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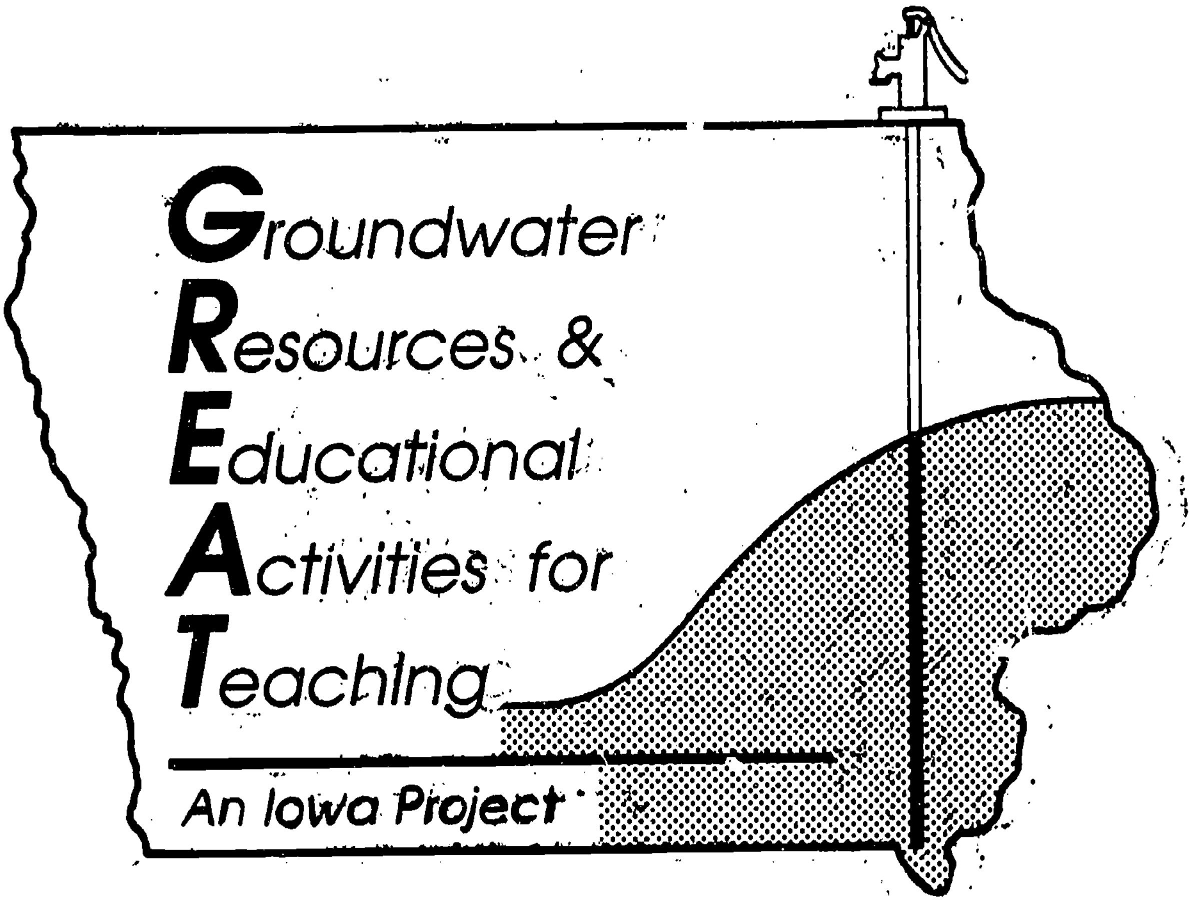
ABSTRACT

These resource materials are a part of a larger plan for groundwater education, as detailed in the Iowa Groundwater Education Strategy. The six units are arranged in priority order. The first unit covers the basics of groundwater and hydrogeology in Iowa. The other five units cover Iowa's groundwater issues in priority order, as outlined in the Iowa Groundwater Protection Strategy 1987. Within each unit are a list of objectives, background information, and some activities. Many of the illustrations are a full page to allow teachers to make an overhead transparency for discussions. In each activity the title is followed by suggested subjects (earth and/or life science; all activities could be appropriate for general science) and an "average" length of time. The Quick Summary, Objectives, and Materials listings follow. The Printed/AV Materials section lists supplementary pages following the activity that could be used to make overhead transparencies, worksheets, etc. Other audiovisual materials that could be obtained may also be listed there. Sometimes more background is given in the Teacher Information section. The Procedure, Alternative, and Extensions all give ideas about how to implement these activities in a classroom. Six plexiglass groundwater models and a set of six groundwater posters accompany the set of GREAT materials when ordered from the Conservation Education Center. following topics are covered: (1) hydrology; (2) fertilizers and pesticides; (3) abandoned waste sites and landfills; (4) leaking underground storage tanks and hazardous materials handling and transportation; (5) direct paths of contamination; and (6) land-applied wastes and sewage treatment. More information on the water of Iowa, hazards of household products, publications on groundwater from the Department of Natural Resources, recycling directory, and information on composting are appended. (KR)



