department of Environmental Control

Leonard Wood
USGS/Water Resources Division
Reston, VA

Jay H. Lehr
Tyler E. Gass
National Water Well Association

John Osgood
Pennsylvania Department of Environmental Resources

James Geraghty, David Miller and Nat Perlmutter
Geraghty and Miller, Inc.

Bob Kent
Texas Department of Water Resources

We also take this opportunity to thank the following for assisting Messrs. Silka and Swearingen in collecting case studies and field testing the evaluation system in the early phases of its development.

John Scribner and Ronald G. Hansen
Alaska Department of Environmental Conservation

Mead Sterling and Lyndon Hammond
Arizona Department of Health

Tom Bailey and Alvin L. Franks
California State Water Resources Control Board

Orville Stoddard
Colorado State Health Department

Dick Woodhall
Connecticut State Health Department

Paul Beam and Frank Andrews
Florida Department of Environmental Regulation

Rauf Piskin
Illinois Environmental Protection Agency

Bruce Latta and Bill Bryson
Kansas State Department of Health and Environment

Charles Bishop
Louisiana Department of Health and Human Resources

Chester Harvey and Fred Eyer
Michigan Department of Natural Resources

Donald G. Williams
Montana Department of Health and Environmental Sciences

Bob Wall, Clark Haberman, Jon Atkinson and Dennis Heitman
Nebraska Department of Environmental Control

Wendall McCurry
Nevada Division of Environmental Protection

Patrick A. Glancy and Jon O. Nowlin
USGS/Water Resources Division
Nevada

Joe Pierce, Maxine Goad, Mike Snavely and John Dudley
New Mexico Environmental Improvement Agency

Dan Serrell
New York Department of Health

Norman Peterson
North Dakota State Health Department

Mark Coleman and Dick Jones
Oklahoma State Department of Health

Harold Sawyer
Oregon Department of Environmental Quality

Jerry Mullican and Bob Kent
Texas Department of Water Resources

Charles Ratte
Vermont Agency of Environmental Conservation

R.M. Sterrett, Eugene Siudyla and Virginia Newton
Virginia Water Control Board

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

INTRODUCTION

An objective of the surface impoundment assessment (SIA) program (see Figure 1) is to rate the contamination potential of ground water from surface impoundments and to develop practices for the evaluation of different surface impoundments (elsewhere referred to as pits, ponds, and lagoons). One of the activities conducted under the SIA program is the application of the evaluation system described in the present manual. This evaluation system applies a numerical rating scheme to different impoundments that yields a first round approximation of the relative ground-water contamination potential of these impoundments.

The basis of this system was developed by Harry E. LeGrand in 1964. LeGrand and Henry S. Brown expanded and improved the system in 1977 under contract to the Office of Drinking Water. The present system described in this manual has been modified by the Office of Drinking Water through consultation with LeGrand and Brown to reflect its ground-water protection philosophy. Before the selection of the present evaluation system, other standardized systems were considered (Cherry, et. al., 1975; Pinder, et. al., 1977; Phillips, 1976) but were not deemed as suitable for the purposes of the assessment. The system is designed to provide an

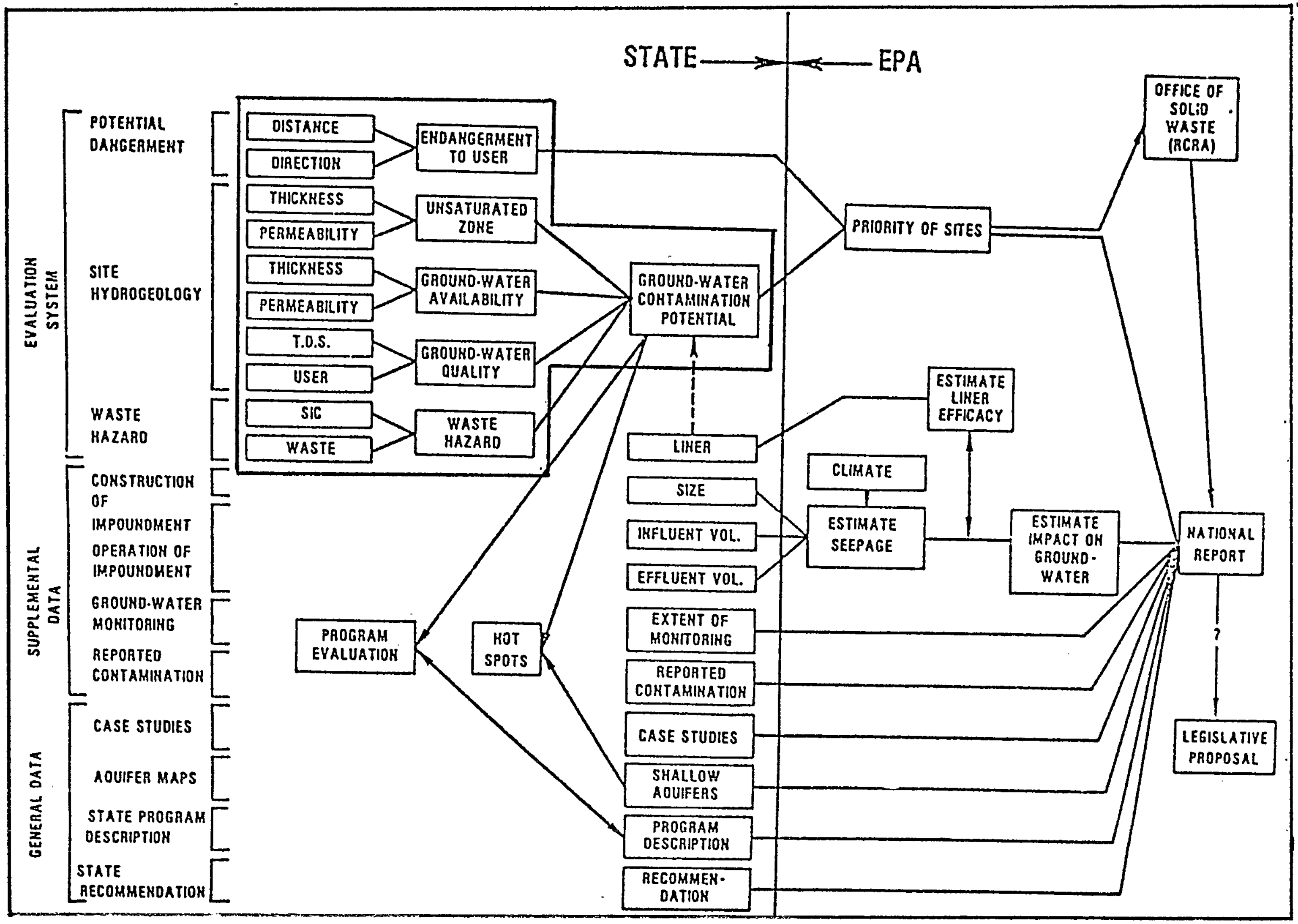


Figure 1. Flow chart of the Surface Impoundment Assessment. The outlined portion is the evaluation system described in this manual.

approximation of the ground-water contamination potential of impoundments at a minimum cost. Precise, in-depth investigations of actual ground-water contamination from surface impoundments (i. e., drilling, etc.) would be too costly and time-consuming and are not involved in this first-round site evaluation. The specific site investigations into actual contamination would begin after this assessment is finished in order to optimize expenditures. Those sites identified as high contamination potential would be addressed first.

The philosophy guiding the development of this surface impoundment evaluation system is that underground drinking water sources must be protected for both present and future users as intended by Congress in the Safe Drinking Water Act, 1974. Ground-water pollution occurs when contaminants reach the water table (saturated zone) beneath the site. This is contrary to the commonly held view that ground-water contamination cannot legally be determined until the contaminated ground water crosses the property boundaries of the facilities. EPA believes that in order to protect the nation's ground-water resources it is necessary to identify potential contamination at the source where preventive measures may be initiated. The purpose of this evaluation system is to rank impoundments in terms of their relative ground-water contamination potential. The evaluation system considers several hydrogeologic parameters in the rating of the site. There are numerous parameters that may be used in evaluating a site. However, many of these parameters are related and their simultaneous consideration would be redundant. Thus, only selected parameters representative of different processes, have been included. The present evaluation system provides a standardized methodology which will ensure more consistent national results.

The parameters used in the present SIA system have been separated into two distinct groups which correspond to the two phases of the evaluation, i.e., 1) the rating of the ground water contamination potential itself and 2) the rating of the relative magnitude of potential endangerment to current users of underground drinking water sources. The parameters considered unique in rating the ground-water contamination potential are 1) the thickness of the unsaturated zone and the type of earth material of that zone, 2) the relative hazard of the waste, and 3) the quantity and quality of the underground drinking water source beneath the site. The parameters considered unique in determining the rating for the potential for endangerment of currently used water resources include: 1) the type of water source, i.e. ground water or surface water, 2) whether that water source is in the anticipated flow direction of the contaminated ground water (if such contamination occurred); and 3) the distance between the potential contamination source and the water source. These parameters account for the basic processes and factors which determine the contamination potential of the site and which indicated the relative threat to underground drinking water sources.

The level of contamination of ground water is subject to varying degrees of attenuation as the water flows through the unsaturated zone and on through the aquifer; however, the evaluation focuses on the potential for contamination of underground water sources. Attenuation mechanisms are very complex, varying with the type of waste, earth material, and physico-chemical environment. A general site evaluation system concerned with an approximation of the contamination potential cannot consider the specific attenuative capabilities of different earth materials for different wastes, particularly since there exists a vast variety of complex wastes possible. This evaluation system therefore treats attenuation in an indirect manner by considering it in combination with permeability.

The evaluation is performed in a sequence (see Figure 2). The first four steps involve the evaluation of the potential for ground water to be contaminated by rating the site's hydrogeology and waste character. The fifth step then determines the site's overall contamination potential relative to other rated sites by combining the first four steps. It must be stressed that this overall rating will express only a site's hydrogeologic

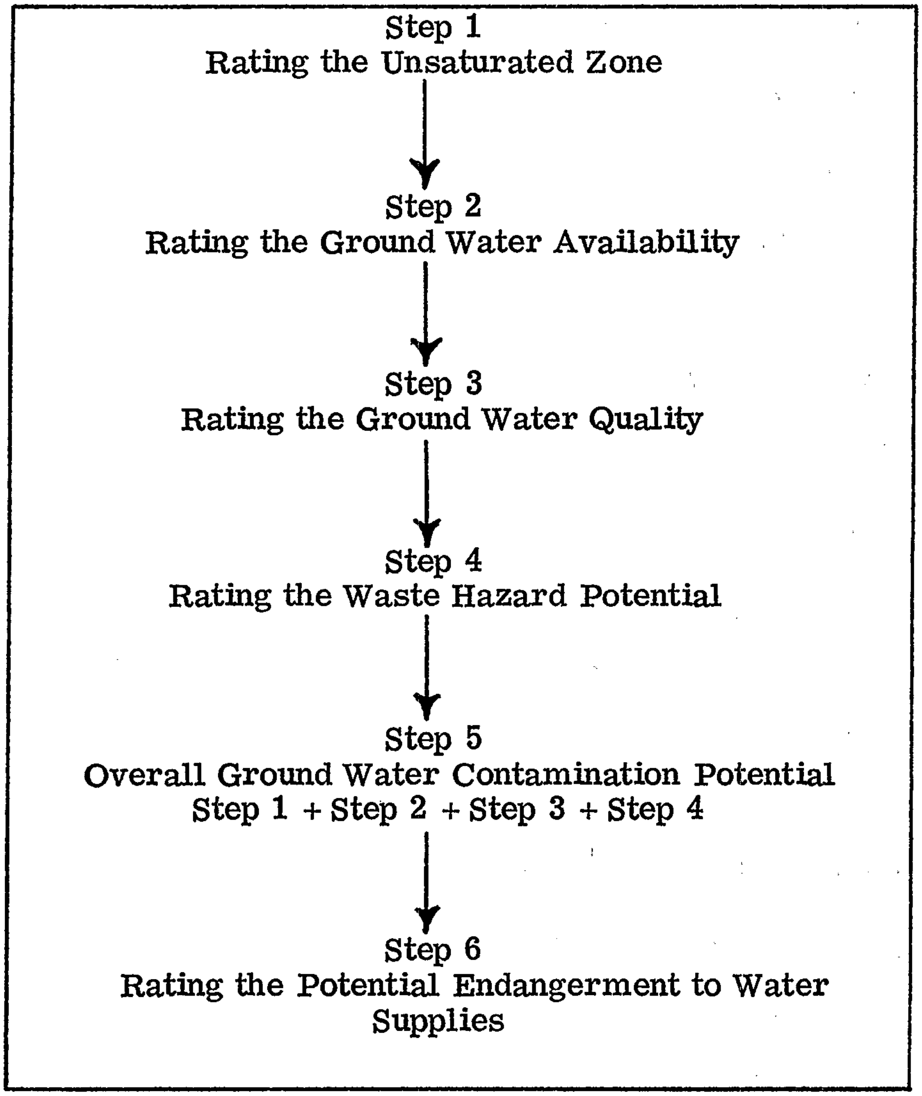


Figure 2. Generalized sequence of steps involved in the SIA evaluation system.

conditions relative to those conditions for all possible sites, and does not relate to a site's absolute degree of ground-water contamination. Such determination of actual contamination involving ground-water monitoring and sampling procedures must be made following site specific investigations. This system allows the investigator to assign priorities to sites on the basis of contamination potential so that the investigator could then concentrate resources upon the further investigation of these sites that rank highest in terms of their contamination potential.

Precise data is not necessary for the application of the SIA evaluation system. Performing precise measurements of the the depth to the water table, the character of the earth materials underlying the site, the hydrogeology at the site, etc., can be costly and time consuming. It must be remembered that this evaluation system is a first-round approximation and therefore estimates based on the best available information will be used with the expectation that they will provide satisfactory results for first-round evaluations.

STEP 1

GUIDANCE FOR RATING THE UNSATURATED ZONE

The earth material characteristics of the unsaturated zone underlying the surface impoundment are rated to determine the potential for contaminants to reach the water table. This step involves the combined rating of a) the thickness of the unsaturated zone, and b) earth material (both consolidated and unconsolidated rock) in the unsaturated zone (see Table I).

Step 1, Part A, Determination of the depth to the saturated zone for Step 1

Contaminants attenuate to varying degrees as they migrate down through the unsaturated zone, depending upon the thickness and the type of earth material. Therefore, more favorable conditions exist where the water table is deeper. The depth to the saturated zone is the depth from the base of the surface impoundment to the water table. This depth may be measured to the water table in unconfined aquifers (See Site 1 in Figure 3) or, in the case of a confined aquifer, to the top of the confined aquifer (See Site 2 in Figure 3). Where a perched water table is known to occur, the depth may be measured

TABLE I

Step 1. Rating of the Unsaturated Zone.

GUIDELINES FOR DETERMINING CATEGORY

Earth Material Category	I	II	III	IV	V	VI
Unconsolidated Rock	Gravel, Medium to Coarse Sand	Fine to Very Fine Sand	Sand with < 15% clay, Silt	Sand with > 15% but ≤ 50% clay	Clay with < 50% sand	Clay
Consolidated Rock	Cavernous or Fractured Limestone, Evaporites, Basalt Lava Fault Zones	Fractured Igneous and Metamorphic (Except Lava) Sandstone (Poorly Cemented)	Sandstone (Moderately Cemented) Fractured Shale	Sandstone (Well Cemented)	Siltstone	Unfractured Shale, Igneous and Metamorphic Rocks
Representative Permeability in gpd/ft^2 -	>200	2 - 200	0.2 - 2	< 0.2	< 0.02	< 0.002
in cm/sec -	$>10^{-2}$	$10^{-4} - 10^{-2}$	$10^{-5} - 10^{-4}$	$<10^{-5}$	$<10^{-6}$	$<10^{-7}$
RATING MATRIX						
Thickness of the Unsaturated Zone (in Meters) >30	9A	6B	4C	2D	0E	0F
>10 ≤30	9B	7B	5C	3D	1E	0G
> 3 ≤10	9C	8B	6C	4D	2E	0H
> 1 ≤3	9D	9F	7C	5D	3E	1F
>0 ≤1	9E	9G	9H	9I	9J	9K

to it rather than the underlying regional water table (See Site 3 in Figure 3). The investigator will decide whether to measure the depth to the perched water table or ignore it and measure to the regional water table. This decision should be based on the extent and thickness of the perched water table and its usefulness as a drinking water source. If the perched water table is currently being utilized as a drinking water source, the depth should be measured to it.