For Earth/Life/General Science 7th - 9th Grades

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GREAT
Groundwater Resources and Educational Activities for Teaching

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Introduction

Iowa law requires water quality issues to be included in seventh and eighth grade science. This is a result of the Groundwater Protection Act which was passed in 1987 in the face of increasing groundwater contamination.

Groundwater quality is important for at least three reasons.

1. Groundwater supplies **drinking water** for about 80% of all Iowans and for virtually all private rural users.
2. Groundwater contamination can affect the **ecosystems** of plants and animals, because groundwater often recharges lakes and streams.
3. Iowa's **economy** depends on groundwater for over three-fourths of the water used for livestock, irrigation and commercial purposes.

The **priority of groundwater issues in Iowa** was agreed upon by the Iowa Legislature, Department of Natural Resources, and other groundwater interests. Iowa's 1987 Groundwater Protection Act was landmark legislation that started to address these issues which are summarized in priority order below.

1. Fertilizers and Pesticides
2. Abandoned Waste Sites & Landfills
3. Leaking Underground Storage Tanks and Handling & Transporting Hazardous Materials
4. Direct Paths of Contamination (Ag-drainage Wells, Abandoned Wells & Sinkholes)
5. Land-applied Wastes & Sewage Treatment

"Protection through prevention" is the basis for Iowa's philosophy for groundwater protection. It has been found to be more feasible, more effective, and less expensive to prevent groundwater contamination than to try to clean it up after it has occurred.

Energy savings from groundwater protection programs can help reduce Iowa's reliance on imported energy--98% of the state's total energy use. Therefore any reduction in our use of petroleum products (such as agricultural chemicals or leaked gasoline) can help Iowa's economy. Also, fewer applications of fertilizers and pesticides result in less tractor fuel used. Proper application of manure or sludge reduces the need for commercial fertilizers which saves natural gas. Waste management alternatives can also save energy through recycling or by burning garbage to produce heat or electricity. Also methane gas, another energy source, can be produced from landfills, manure or sewage sludge.

GREAT (Groundwater Resources and Educational Activities for Teaching) reflects Iowa's philosophy of prevention and priority of issues. It is also a part of a larger plan for groundwater education, as detailed in the Iowa Groundwater Education Strategy. This plan includes materials developed by the University of Northern Iowa (Outlook on Groundwater), by Iowa State University (Groundwater Protection Through Prevention, A Curriculum For Agricultural Education in Secondary Schools), and potential future materials for other curricular areas. Preventing groundwater contamination depends on education. People must be knowledgeable about groundwater problems and motivated to take action to resolve them.

It is hoped that these materials help you do a "GREAT" job of teaching about Iowa's groundwater.

How to Use This Book

Organization of GREAT (Groundwater Resources & Educational Activities for Teaching)

The six **units** are arranged in priority order. The first unit covers the basics of groundwater and hydrogeology in Iowa. The other five units cover Iowa's groundwater issues in priority order, as outlined in the Iowa Groundwater Protection Strategy 1987. These priorities were set by consensus among those with groundwater interests.

Within each unit are a list of objectives, background information, and some activities. Many of the illustrations are a full page to allow you to make an overhead transparency for discussions.

In each activity the title is followed by suggested subjects (earth and/or life science; all activities could be appropriate for general science) and an "average" length of time. The Quick Summary, Objectives, and Materials listings follow. The Printed/AV Materials section lists supplementary pages following the activity that could be used to make overhead transparencies, worksheets, etc. Other audiovisual materials that could be obtained may also be listed here. Sometimes more background is given in the Teacher Information section. The Procedure, Alternative, and Extensions all give ideas about how to implement this in your classroom.