Water tables fluctuate on a diurnal, seasonal and annual basis due to natural and artificial causes. For this assessment system the depth to the water table should be determined on the basis of the seasonal high water table elevation. As is shown in Table I, the depth determination does not have to be exact since the intervals are large. Illustrations of possible well hydrographs are shown in Figures 4 and 5. Figure 4a depicts a hydrograph of a well in Illinois which is only affected by seasonal climatic variation. The depth to water table would be taken as approximately five feet (1.6 meters). In Figure 4b the well hydrograph illustrates a water table which is affected by seasonal pumping variation. Pumping is greatest and, as a result, the water table is lowest during May through September, the hot season when consumption

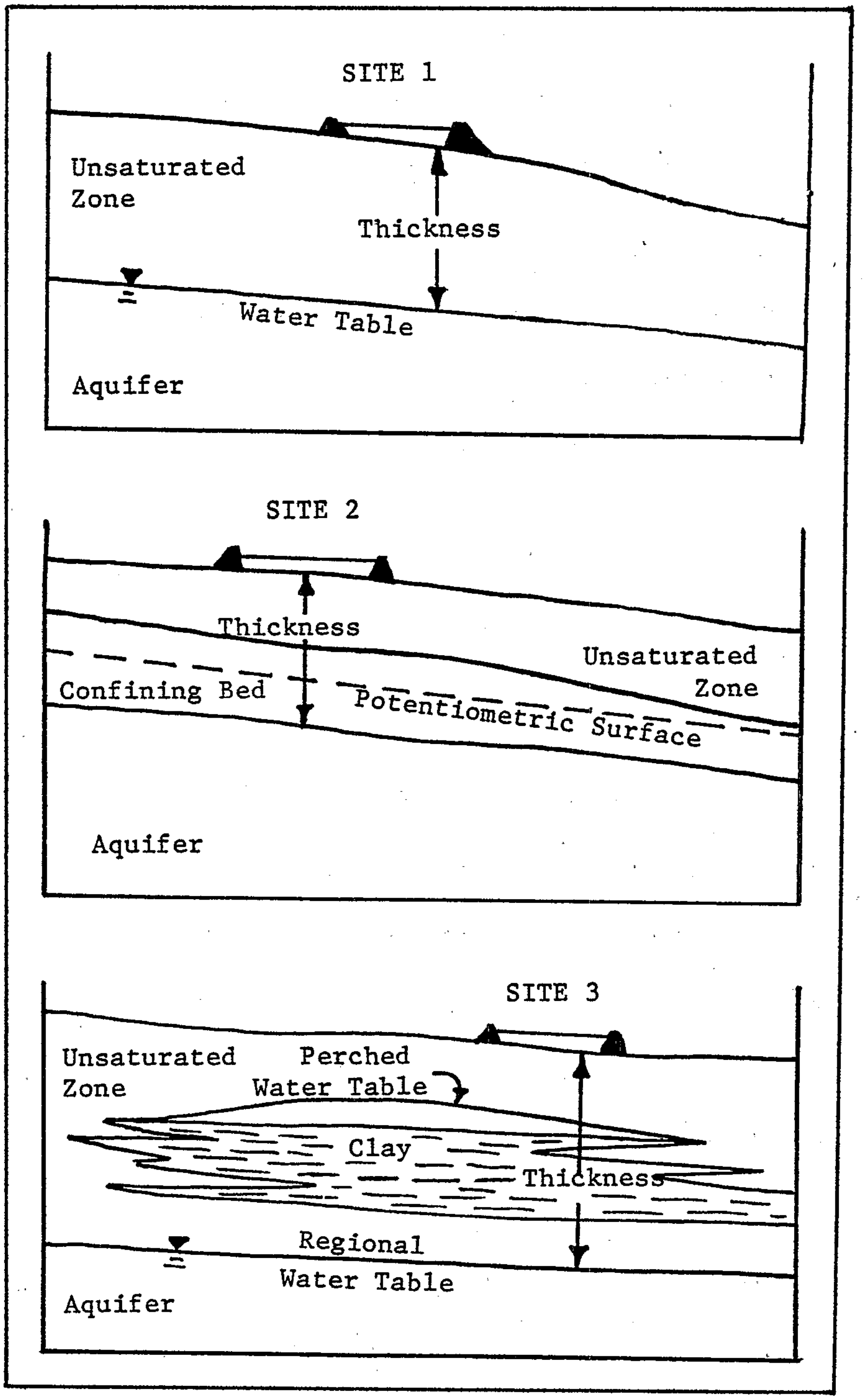


Figure 3. Guide for the determination of the depth to the saturated zone (water table in the unconfined case or top of confined aquifer) for completion of Step 1.

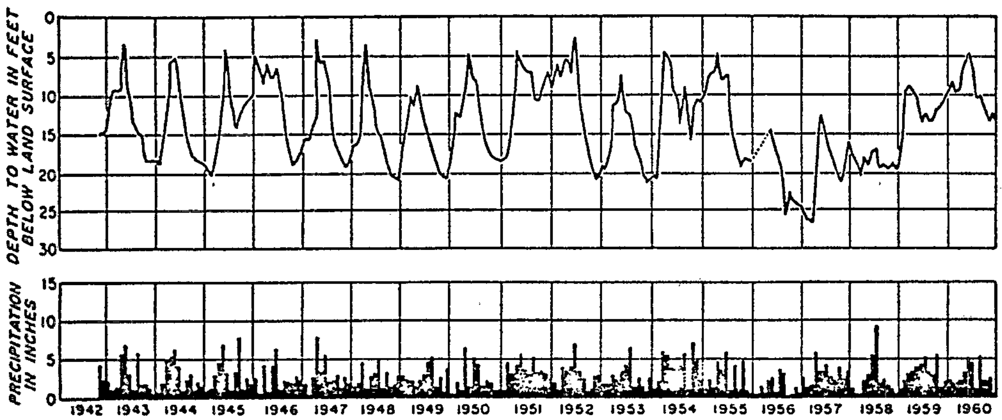


Figure 4A

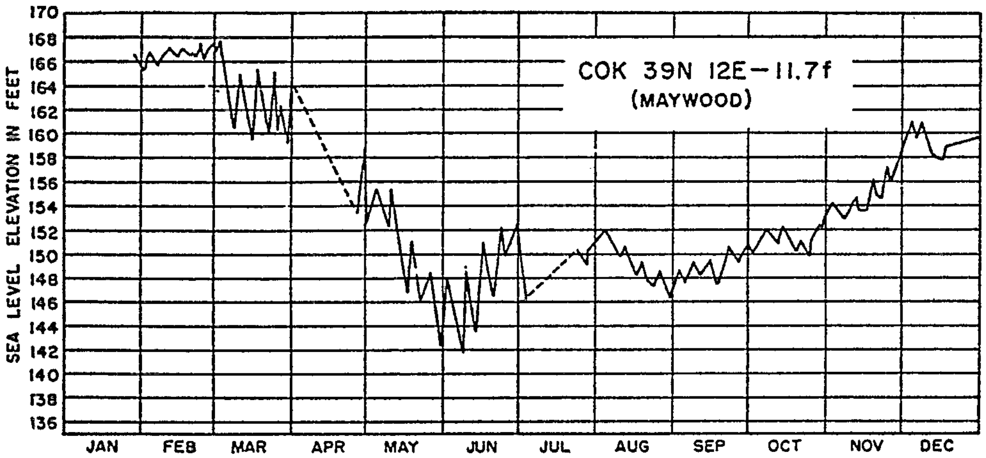


Figure 4B

Figure 4. Well hydrographs of a water well at Maywood, Illinois, showing, in Figure 4A, seasonal fluctuations in a well remote from pumping well influences; and in Figure 4B, fluctuations in a well close to a ground water pumping area (from Walton, 1970, p. 106).

is greatest. During the winter months of November through March the demand decreases and the ground-water table recovers. In this case the depth to the water table would be computed at the highest level, at 168 feet (51.2 meters) of elevation rather than the summer levels of 142 feet (43.3 meters).

Figure 5 shows a long period of record for a well hydrograph located in Ainsworth, Nebraska, in which annual and longer term fluctuations exist. Although the maximum change in water level amounts to only about 6 or 7 feet (2 meters), other areas of the country do experience much greater variation and should be considered. However, in this example, the water level used in determining the depth to the water table should be the higher level of 34 feet (10.4 meters) below the surface. Note that in all these examples, the more conservative estimate is used for depth to the water table.

In the situation where a confined (artesian) aquifer is encountered below a disposal site and an unconfined (water table) aquifer does not exist, the depth is measured to the top of that confined aquifer. Due to the nature of the confined aquifer, the net hydrostatic head of the system may decrease the possibility of contamination. However, conditions are not steady-state and other phenomena may affect the

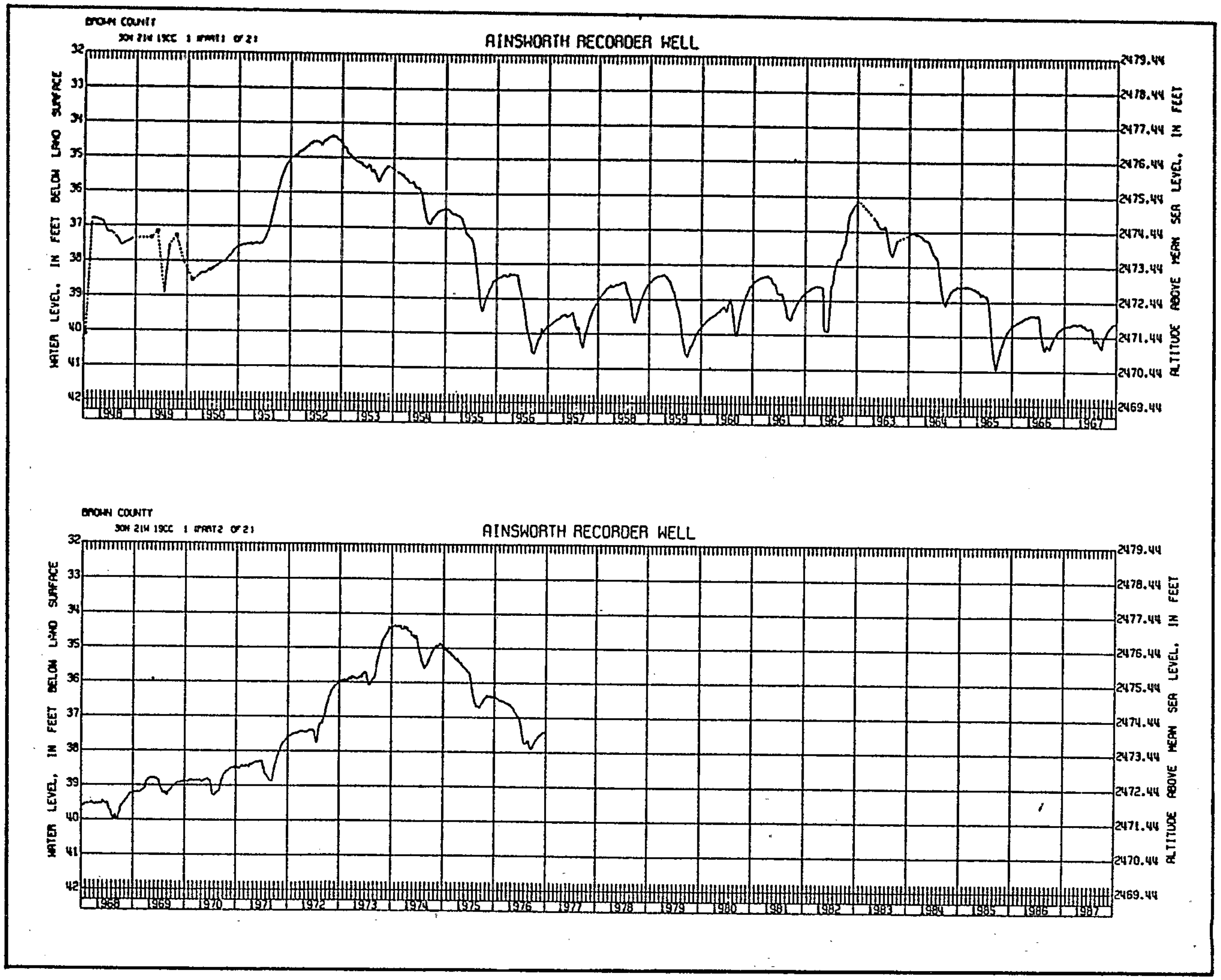


Figure 5. Well hydrograph of the Ainsworth, Nebraska, water supply well showing annual and longer term ground water level fluctuations (from Ellis and Pederson, 1977, p. 67).

net hydrostatic head of the confined aquifer. With the reductions of head which can be experienced (as in many irrigated areas of the country), confined aquifers may become vulnerable to contamination from surface sources through over pumping.

Step 1, Part B, Determination of the earth material category for Step 1

The type of earth material must be identified in order to complete Step 1. Table I contains an ordinal ranking of the general categories of earth materials based upon permeability, secondarily upon sorption character. The inclusion of sorption is based on the general relationships between grain size/surface area and permeability/sorption. Grain size (or pore size) is proportional to permeability and inversely proportional to surface area which is an important factor in sorption mechanisms. As grain size is inversely proportional to sorption capacity, sorption capacity is inversely proportional to permeability. Thus, going from left to right across the earth material categories in Table I, permeability decreases while sorption generally tends to increase. The categories take into account whether the permeability of the material is primary (properties existing at the time of formation such as the pore spaces) or secondary (properties of the material imposed upon it sometime after formation such as joints, fractures, faults and solution channels). Secondary permeability is usually much greater than primary permeability due to the larger pathways. This distinction is very important in the categorization of earth materials as the presence of secondary permeability increases the flow of water and decreases attenuation. Fractures, joints, and faults are caused by earth movement and generally become closed and tighter with depth (generally within a hundred meters) because of increased pressures and decreased weathering effects. Faults often have an associated zone of crushed rock (fault breccia) which may be highly permeable.

The classification of the earth material should follow the guidelines of Table I and of Figures 6 and 7 which supply further assistance in the classification. Figure 6 gives a fairly comprehensive list of driller's terms found in driller's logs and the equivalent classification for Table I. Some groups of terms are assigned to more than one category, in which case the investigator must make a judgement. In Figure 7, the equivalent Unified Soil Classification System codes are shown.