A one-foot plexiglass **groundwater model**, designed to be used by small groups of students, is a part of the GREAT program. Appendix A describes how to use this model which has variations to show the different types of groundwater contamination. You may decide to use all of the variations at once as an introduction, or to use each as a part of the different units. A set of six **groundwater posters** also accompany GREAT, one for each unit. The **other appendices** give further ideas and references.

Choosing What to Put in Your Curriculum

Considerations for Your Classroom

Because most teachers will not have time to do everything in this book, here are some suggestions for the planning and "trimming down" process.

1. **What is the environmental problem?**
   a. **Broad overview** of Iowa's groundwater issues -- To get an idea of the scope of this problem yourself, review the background information for each unit. Then if you don't do something from each unit, try to at least summarize the variety and priority of Iowa's groundwater issues for your students. Also, what are the general concepts underlying these issues?
   b. **Personalize the issue.** Do one of these issues touch particularly close to home for your students? You may want to study that part in more depth.
2. **Motivate your students** to want to be a part of the solution. Help them to see how important it is to protect groundwater. Also, many students find activities more motivating than lectures. However, the reality of time constraints usually dictates a balance in different teaching methods.
3. Have students **practice solving a piece of the problem.** On what part can they personally take action? Try it!

These steps are just another way of checking to see if you have covered these categories of objectives for environmental education: **awareness, knowledge, attitudes, skills, and participation.**

Considerations for Your School District

Can you coordinate your lessons with the other earth/life/general science teachers in your district? Can you divide GREAT into parts to be covered in the different subjects or grade levels?

Don't let all these groundwater considerations be too "draining" on you. Just "dive in" and give it a GREAT try!

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I. ROCK: HYDROGEOLOGY

OBJECTIVES:

Hydrogeologists are all wet.

Upon completion students will be able to:
1. Draw a diagram of the major parts of Iowa's water cycle.
2. Describe how water accumulates in the ground.
3. Differentiate between porosity and permeability and how each affects groundwater movement.
4. Construct an aquifer model and infer how an aquifer works.
5. Trace the path of water in an aquifer.
6. Compare the porosity of different rock types such as limestone, sandstone and shale.
7. Identify the source of their home drinking water.
8. Critically discuss how several processes are commonly used to improve groundwater for drinking.
9. Analyze and describe the major factors that affect natural groundwater quality.
10. Analyze and describe how Iowans use groundwater.

BACKGROUND INFORMATION

Groundwater is one of Iowa's most precious resources. It affects every Iowan each day, but it is being threatened by contamination from many sources. Through the 1987 Groundwater Protection Act, an effort is being made to protect this valuable natural resource.

Water Cycle

Groundwater is an important part of the water cycle or hydrologic cycle. In fact, water may be our most recycled resource. Water falls to Earth as precipitation. Some of the water falls on plants before it reaches the ground. Surface runoff carries rainwater and snowmelt over the land to local rivers and streams. Water also infiltrates into the soil and is retained by the soil in the root zone, where it provides needed moisture for plant growth. Excess water not used in the soil moisture zone percolates down to become groundwater. Eventually groundwater moves through the earth to discharge at streams or wells. To complete this cycle, water is carried back to the air by transpiration from plants and by evaporation from surface bodies of water (evapotranspiration). This water vapor in turn may condense and return to Earth as precipitation.

Iowa's Water Cycle

Iowa's annual average precipitation is about 32". About 2"-3" of this yearly total falls on plants. Runoff in Iowa amounts to about 3"-4". About 26"-27" infiltrates the soil, and about 2"-3" becomes groundwater. About 24"-25" of the state's precipitation returns to the atmosphere as water vapor as a result of evaporation and transpiration.

Groundwater:
out of sight...
out of mind...?

Iowa's groundwater may seem to be less important than the other parts of the water cycle because it is out of sight and thus perhaps often out of mind. Groundwater, however, is a very important part of the cycle. This process provides essential temporary and permanent storage of water within the state. Groundwater is the source of water that Iowans use most.

Groundwater Basics

Groundwater is water under the ground which saturates sediments and rock. The **water table** is the top surface of the saturated zone of these earth materials. Above the water table is a zone of aeration where both air and water are present between particles of material.

Most groundwater is stored and transported in **aquifers**. An aquifer is a zone of sedime[illegible] rock that can store and transmit water, usually enough for prolonged periods of pumping a well. Aquifers vary in size, shape, depth, quality, and content, but they have two characteristics in common: porosity and permeability.

Like the holes in a sponge, an aquifer has openings or pores that can store water. **Porosity** refers to these openings, which may be spaces between individual particles (as occurs in sand and gravel) or cracks and fractures (as occurs in limestone and dolostone). Porosity is the percentage of the total volume of the aquifer that is pore space. The greater the pore space, the higher the aquifer's porosity. The porosity of most aquifers ranges from 10%-40%. Generally the higher the porosity, the better the aquifer in terms of storing water.

Permeability is the ability of sediment or rock to transmit water and other liquids through the pores or openings. Materials with high permeability or with well-connected spaces, make good aquifers. Generally, materials with a high content of fine-grained material such as clay are lower in permeability.

Most aquifers are separated by other layers or bodies of geologic materials that have low permeability and porosity, called **aquitards or confining layers.**

> Gravity never sleeps...
> Water always seeps...

Most wells require a pump to draw groundwater to the surface. Where the well is lower than the aquifer intake or recharge area, groundwater rises in the well under its own pressure to a level above the top of the aquifer, creating an **artesian well**. Sometimes this pressure "head" is enough to cause the water to come up all the way to the land surface, resulting in a **flowing artesian well.**

How fast does groundwater move? Usually very slowly, but it depends on what it's moving through. Water may move through sandstone a few inches or feet per day, but it also moves a thousand times slower through shale and a thousand times faster through gravel.

Types of Aquifers

Aquifers in Iowa can be divided into two general types: surficial aquifers and bedrock aquifers. See Table I-1: General characteristics of Iowa's aquifers. See also Figure F-1: Principal aquifers in Iowa in Appendix F.

I. **Surficial aquifers**, which occur above the bedrock aquifers are of three types: 1) alluvial, 2) glacial drifts and 3) buried channels, a less extensive type of aquifer. These aquifers can be located in Figure I-1: Types of surficial aquifers.

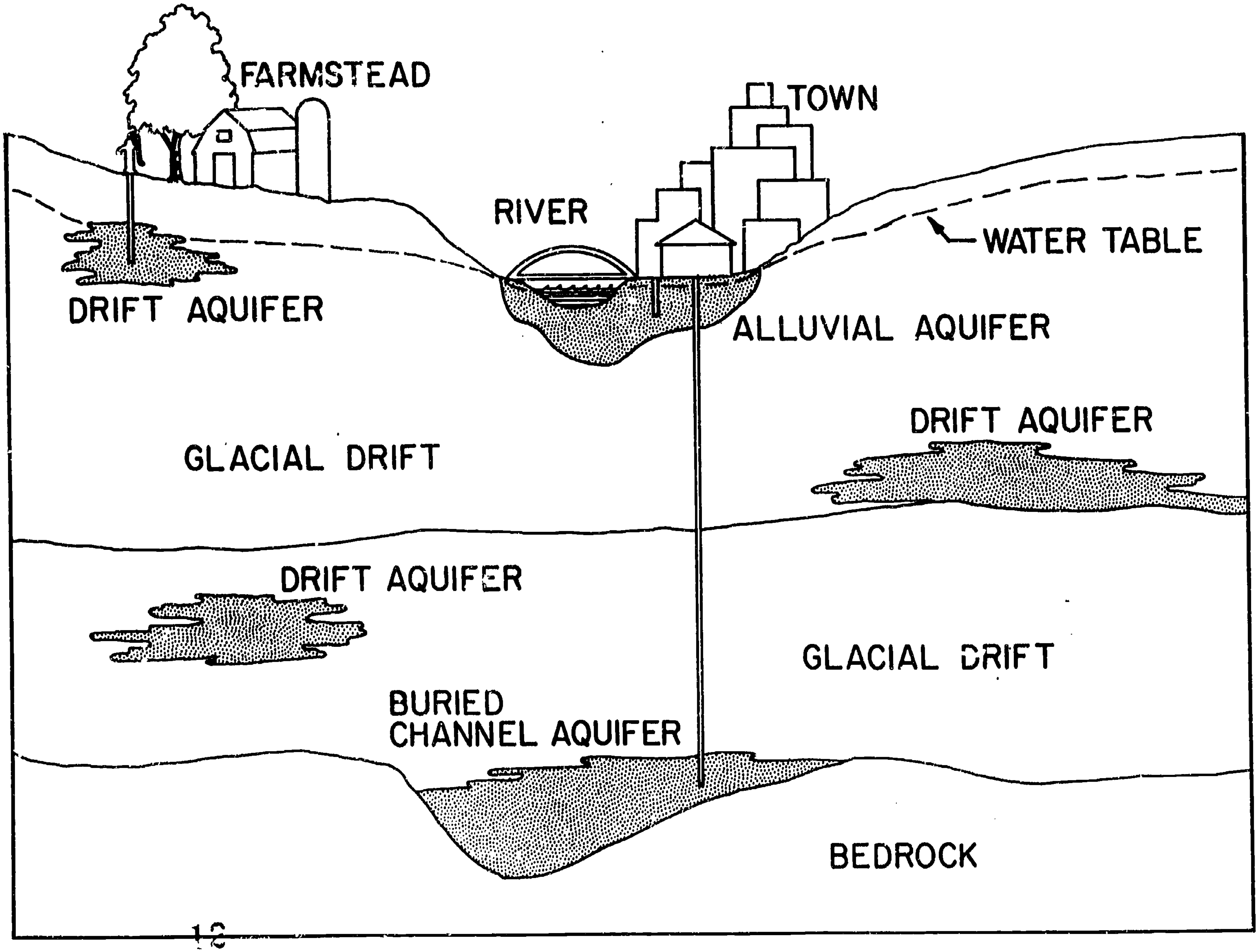
A. **Alluvial aquifers** are saturated sand and gravel deposits filling valleys along rivers and streams. They are usually named after the river which deposited the sand and gravel.