I

Gravel, Sand, Sand and Gravel, and Similar Materials
Specific yield 25 per cent

Boulders
Coarse gravel
Coarse sand
Cobbles
Cobble stones
Dry gravel (if above water table)
Float rocks
Free sand
Gravel
Loose gravel
Loose sand
Rocks

Gravel and sand
Gravel and sandrock
Medium sand
Rock and gravel
Running sand
Sand
Sand, water
Sand and boulders
Sand and cobbles
Sand and fine gravel
Sand and gravel
Sandy gravel
Water gravel

II or III

Fine Sand, Tight Sand, Tight Gravel, and Similar Materials
Specific yield 10 percent

Sand and clay
Sand and clay strata (traces)
Sand and dirt
Sand and hardpan
Sand and hard sand
Sand and lava
Sand and pack sand
Sand and sandy clay
Sand and soapstone
Sand and soil
Sand and some clay
Sand, clay, and water
Sand crust
Sand-little water
Sand, mud, and water
Sand (some water)
Sand streaks, balance clay
Sand, streaks of clay
Sand with cemented streaks
Sand with thin streaks of clay

Coarse, and sandy
Loose sandy clay
Medium sandy
Sandy
Sandy and sandy clay
Sandy clay, sand, and clay
Sandy clay —water bearing
Sandy clay with streaks of sand
Sandy formation
Sandy muck
Sandy sediment
Very sandy clay

Boulders, cemented sand
Cement, gravel, sand, and rocks
Clay and gravel, water bearing
Clay & rock, some loose rock
Clay, sand and gravel
Clay, silt, sand, and gravel
Conglomerate, gravel, and boulders
Conglomerate, sticky clay, sand and gravel
Dirty gravel
Fine gravel, hard
Gravel and hardpan strata
Gravel, cemented sand
Gravel with streaks of clay
Hard gravel
Hard sand and gravel
Packed gravel
Packed sand and gravel
Quicksand and cobbles
Rock sand and clay
Sand and gravel, cemented streaks
Sand and silt, many gravel
Sand, clay, streaks of gravel
Sandy clay and gravel
Set gravel
Silty sand and gravel (cobbles)
Tight gravel

Sandy loam
Sandy loam, sand, and clay
Sandy silt
Sandy soil
Surface and fine sand

Cloggy sand
Coarse pack sand
Compacted sand and silt
Dead sand
Dirty sand
Fine pack sand
Fine quicksand with alkali streak
Fine sand
Fine sand, loose
Hard pack sand
Hard sand
Hard sand and streaks of sandy clay

Hard sand rock and some water sand
Hard sand, soft streaks
Loamy fine sand
Medium muddy sand
Milk sand
More or less sand
Muddy sand
Pack sand
Poor water sand
Powder sand
Pumice sand
Quicksand
Sand, mucky or dirty
Set sand
Silty sand
Sloppy sand
Sticky sand
Streaks fine and coarse sand
Surface sand and clay
Tight sand

Brittle clay and sand
Clay and sand
Clay, sand, and water
Clay with sand
Clay with sand streaks
More or less clay, hard sand and boulders
Mud and sand
Mud, sand, and water
Sand and mud with chunks of clay
Silt and fine sand
Silt and sand
Soil, sand, and clay
Topsoil and light sand
Water sand sprinkled with clay

Float rock (stone)
Laminated
Pumice
Seep water
Soft sandstone
Strong seepage

IV or V

Clay and Gravel, Sandy Clay, and Similar Materials
Specific yield 5 percent

Cemented gravel (cobbles)
Cemented gravel and clay
Cemented gravel, hard
Cement and rocks (cobbles)
Clay and gravel (rock)
Clay and boulders (cobbles)
Clay, pack sand, and gravel
Cobbles in clay
Conglomerate
Dry gravel (below water table)
Gravel and clay
Gravel (cement)
Gravel and sandy clay
Gravel and tough shale
Gravelly clay
Rocks in clay
Rotten cement
Rotten concrete mixture
Sandstone and float rock
Silt and gravel
Soil and boulders

Cemented sand
Cemented sand and clay
Clay sand
Dry hard packed sand
Dry sand (below water table)
Dry sand and dirt
Fine muddy sand
Fine sand, streaks of clay
Fine tight muddy sand
Hard packed sand, streaks of clay
Hard sand and clay
Hard set sand and clay
Muddy sand and clay
Packed sand and clay
Packed sand and shale
Sand and clay mix
Sand and tough shale
Sand rock
Sandstone
Sandstone and lava
Set sand and clay
Set sand, streaks of clay
Cemented sandy clay
Hard sandy clay (tight)
Sandy clay
Sandy clay with small sand streaks, very fine
Sandy shale
Set sandy clay
Silty clay
Soft sandy clay
Clay and fine sand
Clay and pumice streaks

Ash
Caliche
Chalk
Hard lava formation

Clay and sandy clay
Clay and silt
Clay, cemented sand
Clay, compact loam and sand
Clay to coarse sand
Clay, streaks of hard packed sand
Clay, streaks of sandy clay
Clay, water
Clay with sandy pocket
Clay with small streaks of sand
Clay with some sand
Clay with streaks of fine sand
Clay with thin streaks of sand
Porphyry clay
Quicksandy clay
Sand—clay
Sand shell
Shale and sand
Solid clay with strata of cemented sand
Sticky sand and clay
Tight muddy sand
Very fine tight muddy sand

Dry sandy silt
Fine sandy loam
Fine sandy silt
Ground surface
Loam
Loam and clay
Sandy clay loam
Sediment
Silt
Silt and clay
Silty clay loam
Silty loam
Soft loam
Soil
Soil and clay
Soil and mud
Soil and sandy shale
Surface formation
Top hardpan soil
Topsoil
Topsoil and sandy silt
Topsoil—silt

Decomposed hardpan
Hardpan and sandstone
Hardpan and sandy clay
Hardpan and sandy shale
Hardpan and sandy stratas
Hard rock (alluvial)
Sandy hardpan
Semi-hardpan
Washboard

Hard pumice
Porphyry
Seepage soft clay
Volcanic ash

V or VI

Clay and Related Materials
Specific yield 3 percent

Adobe
Brittle clay
Caving clay
Cement
Cement ledge
Choppy clay
Clay
Clay, occasional rock
Crumbly clay
Cube clay
Decomposed granite
Dirt
Good clay
Gumbo clay
Hard clay
Hardpan (H.P.)
Hardpan shale
Hard shale
Hard shell
Joint clay

Lava
Loose shale
Muck
Mud
Packed clay
Poor clay
Shale
Shell
Slush
Soapstone
Soapstone float
Soft clay
Squeeze clay
Sticky
Sticky clay
Tiger clay
Tight clay
Tule mud
Variable clay
Volcanic rock

VI

Crystalline Bedrock (fresh)
Specific yield zero

Granite
Hard boulders
Hard granite

Hard rock
Graphite and rocks
Rock (if in area of known crystalline rocks)

Figure 6. Common driller's terms used in estimating specific yield (from Todd, 1970, p. 205) and the equivalent evaluation system earth material categories.

Step 1 Earth Material Category (and Step 1 Designation)	Unified Soil Classification System Designation	Permeability Range (cm/sec)
Gravel (I)	GW, GP	Permeable
Medium to Coarse Sand (I)	SW, SP	$> 10^{-4}$ cm/sec
Fine to Very Fine Sand (II)	SW, SP	
Sand with $\leq$15% Clay, Silt (III)	GM, SM, SC	Semi-permeable
Sand with $>$15% but $\leq$50% Clay (IV)	GM, SM, ML	10^{-2} to 10^{-6} cm/sec
Clay with $<$50% Sand (V)	OL, MH	Relatively imperme-able
Clay (VI)	CL, CH, OH	$< 10^{-6}$ cm/sec

Figure 7. Earth material categories and their approximate Unified Soil Classification System equivalents.

The geologic conditions beneath the site can be a very complex layering of clays, sands and gravels or consolidated sedimentary rocks such as sandstone, limestone and shale. In these layered situations the rating may be accomplished by considering the probable hydrology of the system. Where the different layers have similar hydrologic properties, the layers may be considered a single hydrologic unit for rating purposes. Where contrasting layers are encountered, best judgement must be exercised in rating the site. For example, if an impermeable shale overlies permeable sandstone rate only the thickness of shale. The investigator must be cautioned, however, that in rating a case where hydrologically unlike layers alternate, the waste is more likely to move through the more permeable zones and avoid the impermeable layers. As an example, a sand containing clay lenses should be rated as if only sand were present (See Figure 8). Similarly, where secondary permeability is present (i.e. fractures, joints and faults) the major path of waste movement is through the large conduits of secondary permeability rather than the interstices of primary permeability. This results in a short circuit of any attenuation capability present in the material. In such cases, the earth material would be rated as the more permeable categories.

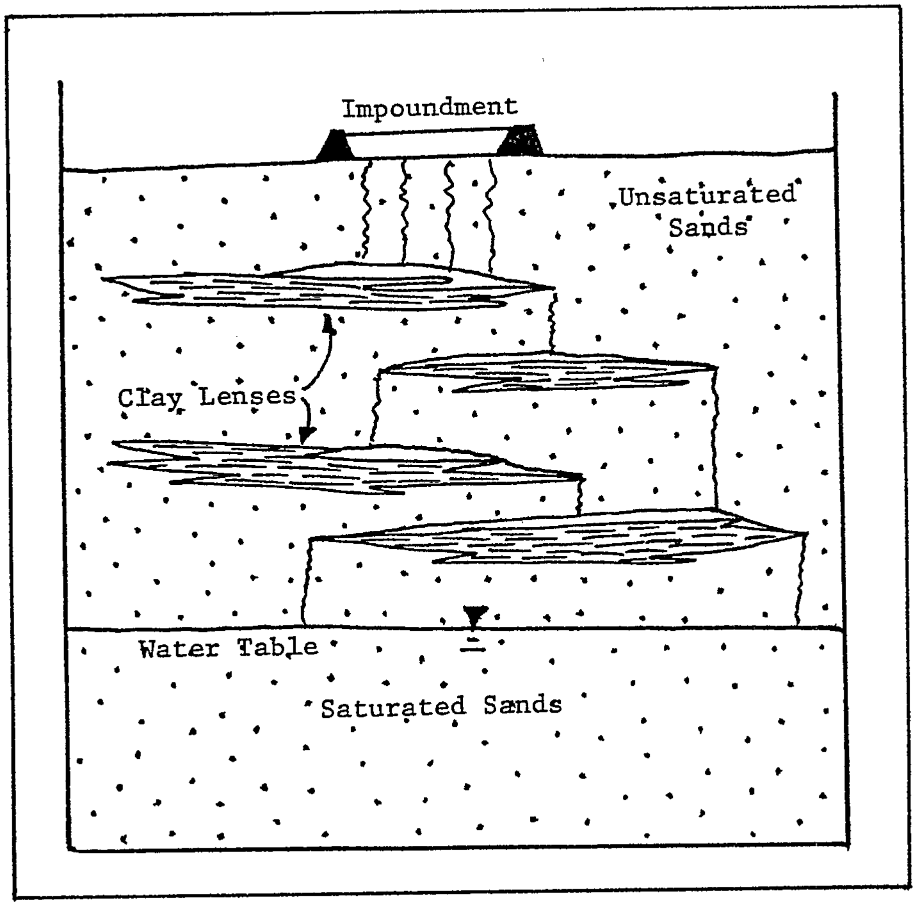


Figure 8. Hypothetical flow paths of waste fluids seeping from a surface impoundment through unsaturated sands containing clay lenses.

Step 1, Part C, The Scoring of Step 1.

After the thickness of the unsaturated zone and the type of earth material in the unsaturated zone have been determined, refer to the Step 1 matrix (in Table 1) and record the appropriate score for the particular values of thickness and material.

Sources of information for completing Step 1.

Many data sources exist for the depth to the water table and the geologic material beneath a site. The site may have specific data available from State files if the site is permitted. The owner/operator may have data on shallow bedrock and soils available from borings or trenches made for the impoundment or nearby building foundations. Nearby water wells may provide data on the geology and ground-water levels, and adjacent road cuts can provide additional information on the subsurface.

General information is available from State agency reports such as the State geological survey, State departments of transportation soil borings, water resources agencies or universities with departments concerned with geology and ground-water resources. The United States Geological Survey also publishes reports and maintains files on ground water occurrence in each State. The U.S. Department of Agriculture, Soil Conservation Service, publishes county soils reports and maps with information on local soil profiles and bedrock, depth to the water table and depth to unweathered bedrock or parent material of the soil.

Example for determining the score for Step 1.

To score a site for Step 1, information is needed on: 1) the depth to the saturated zone and 2) the earth material of the unsaturated zone. The following example illustrates the method of scoring a site and will be utilized in all steps of the evaluation system.

A poultry processing plant, located in the Appalachian Valley and Ridge Province of a Mid-Atlantic State, operates a two acre waste treatment lagoon (about 8000 m) for disposal of poultry processing waste water. The waste treatment lagoon is shown in the site plan of Figure 9; Figure 10 gives the site location in relation to local topography.

Example Step 1, Part A. Determine the depth to the water table to establish the thickness of the unsaturated zone. In this example the depth to the water table may be obtained from the driller's log of the plant water well. Figure 11 shows the driller's report which indicates that the depth to the static water table is 33 feet (about 10 meters). This static water table level is not the seasonal high water table at this site. The seasonal high water table would be expected to occur around 25 feet (7.5 meters).

The depth to the water table could also be estimated by studying the topographic map in Figure 10 if no well data was available. The elevation of the lagoon bottom is estimated to be about 1020 feet (311 meters) Mean Sea Level as the site is located between two 1020 foot contours. The river is about 100 feet (30 meters) to the west and, in the humid eastern climate, the water table can be assumed to be the river level at the river. Since the lagoon is close to the river, the water table is estimated to be about the same elevation as the river, i.e., 990 feet (302 meters). This is determined by noting that the 980 foot (299 meters) elevation crosses the river about 1 mile (1.6 kilometers) downstream and the 1000 foot (305 meters) elevation crosses about 1 mile upstream. Interpolation between 980 and 1000 gives a river elevation of 990 feet. By estimating the lagoon elevation (1020 feet) and adjacent

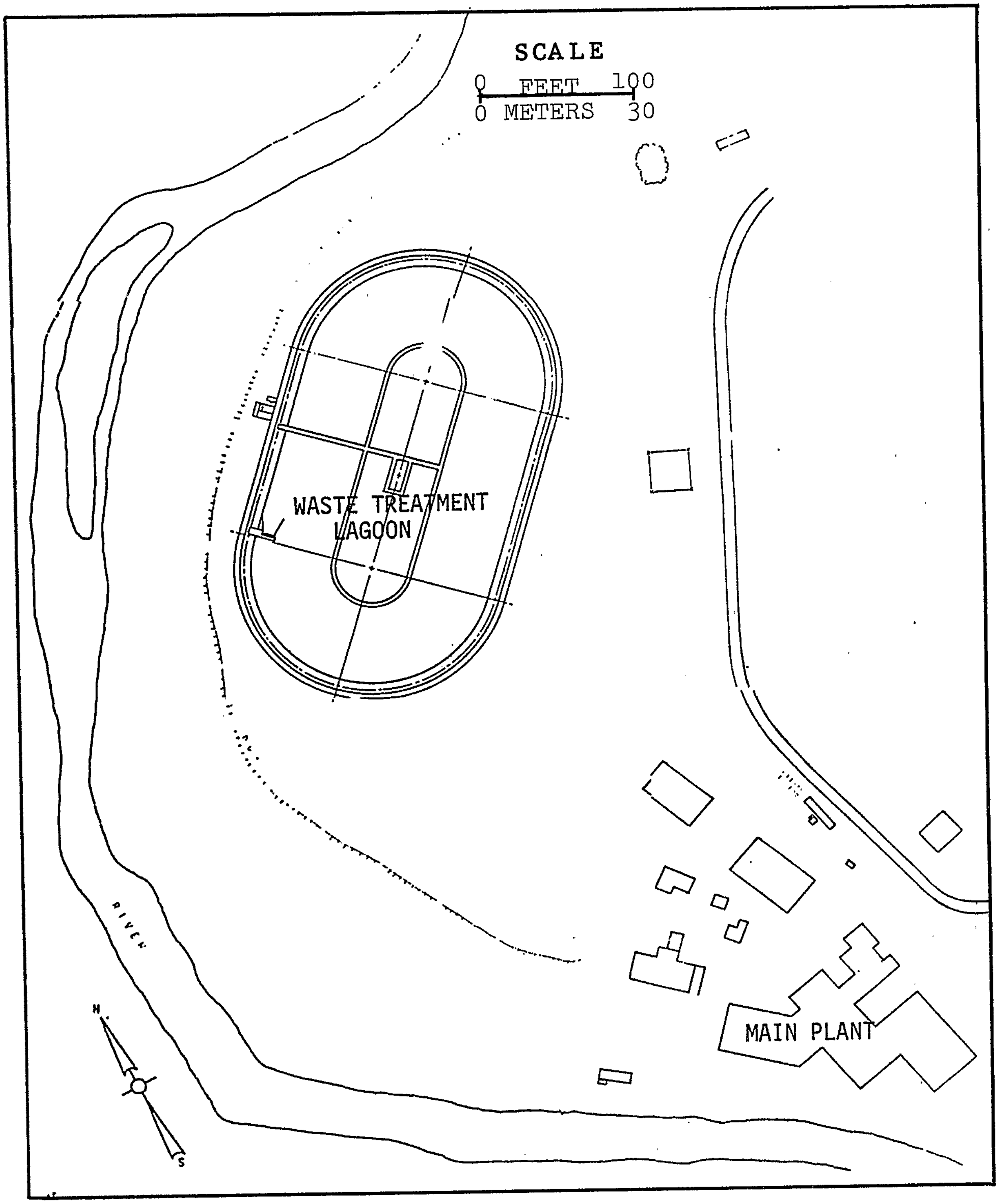


Figure 9. Poultry Processing Plant site plan.