B. **Drift aquifers** are saturated sand and gravel deposits resulting from glacial activity. They occur as isolated, irregular bodies or lenses contained within a deposit of clay-rich glacial drift. The extent of drift aquifers is usually poorly known, and they may be local in their occurrence.

Table I-1. General characteristics of major groundwater sources in Iowa

	Type of Aquifer	Location	Knowledge of Location	Naturally occurring water quality	Susceptibility to contamination	Extent of use	Total Groundwater Use
(Surface Water)		(Rivers, lakes and ponds)			(Very high)		(20%)
Surficial Aquifers	Alluvial	River floodplains throughout the state	Fair to Good	Good to excellent	High	Heavy use along major rivers, important for public & industrial supplies	48%
	Glacial Drift	Scattered throughout the state except northeast corner	Poor	Fair to good	Medium to high	Important for small rural users especially in north, west and south	
	Buried Channel	Scattered throughout the state	Fair	Fair to good	Medium	Local importance in central and east	
Bedrock Aquifers	Dakota (Cretaceous)	Northwest and west-central	Excellent	Poor to good	Medium to low	Moderate - rural and public supplies	6%
	Mississippian	Roughly west of a line from Franklin to Des Moines Counties	Excellent	Good to excellent outcrop areas in north-central. Mostly poor elsewhere	Moderate in north-central, low in central and south-east	Heavy use in north, moderate elsewhere	4%
	Silurian-Devonian	All but northeast and northwest corners	Excellent	Fair to excellent east-central and north-central; Mostly poor in central and south	Moderate to high northeast and north-central, low elsewhere	Heavy use in east-central, northeast and north-central for rural, public and industrial use	11%
	Jordan (Cambrian-Ordovician)	All but northwest corner	Excellent	Fair to excellent eastern half. Poor in south and west	Low	One of most dependable sources for large wells in east half	10%
	Dresbach (Cambrian)	All but northwest corner	Good to Excellent	Fair to good	Low	Locally important in east	

FIGURE 1-1 3 TYPES OF SURFICIAL AQUIFERS



C. **Buried channel aquifers** are saturated sand and gravel deposits formed by glacial or preglacial rivers. They occur as a channel in the surface of the bedrock and are usually buried beneath glacial drift (assorted sizes of earth materials left by a glacier).

II. **Bedrock aquifers** are saturated bodies of rock. In Iowa these aquifers are usually sedimentary rocks of limestone, dolomite or sandstone. (Near Manson, the bedrock aquifer is formed in ancient igneous rocks.) These aquifers are named for either the rock formation or the age of several rock units which are saturated. Such aquifers usually occur over widespread geographic areas.