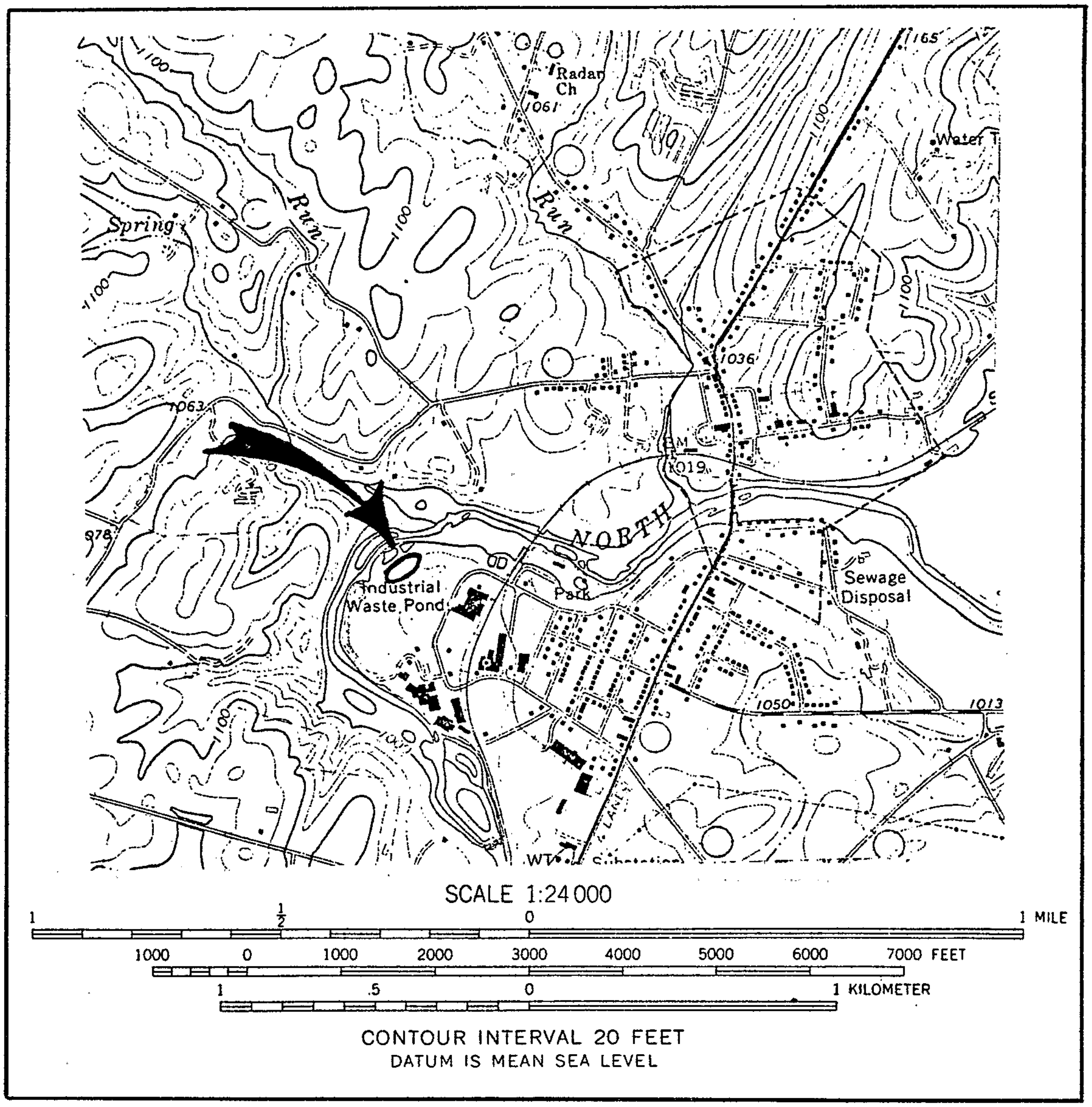


Figure 10. Portion of the 7.5 minute quadrangle topographic map of the Poultry Processing Plant (Marked by arrow).

Well 182-76 **WATER CONDITIONS**

DEPTH

STATIC WATER LEVEL 33'

WATER ZONES (fissures or formations supplying water)

(from)	(to)	(from)	(to)
ft.		ft.	
ft.		ft.	

QUANTITY OF WATER

WELL PUMPED (or bailed) at 15 Gal. per Min. with 400 feet DRAWDOWN after 2 HOURS PUMPING.

FLOW (natural) ______ G.P.M. HEAD ______ ft. (above ground)

REMARKS: Had 15 GPM above 300'

QUALITY OF WATER

COLOR Clear TASTE OK

ODOR No OTHER ______

ANALYSIS: AVAILABLE— Yes ☐ No ☐: ATTACHED Yes ☐ No ☐

TEMPERATURE ______

______ WATER (from) ______ ft. (to) ______ ft.
(salt, brackish, iron, sulfur, acid, other)

USE OF WATER: Domestic ☐ Town ☐ Industry ✓ Farm ☐ Public ☐

CONSTRUCTION

RIG TYPE (or method) Air Rotary
(rotary, cable, bored, driven, etc.)

DATE: Started 8-2-60; Completed 8-8-60

TOTAL DEPTH ______ ft.

BEDROCK at 17 ft.

GROUTING INFORMATION

METHOD USED Gravity

GROUTING MATERIAL Cement + Water

DEPTH OF GROUTING 50

HOLE SIZE (diam) in.	(from) ft.	(to) ft.	CASING SIZE (diam) in.	(from) ft.	(to) ft.
10	0	50	6⅝	0	51' 4"
6½	50	474			

SCREEN (or perforations)

(diam.) ______ in. (from) ______ ft. (to) ______ ft. (opening size) ______

Figure 11. Portion of the driller's report on the water supply well drilled at the Poultry Processing Plant showing the static ground-water level.

river elevations (990 feet), the water table depth is estimated at 30 feet (about 9 meters). This estimate is fairly close to the measured static water level in the well. This method of estimating ground-water levels is useful only for perennial streams and is not reliable in the arid western United States where streams are intermittent. In such cases the ground-water level is often deeper than the stream bed and may have no relationship to the stream level or topography.

Example Step 1, Part B. The second part of completing Step 1 is to estimate the composition of the earth material of the unsaturated zone. For the Poultry Processing Plant, there is a substantial amount of data available from a county geologic report, the driller's report for the water well at the site and, several test borings conducted at the lagoon site. Figure 12 and 13 show the surface bedrock configuration and the structural cross-section of the area. The bedrock at the site is the Edinburg Formation composed of shale and limestone layers tilted at about 70 degrees to the west. The Driller's report containing the well log (Figure 14) indicates that about 16 feet (about 5 meters) of unconsolidated clay and gravel overlie a considerable thickness of variable limestone down to 424 feet (129 meters).

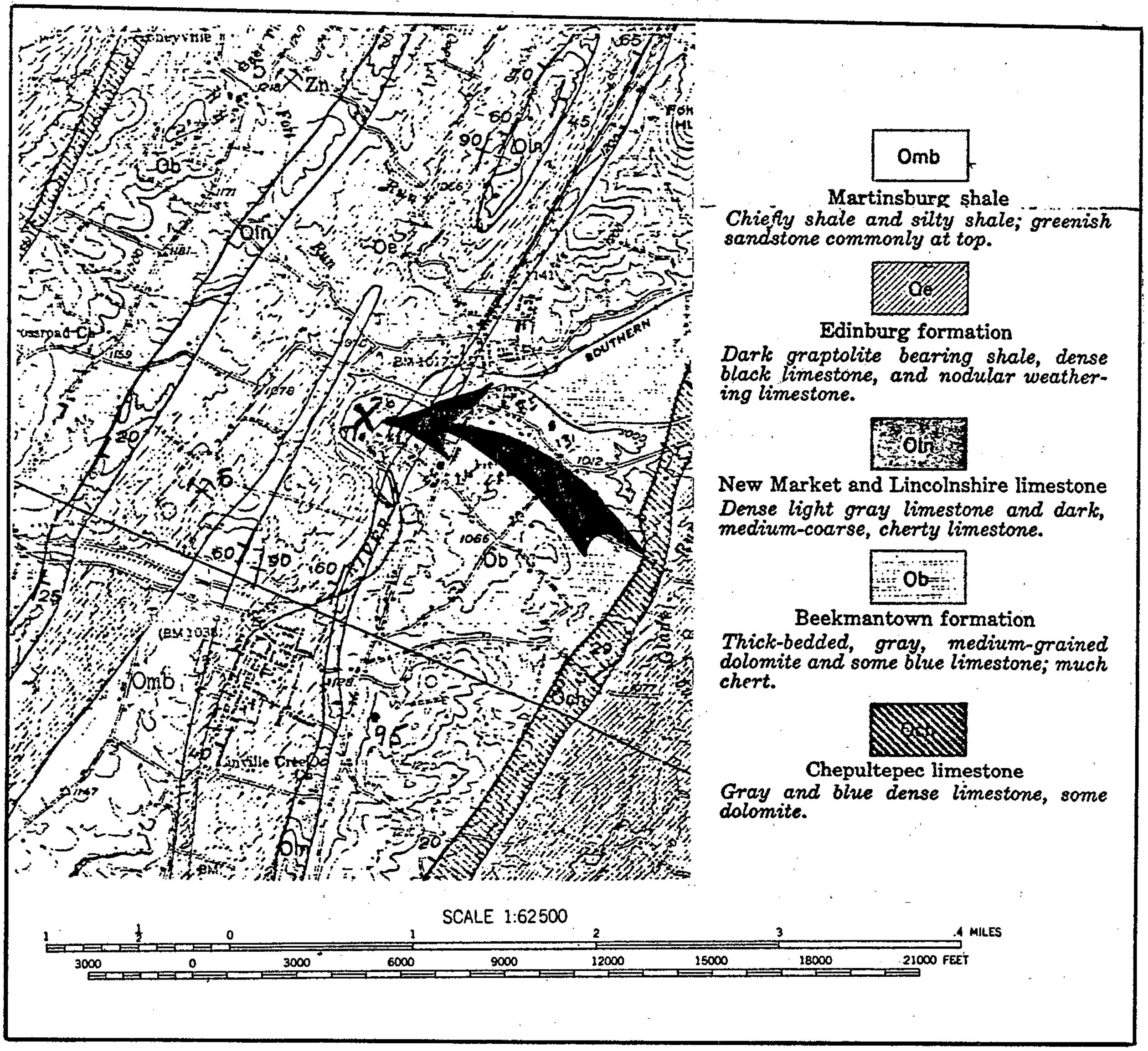
The logs of the test borings shown in Figures 15 indicate a quite variable thickness of sand and gravel (from 12 to 60 feet, or 3 to 18 meters) above limestone. It would be expected in this area of steeply tilted limestone and shale layers to have a rough, variable bedrock surface as a result of differential weathering.

Example, Step 1, Part C. After determining the thickness of the unsaturated zone (7.5 meters) and the type of earth material in the unsaturated zone, the Step 1 score can be determined from the Step 1 matrix in Table I for the following parameters:

Thickness of the unsaturated zone = 7.5 meters

Material of the unsaturated zone = 3 meters of sand and gravel
4.5 meters of limestone

As the sand, gravel and limestone are of similar hydrologic character and in the same earth material category of Step 1, their thickness can be combined so that the Step 1 score would be determined for 7.5 meters of category "I" material rated at 9C. (The presence of a liner would be noted by recording the appropriate code in the reporting form.)



Fugure 12. Portion of the geologic map from the County Geologic Report containing the location of the Poultry Processing Plant (marked by an X and an arrow).

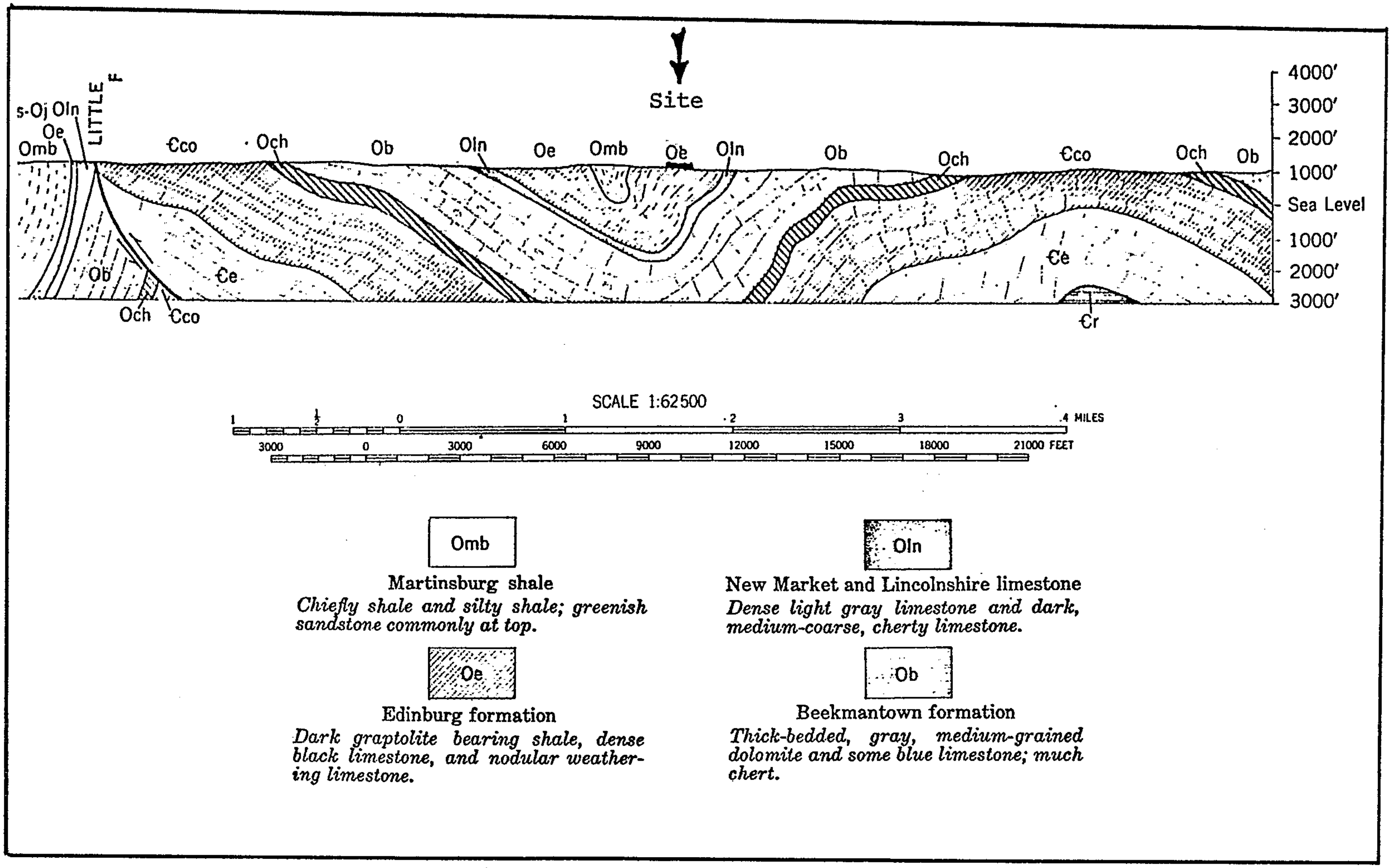


Figure 13. Portion of a geologic cross-section from the County Geologic Report depicting the general subsurface geologic structure around the Poultry Processing Plant (marked by the arrow).

DEPTH (feet) FROM	TO	TYPE OF SOIL OR ROCK PENETRATED (gravel, clay, etc., hardness, color, etc)	REMARKS (water, caving, shot, screen, sample, etc)
0	4	Top Soil	Well 182-76
4	5	Red clay	
5	13	clay - gravel cemented	
13	16	Red clay	
16	23	Gray Limestone	
23	74	" "	
74	75	white Rock Blue Lime Some	Water 3-4 GPM
75	108	Blue Lime with white Rock	
108	118	Blue Lime	
118	119	white Rock	
119	280	Blue Lime with white Rock	10-12 GPM
280	398	Blue Lime Hard + soft	
398	418	Soft Blue Lime	
418	424	Hard Blue Limestone	

Figure 14. Portion of the driller's report on the water supply well drilled at the Poultry Processing Plant showing the well log.

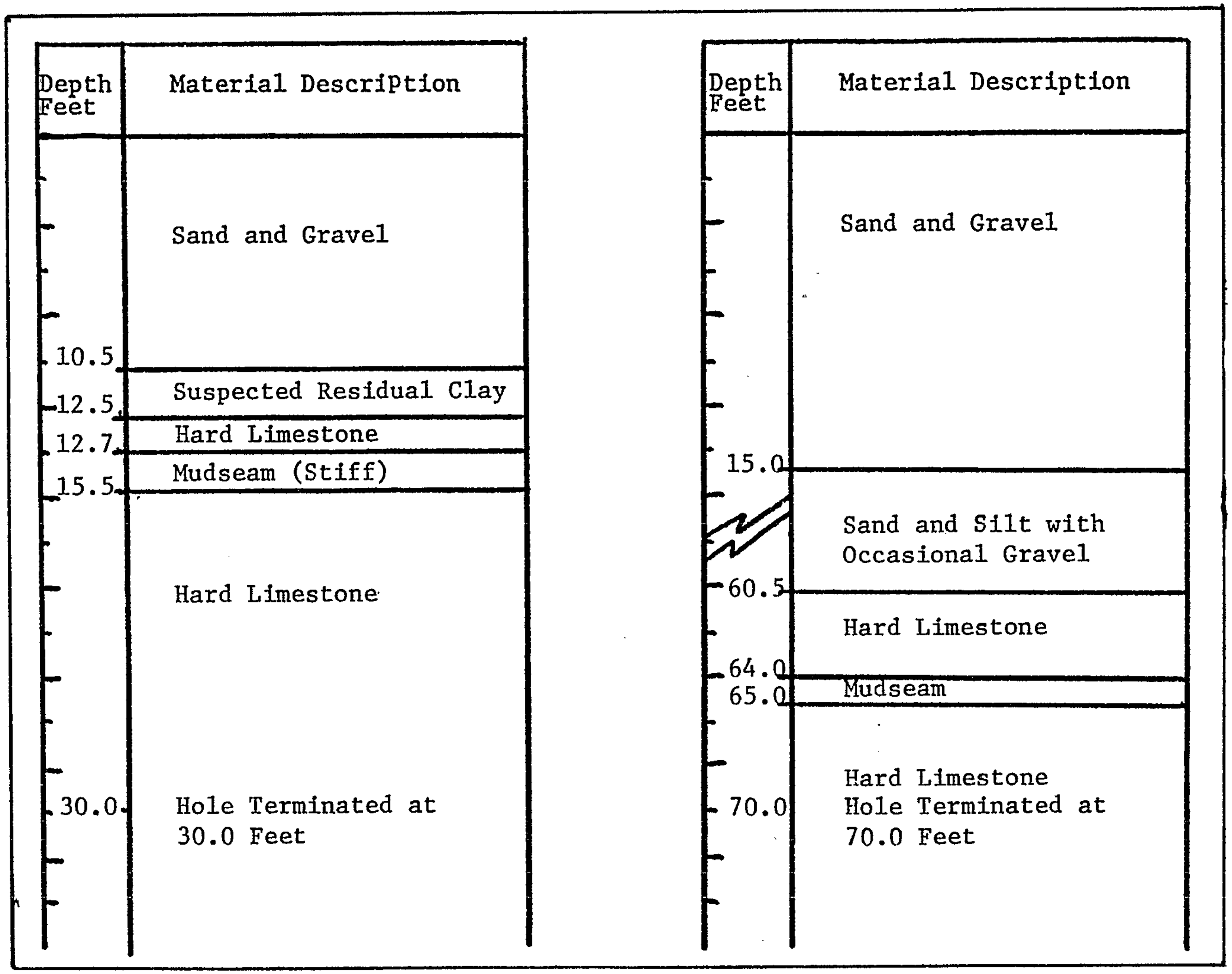


Figure 15. Driller's logs of test borings beneath the waste treatment lagoon at the Poultry Processing Plant.

STEP 2

GUIDANCE FOR RATING GROUND WATER AVAILABILITY

Determining the ground-water availability ranking.

The ability of the aquifer to transmit ground water depends upon the permeability and saturated thickness of the aquifer. Step 2 provides the guidance to determine the ground-water availability rating of the aquifer. Since this evaluation system is a first-round approximation, the ground-water availability rating is not exact, but an approximation. The categories of earth material which make up the saturated zone are the same categories as used in Step 1 but have been combined into good, fair and poor aquifer material categories (Table II).

Estimate the aquifer's saturated thickness (in meters) and the type of earth material in the saturated zone as done for Step 1. Choose the appropriate ranking in the matrix of Step 2 (Table II) from the respective saturated thickness and earth material category. The letter accompanying the ranking is for the purpose of identifying what the ranking's derivation is if, at sometime in the future, there is reason to verify the number.

Sources of information for completing Step 2.

Sources of information in determining the parameters of Step 2 are similar to those of Step 1.

TABLE II

Step 2. Rating of the Ground Water Availability

	Earth Material Category	I	II	III
GUIDELINES FOR DETERMINING CATEGORY	Unconsolidated Rock	Gravel or sand	Sand with $\leq 50\%$ clay	Clay with $< 50\%$ sand
	Consolidated Rock	Cavernous or Fractured Rock, Poorly Cemented Sandstone, Fault Zones	Moderately to Well Cemented Sandstone, Fractured Shale	Siltstone, Unfractured Shale and other Impervious Rock
	Representative Permeability in gpd/ft^2 in cm/sec	 > 2 $> 10^{-4}$	 $0.02 - 2$ $10^{-6} - 10^{-4}$	 < 0.02 $< 10^{-6}$
	RATING MATRIX			
	Thickness of Saturated Zone (Meters) ≥ 30	6A	4C	2E
	3-30	5A	3C	1E
	≤ 3	3A	1C	0E

Example, Step 2.

The type of earth material of the saturated zone can be determined from the county geologic map and cross-section (Figures 11 and 12) and the driller's log of Figure 13. Generally, the material down to greater than 400 feet (122 meters) below the surface is limestone with shale interbeds. From the drillers' report of the pump test (shown in Figure 10) the water supply well near the surface impoundment had 400 feet of drawdown at 15 gpm (57 liters per minute) after 2 hours pumping. From this data the limestone is very tight with little permeability and very little development of open fractures. The category in Step 2 for rating this material would be category II as the saturated zone is capable of producing water but only at moderate to low quantites. From the above sources of information the thickness of the saturated zone is estimated to be several hundred feet. The score for the ground-water availability ranking would be determined for earth material category II and greater than 30 meters thickness, i.e., the Step 2 ranking is "4C."

STEP 3

GUIDANCE FOR RATING THE GROUND-WATER QUALITY

Ground-water quality is a determinant of the ultimate usefulness of the ground water. Waste disposal sites situated in an area of poor quality ground water unsuitable as a drinking water supply would not present the same degree of pollution potential to ground water as the same site situated in an area having very good quality ground water. Step 3 (Table III) is used to determine the ranking of the aquifer's ground-water quality. The ranking is based upon the criteria that has been set forth in the proposed Underground Injection Control Regulations (40 CFR Part 146) of the Safe Drinking Water Act of 1974 (P. L. 93-523). The descriptions are to be used as basic guidelines to assist the investigator in arriving at the appropriate rating of ground-water quality. Consideration of only the background water quality of the aquifer is intended.

Determine the Aquifer Quality Ranking

Determine the total dissolved solids content of the ground water and apply it to the appropriate rating in Step 3, Table III. If the ground water is presently a drinking water supply, the ranking would be a "5" regardless of its total dissolved solids content.

Table III

Step 3. Rating the Ground-Water Quality

Rating	Quality
5	$\leq$ 500 mg/l TDS or a current drinking water source
4	$>$ 500 - $\leq$ 1000 mg/l TDS
3	$>$ 1000 - $\leq$ 3000 mg/l TDS
2	$>$ 3000 - $\leq$ 10,000 mg/l TDS
1	$>$ 10,000 mg/l TDS
0	No ground water present

Sources of information for completing Step 3 .

Ground-water quality data for the determination of the Step 3 rating may be obtained from several sources. If the aquifer is presently used by individuals or communities, no further documentation is required. If industries or agriculture use the ground water, but not currently for human consumption, further quality data may be required for the rating. Many State agencies (i. e., geological surveys, health departments, water boards or commissions and State engineers) and the U. S. Geological Survey have considerable water quality data on file, in published reports and as maps outlining the ground-water quality in the States by aquifer.

Example, Step 3.

The quality of the ground water beneath the Poultry Processing Plant site would be rated "5" since the aquifer does supply drinking water, and in addition based upon driller's report, general State files and published reports, the aquifer has an overall good quality with very low total dissolved solids.

STEP 4

GUIDANCE FOR RATING THE WASTE HAZARD POTENTIAL

Contaminants that may enter ground water have been evaluated by their potential for causing harm to human health (Hazard Potential). The hazard potential rankings for contaminants range from 1 to 9 with 1 being least hazardous and 9 being most hazardous.

Contaminants and their hazard potential rankings are classified in two ways: (1) by contaminant source (Table IV), and (2) by contaminant type (Table V). Standard Industrial Classification (SIC) numbers are used to classify sources. Common sources and types of contaminants and their hazard potential ranges are illustrated in Figure 16.

There are many variables that influence a substance as it enters the ground-water environment such that its true hazard potential as a ground-water contaminant is not likely to be the same as its apparent hazard potential. Most such variables tend to reduce hazard potentials. The hazard potential rankings considered the following factors and their interactions.

TOXICITY - The ability of a substance to produce harm in or on the body of living organisms is extremely important in ranking the hazard potential of that substance. While some substances are highly toxic they may possess low mobility and thus be assigned a lower hazard potential ranking than a less toxic but highly mobile substance.

TABLE IV

CONTAMINANT HAZARD POTENTIAL RANKINGS OF WASTE, CLASSIFIED BY SOURCE FOR STEP 4.

SIC Number		Description of Waste Source	Hazard Potential Initial Rating
01		AGRICULTURAL PRODUCTION - CROPS	1-2
02		AGRICULTURAL PRODUCTION - LIVESTOCK	
	021	Livestock, except Dairy, Poultry and Animal Specialties	3 (5 for Feedlots)
	024	Dairy Farms	4
	025	Poultry and Eggs	4
	027	Animal Specialties	2-4
	029	General Farms, Primarily Livestock	2
10		METAL MINING	
	101	Iron Ores	4
	102	Copper Ores	6
	103	Lead and Zinc Ores	5
	104	Gold and Silver Ores	6
	105	Bauxite and other Aluminum Ores	5
	106	Ferroalloy Ores Except Vanadium	5
	108	Metal Mining Services	4
	1092	Mercury Ore	6
	1094	Uranium-Radium-Vanadium Ores	7
	1099	Metal Ores not elsewhere classified	5
11		ANTHRACITE MINING	7
12		BITUMINOUS COAL AND LIGNITE MINING	7
13		OIL AND GAS EXTRACTION	
	131	Crude Petroleum and Natural Gas	7
	132	Natural Gas Liquids	7
	1381	Drilling Oil and Gas Wells	6
	1382	Oil and Gas Field Exploration Services	1
	1389	Oil and Gas Field Services not elsewhere classified	Variable depending on Activity
14		MINING AND QUARRYING OF NON-METALLIC MINERALS, EXCEPT FUELS	
	141	Dimension Store	2
	142	Crushed and Broken Stone, Including Riprap	2
	144	Sand and Gravel	2
	145	Clay, Ceramic, and Refractory Minerals	2-5
	147	Chemical and Fertilizer Mineral Mining	4-7
	148	Nonmetallic Minerals Services	1-7
	149	Miscellaneous Non-metallic Minerals, except Fuels	2-5

(TABLE IV continued)

SIC Number		Description of Waste Source	Hazard Potential Initial Rating
16		CONSTRUCTION OTHER THAN BUILDING CONSTRUCTION	
	1629	Heavy Construction, not elsewhere classified (Dredging, especially in salt water)	4
20		FOOD AND KINDRED PRODUCTS	
	201	Meat Products	3
	202	Dairy Products	2
	203	Canned and Preserved Fruits and Vegetables	4
	204	Grain Mill Products	2
	205	Bakery Products	2
	206	Sugar and Confectionery Products	2
	207	Fats and Oils	3
	208	Beverages	2-5
	209	Misc. Food Preparation and Kindred Products	2
22		TEXTILE MILL PRODUCTS, ALL EXCEPT LISTINGS BELOW	
	223	Broad Woven Fabric Mills, Wool (including dyeing and finishing)	6
	226	Dying and Finishing Textiles, except Wool Fabrics and Knit Goods	6
	2295	Coated Fabrics, Not Rubberized	6
24		LUMBER AND WOOD PRODUCTS, EXCEPT FURNITURE	
	241	Logging Camps and Logging Contractors	2
	242	Sawmills and Planing Mills	2
	2435	Hardwood Veneer and Plywood	4
	2436	Softwood Veneer and Plywood	4
	2439	Structural Wood Members, not elsewhere classified (laminated wood-glue)	3
	2491	Wood Preserving	5
	2492	Particle Board	4
	2499	Wood Products, not elsewhere classified	2-5
26		PAPER AND ALLIED PRODUCTS	
	261	Pulp Mills	6
	262	Paper Mills Except Building Paper Mills	6
	263	Paperboard Mills	6

(TABLE IV continued)

SIC Number		Description of Waste Source	Hazard Potential Initial Rating
28		CHEMICALS AND ALLIED PRODUCTS [1]	
	2812	Alkalies and Chlorine	7-9
	2813	Industrial Gases	
	2816	Inorganic Pigments	3-8
	2819	Industrial Inorganic Chemicals, not elsewhere classified	3-9
	2821	Plastic Materials, Synthetic Resins, and Nonvulcanizable Elastomers	6-8
	2822	Synthetic Rubber (Vulcanizable Elastomers)	6-8
	2823	Cellulose Man-Made Fibers	6-8
	2824	Synthetic Organic Fibers, except Cellulosic	6-8
	2831	Biological Products	6-9
	2833	Medicinal Chemicals and Botanical Products	3-8
	2834	Pharmaceutical Preparations	6-9
	2841	Soap and Other Detergents, except specialty cleaners	4-6
	2842	Specialty Cleaning, Polishing and Sanitation Preparation	3-8
	2843	Surface Active Agents, Finishing Agents, Sulfonated Oils and Assistants	6-8
	2844	Perfumes, Cosmetics, and other Toilet Preparations	3-6
	2851	Paints, Varnisher, Lacquers, Enamels, and Allied Products	5-8
	2861	Gum and Wood Chemicals	5-8
	2865	Cyclic (coal tar) Crudes, and Cyclic Intermediates, Dyes and Organic Pigments (Lakes and Toners)	6-9
	2869	Industrial Organic Chemicals, not elsewhere listed	3-9

(TABLE IV continued)

SIC Number		Description of Waste Source	Hazard Potential Initial Rating
	2873	Nitrogenous Fertilizers	7-8
	2874	Phosphatic Fertilizers	7-8
	2875	Fertilizer Mixing Only	5
	2879	Pesticides and Agricultural Chemicals, Not Elsewhere Listed	5-9
	2891	Adhesives and Sealants	5-8
	2892	Explosives	6-9
	2893	Printing Ink	2-5
	2895	Carbon Black	1-3
	2899	Chemicals and Chemical Preparations, not Elsewhere Listed	3-9
29		PETROLEUM REFINING AND RELATED INDUSTRIES	
	291	Petroleum Refining	8
	295	Paving and Roofing Materials	7
	299	Misc. Products of Petroleum and Coal	7
30		RUBBER AND MISCELLANEOUS PLASTICS PRODUCTS	
	301	Tires and Inner Tubes	6
	302	Rubber and Plastic Footwear	6
	303	Reclaimed Rubber	6
	304	Rubber and Plastics Hose and Belting	4
	306	Fabricated Rubber Products, not Elsewhere Classified	4
31		LEATHER AND LEATHER PRODUCTS	
	311	Leather Tanning and Finishing	8
		(Remaining Three-Digit Codes)	1-3
32		STONE, CLAY, GLASS, AND CONCRETE PRODUCTS	
	321	Flat Glass	4
	322	Glass and Glassware, Pressed or Blown	4
	324	Cement, Hydraulic	3
	3274	Lime	3
	3291	Abrasive Products	3
	3292	Asbestos	3
	3293	Gaskets, Packing, and Sealing Devices	3
33		PRIMARY METAL INDUSTRIES (EXCEPT AS NOTED BELOW)	3
	3312	Blast Furnaces, Steel Works, and Rolling and Finishing Mills	6
	333	Primary Smelting and Refining of Nonferrous Metals	7

(TABLE IV continued)

SIC Number		Description of Waste Source	Hazard Potential Initial Rating
34		FABRICATED METAL PRODUCTS, EXCEPT MACHINERY AND TRANSPORTATION EQUIPMENT (EXCEPT AS NOTED BELOW)	5
	347	Coating, Engraving, and Allied Services	8
	3482	Small Arms Ammunition	7
	3483	Ammunition, Except for Small Arms not Elsewhere Classified	7
	3489	Ordnance and Accessories, not Elsewhere Classified	7
	349	Misc. Fabricated Metal Products	3-6
35		MACHINERY, EXCEPT ELECTRICAL	5-7
36		ELECTRICAL AND ELECTRONIC MACHINERY, EQUIPMENT AND SUPPLIES (EXCEPT AS NOTED BELOW)	5-7
	3691	Storage Batteries	8
	3692	Primary Batteries, Dry and Wet	8
37		TRANSPORTATION EQUIPMENT	5-8
38		MEASURING, ANALYZING, AND CONTROLLING INSTRUMENTS; PHOTOGRAPHIC, MEDICAL, AND OPTICAL GOODS; WATCHES AND CLOCKS (EXCEPT AS NOTED BELOW)	4-6
	386	Photographic Equipment and Supplies	7
39		MISCELLANEOUS MANUFACTURING INDUSTRIES	3-7
49		ELECTRIC, GAS, AND SANITARY SERVICES	
	491	Electric Services	3-5
	492	Gas Production and Distribution	3
	494	Water Supply	2
	4952	Sewerage Systems	2-5
	4953	Refuse Systems (except Municipal Landfills)	2-9
	496	Steam Supply	2-4

TABLE V

CONTAMINANT HAZARD POTENTIAL RANKINGS OF WASTES, CLASSIFIED BY TYPE[1] FOR STEP 4

	Description	Hazard Potential Initial Rating	ID Number *
A.	**SOLIDS**		
	Ferrous Metals	1-4[2]	1100
	Non-Ferrous Metals	1-7[2]	1200
	Resins, Plastics and Rubbers	2	1300
	Wood and Paper Materials (except as noted below)	2	1400
	- Bark	4	1401
	Textiles and Related Fibers	2	1500
	Inert Materials (except as noted below)	2	1600
	- Sulfide Mineral-Bearing Mine Tailings	6	1601
	- Slag and other Combustion Residues	5	1602
	- Rubble, Construction & Demolition Mixed Waste	3	1603
	Animal Processing Wastes (Except as noted below)	2-4	1700
	- Processed Skins, Hides and Leathers	6	1701
	- Dairy Wastes	4	1702
	- Live Animal Wastes-Raw Manures (Feedlots)	5	1703
	- Composts of Animal Waste	2-4	1704
	- Dead Animals	5	1705
	Edible Fruit and Vegetable Remains - Putrescables	2-3	1800
B.	LIQUIDS		
	Organic Chemicals (Must be chemically Classified)[2]		2000
	- Aliphatic (Fatty) Acids	3-5	2001
	- Aromatic (Benzene) Acids	7-8	2002
	- Resin Acids		2003
	- Alcohols	5-7	2004
	- Aliphatic Hydrocarbons (Petroleum Derivatives	4-6	2005
	- Aromatic Hydrocarbons (Benzene Derivatives)	6-8	2006
	- Sulfonated Hydrocarbons	7-8	2007
	- Halogenated Hydrocarbons	7-9	2008
	- Alkaloids	7-9	2009
	- Aliphatic Amines and Their Salts	1-4	2010
	- Anilines	6-8	2011
	- Pyridines	2-6	2012
	- Phenols	7-9	2013
	- Aldehydes	6-8	2014
	- Ketones	6-8	2015
	- Organic Sulfur Compounds (Sulfides, Mercaptans)	7-9	2016
	- Organometallic Compounds	7-9	2017
	- Cyanides	7-9	2018
	- Thiocyanides	2-6	2019
	- Sterols		2020
	- Sugars and Cellulose	1-4	2021
	- Esters	6-8	2022

Description	Hazard Potential Initial Rating	ID Number*
Inorganic Chemicals (Must be Chemically Classified)[2]		2100
- Mineral and Metal Acids	5-8	2101
- Mineral and Metal Bases	5-8	2102
- Metal Salts, Including Heavy Metals	6-9	2103
- Oxides	5-8	2104
- Sulfides	5-8	2105
- Carbon or Graphite	1-3	2106
Other Chemical Process Wastes Not Previously Listed (Must be Chemically Classified)[2]		2200
- Inks	2-5	2201
- Dyes	3-8	2202
- Paints	5-8	2203
- Adhesives	5-8	2204
- Pharmaceutical Wastes	6-9	2205
- Petrochemical Wastes	7-9	2206
- Metal Treatment Wastes	7-9	2207
- Solvents	6-9	2208
- Agricultural Chemicals (Pesticides, Herbicides, Fungicides, etc.)	7-9	2209
- Waxes and Tars	4-7	2210
- Fermentation and Culture Wastes	2-5	2211
- Oils, including Gasoline, Fuel Oil, etc.	5-8	2212
- Soaps and Detergents	4-6	2213
- Other Organic or Inorganic Chemicals, includes Radioactive Wastes	2-9	2214
Conventional Treatment Process Municipal Sludges	4-8	2300
- From Biological Sewage Treatment	4-8	2301
- From Water Treatment and Conditioning Plants (Must be Chemically Classified)[2]	2-5	2302

* ID Number is for identification of waste type in the Reporting Form.

[1] Classification based on material in Environmental Protection Agency Publication, 670-2-75-024, pages 79-85, Prepared by Arthur D. Little, Inc. and published in 1975.

[2] For individual material ranking refer to solubility-toxicity tables prepared by Versar, Inc. for the Environmental Protection Agency.

MOBILITY - The material must be able to enter the ground-water environment and travel with the ground water. Certain substances are essentially immobile (eg., asbestos fibers) while others are highly mobile with most substances falling between these extremes.

PERSISTENCE - Some substances such as halogenated hydrocarbons decay or degrade very slowly and receive a higher hazard potential ranking than other equally toxic materials that decay more rapidly.

VOLUME - Some substances, such as tailings or slimes from mining operations, are only moderately toxic but because they are produced in enormous quantities are given a somewhat higher hazard potential ranking.

CONCENTRATION - Substances entering the ground-water environment in concentrations which could potentially endanger human health are ranked. Concentration may decrease with dilution and attenuation but the amount of decrease at a given place depends, in part, on waste mobility, waste interaction with soils and aquifer material, etc.

Determining the Waste Hazard Potential for Step 4.

Wastes may be simple in composition, but most are complex and the hazard potential rankings given in Tables IV and V are maximum values based on the most hazardous substance present in the contaminant. Such rankings are, of necessity, generalizations because of the unknown interactions that occur between substances and the variables of the ground-water environment.

For those substances or sources that show a hazard potential ranking range (e.g., 5-8) additional information concerning the specific nature of the source or contaminant is required for assigning a specific ranking. Specific rankings in such cases must be personal judgements by the assessor. Additional information for determining a specific ranking may be available from the source of the contaminant, i.e., the industry may be able to supply specific information about the contaminant. In the event specific information is not available from the source, additional information may be obtained from an examination of descriptions of average contaminant characteristics listed in several publications cited below. For cases when there is considerable pretreatment of the waste, the ranking may be lowered to the bottom of its range. If no additional information is available, the first round approximation ranking must assume the worst case and a low confidence rating be given the ranking.

If sufficient information exists about the material (i.e., exact composition, concentration, volume, treatment prior to coming in contact with the ground, etc.) the rating may be lowered. In considering whether to lower the rating, some compounds degrade aerobically or anaerobically and the products of degradation are more hazardous than the parent chemical. Initial rankings may be modified downward provided:

1. The hazardous material in question has been effectively treated to lower its hazard potential as a ground-water pollutant. Several references describe best available methods for treating contaminants to reduce their toxicity, for example see:

- Sax, 1965, Dangerous Properties of Industrial Materials.
- Identification of Potential contaminants of underground water sources from land spills, by Versar, Inc. (Task II of EPA contract No. 68-01-4620.
- EPA, 1973, Report to Congress on Hazardous Waste Disposal
- Powers, 1976, How to Dispose of Toxic Substances and Industrial Wastes.

2. It can be shown that the hazardous material in question has low mobility in the specific site it is contaminating. Most solid and inert substances have low mobility. Substances with high solubilities tend to be most mobile. Mobility depends on a complex interplay of many factors and only a few substances have been studied sufficiently to predict with any degree of confidence their specific mobilities at a specific site.

3. The volume and/or concentration of the hazardous material is so small that there is a good probability that it will be diluted to safe (drinking water standard) levels at the point of concern.

Example for Determining the Score for Step 4 .

The waste in the Poultry Processing Plant lagoon is a meat product waste, SIC number 201 and would receive a "3" rating.

STEP 5

DETERMINATION OF THE SITE'S OVERALL GROUND-WATER CONTAMINATION POTENTIAL

After the site has been rated on Steps 1, 2, 3 and 4, the overall ground-water contamination potential of the site can be determined by totalling these scores. This overall score allows a comparison of one site with other rated sites by indicating the general, overall contamination potential. Sites may be rated identically, yet be very different in one or several of the parameters included in the overall score; thus the overall score of Step 5 should be used with caution in assessing a particular site's potential to allow ground-water contamination. In addition, this overall score cannot be used to assess the actual amount of ground-water contamination at the site. The score is only for relative comparison with other sites. An actual determination of ground-water contamination requires an intensive on-site investigation.

EPA has not formulated an interpretation of the overall ground water contamination score other than as a relative means to prioritize sites.

<u>Step 5. Determination of the Site's Ground-Water Contamination Potential Rating.</u>

The site's ground-water contamination potential rating is the addition of the rating scores for the first four steps:

Contamination Potential = Step 1 + Step 2 + Step 3 + Step 4.

The highest ground-water contamination potential rating a site can receive is "29" while the lowest is "1."

Example for determining the score for Step 5.

The overall ground-water contamination potential score for the Poultry Processing Plant lagoon is determined in Step 5 by adding the scores from Steps 1, 2, 3, and 4:

Step 5 Rating = Step 1 + Step 2 + Step 3 + Step 4

= 9 + 4 + 5 + 3 = 21

STEP 6

DETERMINATION OF THE POTENTIAL ENDANGERMENT TO CURRENT WATER SUPPLIES

The distance from the impoundment to a ground or surface water source of drinking water and the determination of anticipated flow direction of the waste plume are used to ascertain the potential endangerment to current water supplies presented by the surface impoundment. For many assessments this step can be accomplished by measuring the horizontal distance on a 7. 5 topographic map, or similar scale. In order to use this step, the anticipated direction of ground water flow within 1600 meters (1 mile) of the impoundment must be determined. Ground-water movement depends upon natural ground-water flow direction, variations due to pumping wells, mounding of the grounc water beneath the site and other factors influencing flow direction, such as faults, fractures and other geologic features.

In the case of artesian wells, the anticipated flow direction of the waste plume generally would not be in the direction of the artesian well intake. Artesian wells are located in confined aquifers separated hydraulically from the surface sources of contamination by relatively impermeable confining layers, and wells tapping the confined zone generally will not be drawing ground water from upper zones.

Artesian wells should not be considered in this step unless there is an indication that the anticipated flow direction of the contaminated ground water would be in the direction of that well. To score Step 5, prioritized cases (cases A-D) have been established for rating the site according to the potential magnitude of endangerment to current sources. These priorities are detailed in Step 6 (Table VI). To score a site when a water table is nearly flat and the flow direction is indeterminable, a circle with a 1600 meter radius should be drawn around the site for designating the area of concern. In this situation the evaluator would use the same criteria, in sequential order, begining with Case A, Case B, and then Case D, eliminating Case C.

After the distance has been determined, use the Step 6 rating matrix to determine the rating under the column of the appropriate case.

TABLE VI

Step 6. Rating the Potential Endangerment to a Water Supply

Case A - Highest Priority: Rate the closest water well within 1600 meters of the site that is in the anticipated direction of waste plume movement.

Case B - Second Priority: If there is no well satisfying Case A, rate the closest surface water within 1600 meters of the site that is in the anticipated direction of the waste plume movement.

Case C - Third Priority: If no surface water or water well satisfying Case A or B exists, rate the closest water supply well or surface water supply within 1600 meters of the site that is not in the anticipated direction of waste plume movement.

Case D - Lowest Priority: If there are no surface waters or water wells within 1600 meters of the site in any direction, rate the site as "OD."

Select the appropriate rating for the given distance and case:

Distance (Meters)	Case A	Case B	Case C	Case D
≤ 200	9A	8B	7C	-
>200, ≤ 400	7A	6B	5C	-
>400, ≤ 800	5A	4B	3C	-
>800, ≤ 1600	3A	2B	1C	-
>1600				OD

Example for determining the score for Step 6.

The potential health hazard to existing water supply sources which the Poultry Processing Plant presents is found by determining what types of water supplies are present and their distances from the lagoon. The drilled well described in Figure 11 is for industrial water supply. Surface water (a river) is within about 30 meters of the lagoon as shown in Figure 9. Step 6 requires an estimation of the anticipated flow direction. In this example, the anticipated flow of the waste plume is to the river. The rating of Step 6 would be based on Case B, and would be scored "8B".

STEP 7

DETERMINING THE INVESTIGATOR'S DEGREE OF CONFIDENCE

The evaluation of a surface impoundment's ground-water contamination potential involves three steps and about twice as many separate variables. In many situations the investigator will not have comprehensive information concerning the variables and will have to evaluate the site on the basis of estimation or approximation. For this reason a rating of the investigator's confidence in scoring each step will be made. The following outline is intended to assist the investigator in rating the confidence of the data for each step, with "A" the highest confidence, "C" the lowest.

<u>Step 1 confidence rating for determining the earth material of the unsaturated zone</u>.

Rating	Basis for Determination of Rating
A	Driller's logs containing reliable geologic descriptions and water level data; U. S. Department of Agriculture soil survey used in conjunction with large scale, modern geologic maps. Published ground-water reports on the site.
B	Soil surveys or geologic maps used alone.

	General ground-water reports.
	Drillers' logs with generalized descriptions.
	Drillers logs or exposures such as deep road cuts near the site of contamination allowing interpolation within the same general geologic unit.
C	On site examination with no subsurface data and no exposures of subsurface conditions nearby.
	Estimation of water levels or geology based on topography and climate.
	Extrapolations of well logs, road cuts, etc. where local geology is not well known.
	Estimation based on generalized geologic maps.
	Estimations based on topographic analysis.

Step 2 confidence rating for determining the ground-water availability ranking.

This step involves the earth material categorization and thickness of the aquifer's saturated zone. The confidence rating for Step 2, Part A follows the same basis as Step 1, Part B above.

Step 3 confidence rating for determining background ground-water quality.

Rating	Basis for Determination of Rating
A	Water quality analyses indicative of background ground-water quality from wells at the site or nearby wells or springs or known drinking water supply wells in vicinity.

B	Local, county, regional and other general hydrogeology reports published by State or Federal agencies on background water quality.
	Interpolation of background ground-water quality from base flow water quality analyses of nearby surface streams.
C	Estimates of background ground-water quality from mineral composition of aquifer earth material.

Step 4 confidence rating for waste character.

Rating	Basis for Determination of Rating
A	Waste character rating based on specific waste type.
B	Waste character rating based on SIC category.

Step 6 confidence rating for determination of the anticipated direction of waste plume movement.

Rating	Basis for Determination of Rating
A	Accurate measurements of elevations of static water levels in wells, springs, swamps, and permanent streams in the area immediately surrounding the site in question.
	Ground-water table maps from published State and Federal reports.

B	Estimate of flow direction from topographic maps in non cavernous area having permanent streams and humid climate.
	Estimate of flow direction from topographic maps in arid regions of low relief containing some permanent streams.
C	Estimate of flow direction from topographic maps in cavernous, predominantly limestone areas (karst terrain).
	Estimate of flow direction from topographic maps in arid regions of highly irregular topography having no permanent surface streams.

Example for determining the confidence rating for each step.

Based upon the guidance just presented, the confidence ratings for the Poultry Processing Plant are:

	Confidence Rating
Step 1	A--Based upon measurement in on site well.
Step 2	A--Based upon well logs of on site well.
Step 3	A--Based upon water well analyses.

Step 4	B--Based upon SIC category.
Step 6	B--Estimate of flow direction from topographic map in humid region.

STEP 8

MISCELLANEOUS IDENTIFIERS

This step allows the evaluator to identify any additional significant variable not noted in the rating system. Such parameters are:

<u>Identifier</u>

R - The site is located in a ground-water recharge area,

D - The site is located in a ground-water discharge area,

F - The site is located in a flood plain and is susceptable to flood hazard,

E - The site is located in an earthquake prone area,

W - The site is located in the area of influence of a pumping water supply well,

K - The site is located in karst topography or fractured, cavernous limestone region.

C - The ground water under the site has been contaminated by man-made causes (i.e., road salt, feed lot, industrial waste).

M - Known ground-water mound exists beneath the site.

I - Interceptor wells or other method employed to inhibit contaminated ground-water migration (endangerment to water supply wells may be reduced).

STEP 9

RECORD THE FINAL SCORE

In order to present the rating scores from the previous nine steps of the evalution system in a logical manner, Step 9 provides a systematic format in which the evaluation of the site can be recorded. The nine steps are not recorded in numerical order as the focus of the evaluation is on the ground-water pollution potential score of Step 5. Thus, Step 5 is listed first, followed by Steps 1, 2, 3, 4, 6 and 8. The example of the Poultry Processing Plant waste treatment lagoon has been listed on page 63 on the following sample reporting form. The confidence scores of Step 7 have been distributed among the appropriate steps.

TABLE VII

RATING OF THE GROUND WATER POLLUTION POTENTIAL:

9	C	A	4	C	A	5	A	3	B	2	1	8	B	B	R	F	
Unsat. Zone		Confidence	G. W. Avail.		Confidence	G. W. Qual.	Confidence	Waste	Confidence	G. W. Poll. Potential		Health Hazard		Confidence	Miscellaneous Identifiers		
STEP 1			STEP 2			STEP 3		STEP 4		STEP 5		STEP 6					

APPENDIX A

TYPICAL SOURCES AND TYPES OF DATA USEFUL IN APPLYING THE ASSESSMENT SYSTEM

Type of Data	Typical Sources	Useful in determining Steps			
		1	2&3	4	6
Property survey	County Records, property owner	*		X	
Well drillers logs	Well Driller, property owner, state records	*	*		X
Water level measure ments	Well owners' observations, well drillers' logs, topographic maps, ground water maps (reports)	*	X		*
Topographic Maps	U.S. Geological Survey and designated state sales offices	X			*
Air Photos	U.S. Dept of Agriculture, U.S. Forest Service, etc.				*
County Road Maps	State agencies				*
Ground Water Reports	U.S. Geological Survey, State agencies	*	*		X
Soil Surveys of Counties	U.S. Department of Agriculture	*	X		X
Geologic Maps	U.S. Geological and State Surveys	X	X		X
Waste Character	Owner/operator, State or Federal permits, SIC Code			X	

* - Source of data may be especially useful

X - Source of data may be of slight use or may be used indirectly

APPENDIX B

MEASURING UNIT CONVERSION TABLE

inch (in)	x	2.54	=	centimeter (cm)
centimeter	x	0.3937	=	inch
feet (ft)	x	0.3048	=	meter (m)
meter	x	3.2808	=	feet
mile (mi)	x	1.609	=	kilometer (km)
kilometer	x	0.621	=	mile
U.S. gallon (gal)	x	0.0038	=	cubic meter (m^3)
cubic meter	x	264.17	=	U.S. gallon
cubic feet (ft^3)	x	0.0283	=	cubic meter
cubic meter	x	35.314	=	cubic feet
acre-foot (ac-ft)	x	123.53	=	cubic meter
cubic meter	x	0.0008	=	acre-feet
hectare	x	10,000.0	=	square meter (m^2)
square meter	x	0.0001	=	hectare
hectare	x	2.471	=	acre
acre	x	0.4047	=	hectare
<u>Hydraulic Conductivity</u>				
gpd/ft^2	x	4.72×10^{-5}	=	cm/sec
cm/sec	x	21.2×10^{3}	=	gpd/ft^2
Darcy	x	18.2	=	gpd/ft^2
Darcy	x	8.58×10^{-4}	=	cm/sec

APPENDIX C

GLOSSARY

Aquifer - a formation, group of formations or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Artesian ground water - synonymous with confined ground water which is a body of ground water overlain by material sufficiently impervious to sever free hydraulic connection with overlying ground water. Confined ground water is under pressure great enough to cause water in a well tapping that aquifer to rise above the top of the confined aquifer.

Discharge area - geographic region in which ground water discharges into surface water such as at springs and seeps and subsurface seepage into streams, lakes and oceans (referred to as base flow in streams).

Karst topography - geologic region typified by the effects of solution of rocks by water. Rock types most likely effected are limestone dolostone, gypsum and salt beds. Features produced are caverns, collapse features on the surface (sink holes), underground rivers and zones of lost circulation for well drillers.

Perched water table - unconfined ground water separated from an underlying body of ground water by an unsaturated zone. Its water table is a "perched water table" and is sustained by a "perching bed" whose permeability is so low that water percolating downward through it is not able to bring water in the underlying unsaturated zone above atmospheric pressure.

Plume of contaminated ground water - as contaminants seep or leach into the subsurface and enter the ground water, the flow of the ground water past the site of contamination causes the contaminated ground water to move down gradient. This action results in the creation of a "plume" shaped body of ground water containing varying concentrations of the contaminant, extending down gradient from place of entry. The shape of the plume of contaminated ground water is affected by attenuation of the specific contaminants and, to a lesser extent, by dispersion.

Primary permeability - permeability due to openings or voids existing when the rock was formed, i. e. , intergranular interstices.

Recharge area - geographic region in which surface waters infiltrate into the ground, percolate to the water table and replenish the ground water. Recharge areas may be well defined regions such as limestone outcrops or poorly defined broad regions.

Saturated Zone - the zone in the subsurface in which all the interstices are filled with water.

Secondary permeability - permeability due to openings in rocks formed after the formation of the rock, i. e., joints, fractures, faults, solution channels and caverns.

Unsaturated zone - formerly the "zone of aeration" or "vadose zone". It is the zone between the land surface and the water table, including the "capillary fringe".

Water table - that surface in an unconfined ground-water body at which the pressure is atmospheric. Below the water table is the saturated zone and above is the unsaturated zone.

APPENDIX D

SELECTED REFERENCES

Alexander, Martin, "The Breakdown of Pesticides in Soils, in Brody, N. C.," Agriculture and the Quality of Our Environment, Plimpton Press, Norwood, Massachusetts, pp 331-342, 1967.

Belter, W. G., "Ground Disposal: Its Role in the U. S. Radioactive Waste Management Operations,: in Comptes Rendus, Collogue International sur la Retention et la Migration de Jons Radioactifs dans les Sols, Centre d'Etudes Nucleaires, Saclay, France, pp 3-10, 1963.

Bredehoeft, J. D., and G. F. Pinder, "Mass Transport in Flowing Groundwater," Water Resources Research, Vol 9, No. 1, pp 194-210, 1973.

Born, S. M., and D. A. Stephenson, "Hydrogeologic Considerations in Liquid Waste Disposal," Journal of Soil and Water Conservation, Vol 24, No. 2, pp 52-55, 1969.

Brown, R. E., Hydrologic Factors Pertinent to Ground-Water Contamination, Public Health Service Technical Report W61-5, pp 7-20, 1961.

Brown, R. H., and J. R. Raymond, "The Measurements of Hanford's Geohydrologic Features Affecting Waste Disposal," in Proceedings of the Second Atomic Energy Commission Working Meeting - Ground Disposal of Radioactive Waste, Chalk River, Canada, U. S. Department of Commerce TID 7628, pp 77-98, 1962.

Carlston, C. W., "Tritium - Hydrologic Research: Some Results of the U. S. Geological Survey Research Program," Science 143 (3608), pp 804-806, 1964.

Cartwright, K., and F. B. Sherman, "Evaluating Sanitary Landfill Sites in Illinois," Illinois State Geological Survey Environmental Geology Note No. 27, 15 pp, August 1969.

Cherry, J. A., G. E. Grisak, and R. E. Jackson, "Hydrogeological Factors in Shallow Subsurface Radioactive-Waste Management in Canada," Proceedings International Conference on Land For Waste Management, Ottawa, Canada, October 1-3, 1973.

Clark, D.A. and J.E. Moyer, 1974, An Evaluation of Tailings Ponds Sealants, EPA-660/2-74-065.

Cole, J.A. (ed.), Groundwater Pollution in Europe, Water Information Center, Port Washington, New York, 347 pp, 1975.

DaCosta, J.A., and R.R. Bennett, "The Pattern of flow in the Vicinity of a Recharging and A Discharging Pair of Wells in an Aquifer Having Areal Parallel Flow," International Union Geodesy and Geophysic, International Association Committee Subterranean Waters, 1961.

Davis, S.N. and R.J.M. DeWiest, 1966, Hydrogeology, John Wiley and Sons, Inc., New York.

DeBuchannanne, G.D., and P. E. LaMoreaux, Geologic Control Related to Ground Water Contamination, Public Health Service Technical Report W61-5, pp 3-7, 1961.

Deutsch, M., Groundwater Contamination and Legal Controls in Michigan, Public Health service Technical Report W61-5, pp 98-110., 1961.

Ellis, M.J. and D.T. Pederson, 1977, Groundwater Levels in Nebraska, 1976, Conservation and Survey Division, University of Nebraska-Lincoln.

Engineering-Science, Inc., "Effects of Refuse Dumps on Groundwater Quality," Resources Agency California State Water Pollution Control Board, Pub. 211, 1961.

Geswein, A.J. and 1975, Liners for Land Disposal Sites--An Assessment, EPA/530/SW-137.

Giddings, M.T., "The Lycoming County, Pennsylvania, Sanitary Landfill: State-of-the-Art in Ground-Water Protection," Ground Water, Vol 2, Special Issue, pp 5-14, 1977.

Haxo, H.E., Jr., and R.M. White, 1976, Evaluation of Liner Materials Exposed to Leachate, Second Interim Report, EPA-600/2-76-255.

Haxo, R.S. and R.M. White, 1977, Liner Materials Exposed to Hazardous and Toxic Sludges, First interim Report, EPA-600/2-77-081.

Hughes, J.L., Evaluation of Ground-Water Degradation Resulting From Waste Disposal to Alluvium Near Barstow, California, U.S. Geological Survey Prof. Paper 878, 33 pp, 1975.

Hughes, G.M., and K. Cartwright, "Scientific and Administrative Criteria for Shallow Waste Disposal," Civil Engineering-ASCE, Vol 42, No. 3, pp 70-73, 1972.

Hughes, G.M., R.A. Landon, and R.N. Farvolden, Hydrogeology of Solid Waste Disposal Sites in Northeastern Illinois, U.S. Environmental Protection Agency, Report SW-122, 154 pp, 1971.

LeGrand, H.E., "System for Evaluating the Contamination Potential of Some Waste Sites," American Water Works Association Journal, Vol 56, No. 8, pp 959-974, 1964a.

LeGrand, H.E., "Management Aspects of Ground-Water Contamination," Journal Water Pollution Control Federation, Vol 36, No. 9, pp 1133-1145, 1964b.

LeGrand, H.E., "Patterns of Contaminated Zones of Water in the Ground," Water Resources Research, Vol 1, No. 1, pp 83-95, 1965.

LeGrand, H.E., "Monitoring the Changes in Quality of Ground Water," Ground Water, Vol 6, No. 3, pp 14-18, 1968.

Lieber, Maxim, N.M. Perlmutter, and H.L. Frauenthal, "Cadmium and Chromium in Nassau County Groundwater," Journal American Water Works Association, Vol 56, No. 6, p 742, 1964.

Meyer, C.F. (ed.), Polluted Groundwater: Some Causes, Effects, Controls and Monitoring, U.S. Environmental Protection Agency, Report No. EPA-600/4-73-001b, Washington, D.C., 325 pp, June 1974.

Miller, D.W., F.A. Deluca, and T.L. Tessier, Ground Water Contamination in the Northeast States, U.S. Environmental Protection Agency, Report No. EPA-660/2-74-056, Washington, D.C., 325 p, June 1974.

Miller, D.W. (editor), Waste Disposal Practices and Their Effects on Ground Water, U.S. Environmental Protection Agency, Report No. EPA-570/9-77-001, Final Report to Congress, 1977.

Morrison, W.R., R.A. Dodge, J. Merriman, C.M. Ellsperman, Chungming Wong, W.F. Savage, W.W. Rinne and C.L. Granses, 1970, Pond Linings for Desalting Plant Effluents, U.S. Dept. of the Interior, Office of Saline Water, Research and Development Progress Report No. 602.

Palmquist, R., and L.V.A. Sendlein, 'The Configuration of Contamination Enclaves from Refuse Disposal Sites on Floodplains, Ground Water, Vol 13, No. 2, pp 167-181, 1975.

Panel on Land Burial, Committee on Radioactive Waste Management, The Shallow Land Burial of Low-Level Radioactively Contaminated Solid Waste, National Research Council, National Academy of Sciences, Washington, D. C., 150 pp 1976.

Papadopolos, S. S., and I. J. Winograd, Storage of Low-Level Radioactive Wastes in the Ground Hydrogeologic and Hydrochemical Factors with an Appendix on the Maxey Flats, Kentucky, Radioactive Waste Storage Site: Current Knowledge and Data Needs for a Quantitative Hydrogeologic Evaluation, U.S. Environmental Protection Agency, Report No. EPA-520/3-74-009, Reston, Virginia, 40 pp, 1974.

Parsons, P. J., "Underground Movement of Radioactive Wastes at Chalk River," in Proceedings of the Second Atomic Energy Commission Working Meeting - Ground Disposal of Radioactive Wastes, Chalk River, Canada, U.S. Department of Commerce, TID 7628, pp 17-64, 1962.

Perlmutter, N M., M. Lieber, and H. L. Frauenthal, "Waterborne Cadmium and Hexavalent Chromium Wastes in South Farmingdale, Nassau County, Long Island, New York," U. S. Geological Survey Prof. Paper 475-C, pp 179-184, 1963.

Peters, J.A., 1968, Ground Water Course, State of California, The Resources Agency, Dept. of Water Resources, Sacramento, Calif., pp. 5-7.

Pettyjohn, W.A., "Water Pollution in Oil Field Brines and Related Industrial Wastes in Ohio," in Water Quality in a Stressed Environment, Burgess Publishing Company, Minneapolis, Minnesota, pp 166-180, 1972.

Phillips, C.R., Development of a Soil-Waste Interaction Matrix, Canada, Environmental Protection Service, Solid Waste Management Report EPS-EX-76-10, 89 pp, 1976.

Pinder, F. F., "A Galekin -Finite Element Simulation of Groundwater Contamination on Long Island, New York," Water Resources Research, Vol. 9, No. 6, pp 1657-1669, 1973.

Pinder, G. G., W.P. Saukin and M. Th. Van Genuchten, 1976, Use of Simulation for Characterizing Transport in Soils Adjacent to Land Disposal Sites, Research Report 76-WR-6, Water Resources Program, Department of Civil Engineering, Princeton University.

Robson, S.G., and J.D. Bredehoeft, "Use of a Water Quality Model for the Analysis of Ground Water Contamination at Barstow, California," Geological Society of America Abstracts with Programs, Annual Meetings, Vol 4, No. 7, pp 640-641, 1972.

Romero, J.C., "The Movement of Bacteria and Viruses through Porous Media," Ground Water, Vol 8, No. 2, pp 37-48, 1970.

Sendlein, L.V.A., and R.C. Palmquist, "Strategic Placement of Waste Disposal Sites in Karst Regions,: in Karst Hydrology, Memoirs of the 12th Congress of the International Association of Hydrogeologists, published by University of Alabama at Huntsville Press, pp 328-335, 1977.

Simpson, E.S., Transverse Dispersion in Liquid Flow through Porous Media, U.S. Geological Survey Prof. Paper 411-C, 30 pp, 1962.

Theis, C.V., "Notes on Dispersion in Fluid Flow by Geological Factors," in Proceedings of the Second Atomic Energy Commission Working Meeting, Ground Disposal of Radioactive Wastes, Chalk River, Canada, U.S. Department of Commerce TID 7628, pp 166-178, 1962.

Thomas, Henry, "Some Fundamental Problems in the Fixations of Radioisotopes in Solids," Proceedings U.N. International Conference: Peaceful Uses Atomic Energy, 18, pp 37-42, 1958.

Todd, D.K., 1959, Ground Water Hydrology, John Wiley and Sons, Inc., New York, p. 53.

______________, 1970, The Water Encyclopedia, The Water Information Center Inc., 559 pp.

Todd, D.K., and E.E. McNulty, Polluted Groundwater: A Review of the Significant Literature, U.S. Environmental Protection Agency, Report No. EPA-680/4-74-001, Washington, D.C., 215 pp, March 1974.

Todd, D.K., R.M. Tinlin, K.D. Schmidt, and L.G. Everett, Monitoring Groundwater Quality: Monitoring Methodology, U.S. Environmental Protection Agency, Report No. EPA-600/4-76-026, Las Vegas, Nevada, 154 pp, June 1976.

Vogt, J.E., "Infectious Hepatitis Outbreak in Posen, Michigan," in Ground Water Contamination, Proceedings of 1961 Symposium, pp 87-91, 1961.

Walton, W. C., 1970, Ground Water Resource Evaluation, McGraw-Hill Book Co., New York, p. 36.

Waltz, J. P., "Methods of Geologic Evaluation of Pollution Potential at Mountain Homesites," Ground Water, Vol 10, No. 1, pp 42-47, 1972.

Walz, D. H., and K. T. Chestnut, "Land Disposal of Hazardous Wastes: An Example from Hopewell, Virginia," Ground Water, Vol 15, No. 1, pp 75-79, 1977.

Wenzel, L. K., Methods for Determining Permeability of Water-Bearing Materials, U. S. Geological Survey Water Supply Paper 887, 1942.

APPENDIX B

APPENDIX B-I

LOCATED ACTIVE SITES & IMPOUNDMENTS

State	Agricultural Sites	Agricultural Imps	Municipal Sites	Municipal Imps	Industrial Sites	Industrial Imps	Mining Sites	Mining Imps	Oil & Gas Sites	Oil & Gas Imps	Other Sites	Other Imps	Total Sites	Total Imps
AK	11	12	107	142	10	22	1	3					129	179
AL	404	409	378	562	249	628	33	96	1	1			1065	1696
AR	204	236	346	490	163	322	16	29	132	5729			861	6806
AS			2	2	2	3							4	5
AZ	52	86	374	980	135	336	79	211	1	2			641	1615
CA	190	394	839	3390	523	1596	81	183	117	2014			1750	7577
CO	221	392	443	823	263	939	78	216	262	1261			1267	3631
CT	18	19	120	359	162	372	5	8					305	758
DE	5	10	14	35	33	86							52	131
FL	312	509	2527	3505	747	1306	58	290					3644	5610
GA	733	748	430	513	158	293	42	86					1363	1640
GM	6	31	34	48	10	80	19	37			33	38	102	234
HI	43	50	30	44	21	202							94	296
IA	576	721	759	1268	100	194	6	13			343	343	1784	2539
ID	38	67	134	311	50	110	31	50					253	538
IL	171	246	978	2142	380	974	132	264	2810	3051			4471	6677
IN	578	766	480	666	213	492	146	264	480	490			1897	2678
KS	1020	1816	422	833	107	245	3	5	418	429			1970	3328

LOCATED ACTIVE SITES & IMPOUNDMENTS

State	Agricultural Sites	Agricultural Imps	Municipal Sites	Municipal Imps	Industrial Sites	Industrial Imps	Mining Sites	Mining Imps	Oil & Gas Sites	Oil & Gas Imps	Other Sites	Other Imps	Total Sites	Total Imps
KY	61	131	199	262	147	259	124	152	109	118			640	922
LA			72	113	213	865	3	8	696	1818			984	2804
MA	8	20	210	1811	122	377	1	3					341	2211
MD	79	97	79	122	124	248	161	369					443	836
ME	28	33	56	111	48	175							132	319
MI	557	659	689	1063	891	1648	50	135					2187	3505
MN	1404	1530	381	866	112	277	55	60					1952	2733
MO	2006	2123	1318	2035	282	436	51	89					3657	4683
MS	421	476	476	533	399	640	5	10	5	8			1306	1667
MT	85	129	227	466	61	233	31	107	264	331			668	1266
NC	100	132	256	352	339	542	14	25					709	1051
ND	248	285	363	748	8	26	25	85	23	24			667	1168
NE	619	1139	360	702	81	227	1	1	570	1183	1	2	1632	3254
NH	15	22	107	202	30	50							152	274
NJ	3	8	74	185	219	670	15	33					311	896
NM	88	142	337	863	293	732	86	836	12097	15173			12901	17746
NV	3	11	87	259	24	82	102	189					216	541
NY	71	56	395	684	299	645	28	119	277	333			1070	1837
OH	154	184	458	727	854	1528	541	12753	1280	1345			3287	16537
OK	330	429	749	1316	224	422	85	138	1547	2233			2935	4538
OR	58	74	211	396	90	214	11	30					370	714

LOCATED ACTIVE SITES & IMPOUNDMENTS

State	Agricultural Sites	Agricultural Imps	Municipal Sites	Municipal Imps	Industrial Sites	Industrial Imps	Mining Sites	Mining Imps	Oil & Gas Sites	Oil & Gas Imps	Other Sites	Other Imps	Total Sites	Total Imps
PA	249	339	404	761	668	1680	4331	5611	571	20471	1123	5362	7346	34224
PR	300	302	4	4	23	78							327	384
RI	9	17	8	24	27	92							44	133
SC	1068	1107	595	753	203	397	2	2					1868	2259
SD	279	343	276	487	20	51	4	14	27	31			606	926
TN	271	368	143	177	211	484	121	296					746	1325
TT			3	5									3	5
TX	510	1181	761	1658	612	2272	47	144	1742	5485			3672	10740
UT	6	8	42	182	30	78	3	10	130	2067			211	2345
VA	393	557	399	546	254	507	166	365					1212	1975
VI			7	7	2	10							9	17
VT	128	130	64	96	21	45	1	3					214	274
WA	133	174	168	360	91	468	11	47					403	1049
WI	392	427	301	644	323	635	6	14					1022	1720
WV	13	16	322	408	104	348	249	1089					688	1861
WY	6	8	88	138	44	99	40	139	968	1354			1146	1738

APPENDIX B-II

ASSESSED ACTIVE SITES & IMPOUNDMENTS

State	Agricultural Sites	Agricultural Imps	Municipal Sites	Municipal Imps	Industrial Sites	Industrial Imps	Mining Sites	Mining Imps	Oil & Gas Sites	Oil & Gas Imps	Other Sites	Other Imps	Total Sites	Total Imps
AK	6	6	38	38	7	7	1	2					52	53
AL	201	201	169	169	83	83	14	14					467	467
AR	46	46	146	146	153	153	14	14	131	131			490	490
AS													0	0
AZ	5	5	43	43	92	92	18	18					158	158
CA	172	194	796	1087	475	613	79	97	107	117			1629	2108
CO	35	35	68	68	36	37	10	10	40	41			189	191
CT	14	14	107	107	158	158	5	5					284	284
DE	5	10	14	36	32	85							51	131
FL	311	508	2523	3487	740	1299	57	289					3631	5583
GA	251	251	141	141	117	117	28	28					537	537
GM	6	6	32	32	10	10	18	18			33	33	99	99
HI	42	46	30	37	21	41							93	124
IA	57	57	74	74	80	80							211	211
ID	38	38	128	129	46	46	30	30					242	243
IL	170	170	204	204	379	379	130	130	183	183			1066	1066
IN	569	569	477	477	206	206	146	146	473	473			1871	1871
KS	100	100	42	42	49	49			20	20			211	211

ASSESSED ACTIVE SITES & IMPOUNDMENTS

State	Agricultural		Municipal		Industrial		Mining		Oil & Gas		Other		Total	
	Sites	Imps	Sites	Imps	Sites	Imps	Sites	Imps	Sites	Imps	Sites	Imps	Sites	Imps
KY	60	130	186	250	141	255	121	151	109	118			617	904
LA			70	70	204	204	2	2	41	41			317	317
MA	3	3	138	139	75	75							216	217
MD	68	69	79	79	122	122	128	128					397	398
ME	28	28	56	56	48	48							132	132
MI	82	82	117	117	167	167	23	23					389	389
MN	673	751	378	844	110	279	5	8					1166	1882
MO	827	827	652	652	272	272	45	45					1796	1796
MS	157	157	189	189	363	365	5	5	5	5			719	721
MT	18	18	33	33	39	39	14	14	48	48			152	152
NC	76	76	241	241	327	327	13	13					657	657
ND	248	287	360	739	8	26	25	65	23	23			664	1140
NE	30	30	48	48	70	71	1	1	22	22			171	172
NH	15	22	107	202	30	59							152	283
NJ	2	2	39	39	126	172	7	7					174	220
NM	4	4	98	98	40	40	73	73					215	215
NV	2	2	14	16	12	15	9	9					37	42
NY	14	14	43	43	92	93	1	1	20	20			170	171

ASSESSED ACTIVE SITES & IMPOUNDMENTS

State	Agricultural Sites	Agricultural Imps	Municipal Sites	Municipal Imps	Industrial Sites	Industrial Imps	Mining Sites	Mining Imps	Oil & Gas Sites	Oil & Gas Imps	Other Sites	Other Imps	Total Sites	Total Imps
OH	128	128	430	430	806	807	133	134	1200	1200			2697	2699
OK	49	50	63	63	145	148	35	36	151	151			443	448
OR	55	55	207	213	90	90	11	11					363	369
PA	242	243	398	401	652	1021	124	129	116	116	294	294	1826	2204
PR	102	102	2	2	16	16							120	120
RI	9	17	8	24	27	88							44	129
SC	921	955	579	731	200	390	2	2					1702	2078
SD	278	334	267	475	18	50	4	14	27	31			594	904
TN	41	41	20	20	147	148	17	17					225	226
TT			3	3									3	3
TX	50	51	110	110	610	610	28	28	103	103			901	902
UT	5	7	39	169	29	79	3	10	128	128			204	393
VA	20	21	34	34	87	87	11	11					152	153
VI			7	7	2	2							9	9
VT	127	129	61	93	19	41	1	3					208	266
WA	17	22	25	57	85	446	2	10					129	535
WI	200	200	199	199	202	202	5	5					606	606
WV	12	14	314	394	99	326	37	274					462	1008
WY	6	6	29	29	29	29	13	14	357	359			434	437

APPENDIX B-III

LOCATED ABANDONED SITES & IMPOUNDMENTS

State	Agricultural Sites	Agricultural Imps	Municipal Sites	Municipal Imps	Industrial Sites	Industrial Imps	Mining Sites	Mining Imps	Oil & Gas Sites	Oil & Gas Imps	Other Sites	Other Imps	Total Sites	Total Imps
AK	1	1	26	30									27	31
AL														
AR			2	10	10	14							12	24
AS														
AZ	1	8	13	33			6	7					20	48
CA	3	5	10	37	4	9	1	5	12	19	1	26	31	101
CO														
CT	1	1	16	63	65	121	1	3					83	188
DE														
FL														
GA	12	12	49	50	3	7	1	1					65	70
GM														
HI														
IA														
ID														
IL	5	6	88	134	69	139	16	28	413	438			591	745
IN														
KS														

LOCATED ABANDONED SITES & IMPOUNDMENTS

State	Agricultural Sites	Agricultural Imps	Municipal Sites	Municipal Imps	Industrial Sites	Industrial Imps	Mining Sites	Mining Imps	Oil & Gas Sites	Oil & Gas Imps	Other Sites	Other Imps	Total Sites	Total Imps
KY														
LA			1	1	20	39			28	37			49	77
MA	1	6	18	142	8	25					6	35	33	208
MD			1	1	12	24							13	25
ME	3	3	13	16	23	111	2	3					41	133
MI	2	2	6	10	63	114					5	9	76	135
MN	2	2	11	13	18	29	104	116					135	160
MO	4	4	250	250	221	221	4	4			28	28	507	507
MS	47	52	5	6									52	58
MT														
NC	1	1	6	6	15	15	4	8					26	30
ND														
NE														
NH			1	1	1	3							2	4
NJ	3	5	6	24	37	100							46	129
NM	2	3	18	47	9	32	7	10	3	24			39	116
NV					4	264	6	118					10	382
NY			7	8	33	44							40	52

LOCATED ABANDONED SITES & IMPOUNDMENTS

State	Agricultural Sites	Agricultural Imps	Municipal Sites	Municipal Imps	Industrial Sites	Industrial Imps	Mining Sites	Mining Imps	Oil & Gas Sites	Oil & Gas Imps	Other Sites	Other Imps	Total Sites	Total Imps
OH														
OK														
OR														
PA	7	17	18	30	130	395	60	97	6	18	13	70	234	627
PR														
RI					3	13							3	13
SC														
SD														
TN	9	12	1	1	47	136	1	1	1	1			59	151
TT														
TX	60	120	31	54	79	191							170	365
UT														
VA	4	4	13	19	8	15	5	24					30	62
VI														
VT	1	1	4	4	5	12							10	17
WA														
WI	2	2	2	2	42	67	3	11					49	82
WV	2	3	14	14	8	19	42	150					66	186
WY														

APPENDIX B-IV

ASSESSED ABANDONED SITES & IMPOUNDMENTS

State	Agricultural Sites	Agricultural Imps	Municipal Sites	Municipal Imps	Industrial Sites	Industrial Imps	Mining Sites	Mining Imps	Oil & Gas Sites	Oil & Gas Imps	Other Sites	Other Imps	Total Sites	Total Imps
AK			5	5									5	5
AL														
AR			2	2	10	10							12	12
AS														
AZ														
CA	3	3	10	13	3	3	1	1	10	14	1	3	28	37
CO														
CT	1	1	16	16	62	63	1	1					80	81
DE					4	4							4	4
FL														
GA	1	1	1	1	1	1	1	1					4	4
GM														
HI														
IA														
ID														
IL	5	5	21	21	69	69	16	16	30	30			141	141
IN														
KS														

ASSESSED ABANDONED SITES & IMPOUNDMENTS

State	Agricultural Sites	Agricultural Imps	Municipal Sites	Municipal Imps	Industrial Sites	Industrial Imps	Mining Sites	Mining Imps	Oil & Gas Sites	Oil & Gas Imps	Other Sites	Other Imps	Total Sites	Total Imps
KY														
LA			1	1	19	19			3	3			23	23
MA	1	1	13	13	6	6					6	6	26	26
MD			1	1	4	4							5	5
ME	3	3	13	13	22	22	2	2					40	40
MI			3	3	27	27					4	4	34	34
MN	2	2	11	13	18	29	14	14					45	58
MO														
MS	14	14	4	4									18	18
MT														
NC	1	1	6	6	15	15	4	4					26	26
ND														
NE														
NH			1	1	1	3							2	4
NJ	2	2	3	3	25	25							30	30
NM			5	5	4	4	4	4	1	1			14	14
NV					2	3	3	4					5	7
NY			1	1	2	2							3	3

ASSESSED ABANDONED SITES & IMPOUNDMENTS

State	Agricultural		Municipal		Industrial		Mining		Oil & Gas		Other		Total	
	Sites	Imps	Sites	Imps	Sites	Imps	Sites	Imps	Sites	Imps	Sites	Imps	Sites	Imps
OH														
OK														
OR														
PA	7	7	17	17	128	197	56	56	6	6	12	13	226	296
PR														
RI					3	13							3	13
SC														
SD														
TN														
TT														
TX	7	7	8	8	11	11							26	26
UT														
VA					2	2							2	2
VI														
VT	1	1	4	4	5	12							10	17
WA														
WI	1	1	1	1	20	20	2	2					24	24
WV					6	14							6	14
WY														

*U.S. GOVERNMENT PRINTING OFFICE : 1984 0-421-082/509