Natural Groundwater Quality

Iowa's natural groundwater quality varies considerably across the state. Groundwater commonly contains dissolved minerals such as magnesium, calcium, sodium, iron, fluoride, and sulfate. The problem with many natural contaminants is not safety, but aesthetics (taste, odor, or color). See Table I-2. For example, high levels of iron can stain plumbing fixtures and laundry and give drinking water an unpleasant taste and odor.

As water percolates through the ground, it dissolves some of the minerals in the materials it encounters, increasing its mineral concentration. Therefore, in general, **the deeper the aquifer, the more dissolved minerals it has, and the poorer the natural water quality**. For example, Figure I-2 shows a generalized cross-section of the Jordan aquifer in Iowa tapped by two wells, one near Council Bluffs in the west and one near Dubuque in northeastern Iowa. In eastern Iowa, the Jordan aquifer is near the surface and has better natural water quality, but in western Iowa, the depth to the aquifer increases and the natural water quality becomes more highly mineralized.

Typically, the natural quality of groundwater found in alluvial aquifers is best. Drift aquifers and buried channel aquifers located throughout Iowa are highly variable in both water quantity and quality.

Figure I-3 shows that the natural water quality of bedrock aquifers is good in northeastern and eastern Iowa and fair in northwestern Iowa. Southern Iowa generally has the state's poorest natural groundwater quality.

Radioactive elements are other naturally occurring contaminants that are occasionally found in groundwater supplies. Generally, radioactivity is not a widespread problem in Iowa, but levels can be high in some rock aquifers, especially in northwest, central, and southeast Iowa, where levels may exceed state drinking-water standards.

Susceptibility To Contamination By People

Some of the factors that affect groundwater's susceptibility to contamination are: depth to the aquifer, rate of water movement, and soil type. In addition to filtration factors, anything that provides a direct pathway to groundwater increases its susceptibility to contamination. This includes fractures in rocks, sinkholes, poor wells, and agricultural drainage wells.

Aquifers near the surface are more easily polluted than deep aquifers. Alluvial, drift, and shallow, unprotected bedrock aquifers are the most susceptible to contamination caused by people. Thus the depth to an aquifer can be both an advantage and a disadvantage. Deep aquifers provide better protection from surface contamination but often contain more dissolved minerals resulting in poorer natural water quality.

Surface contaminants can flow or be carried with rainfall as it percolates into soil or rock material and moves into shallow groundwater systems. The rate of infiltration can affect groundwater quality by enabling contaminants to move either rapidly or slowly. This rate also affects how long water stays in upper soil layers for filtering.

Table I-2. Commonly occurring minerals in Iowa well water.

Mineral	Effects on water quality
Iron	-Imparts yellow or reddish-brown color to water at concentrations greater than 0.05 mg/l (milligrams per liter). -Staining of plumbing fixtures and laundry. -Creates slightly bitter or astringent taste. -High concentrations may effect color and taste of some beverages. -Iron deposits may plug pipes and well screens.
Manganese	-Imparts dark brown color to water. -Staining of laundry and plumbing fixtures. -Impairs taste of drinking water and beverages. -Frequently occurs together with iron.
Calcium and magnesium (hardness)	-Cause water hardness which reduces lathering and sudsing capacity of soaps. -Form soap scum and film. -Form scale in pipes, water heaters, radiators, and boilers which may clog or impede the heat transfer capability.
Sodium	-Of special concern to persons on sodium-restricted diets.
Flouride	-Provides effective prevention of dental decay when in drinking water. -Will cause mottling (discoloration) of teeth if drinking water contains excessive fluoride.
Chloride	-Can cause objectionable tastes in drinking water.
Sulfate	-May combine with other minerals to form hard scale in boilers or water heaters. -Can cause undesirable taste in drinking water. -Combines with sodium or magnesium to form Glauber salt or Epsom salt. Both are well-known laxatives and sufficient concentrations will frequently cause diarrhea among people or young livestock which are unaccustomed to high-sulfate waters. Both humans and livestock appear to become acclimated to sulfate over a period of time.
Hydrogen sulfide	-Exists as a dissolved gas in some well water, but derived in part from microbial action on water with a natural sulfate content. -Produces a characteristic "rotten egg" odor in low concentrations but cannot be detected in high concentrations. -Causes water to be highly corrosive. -The gas is extremely toxic in high concentrations. Special safety precautions should be taken when entering well pits or other poorly ventilated enclosures where this gas might possibly concentrate.

Source: ISU Cooperative Extension Service, PM987, Water Quality for Home & Farm.

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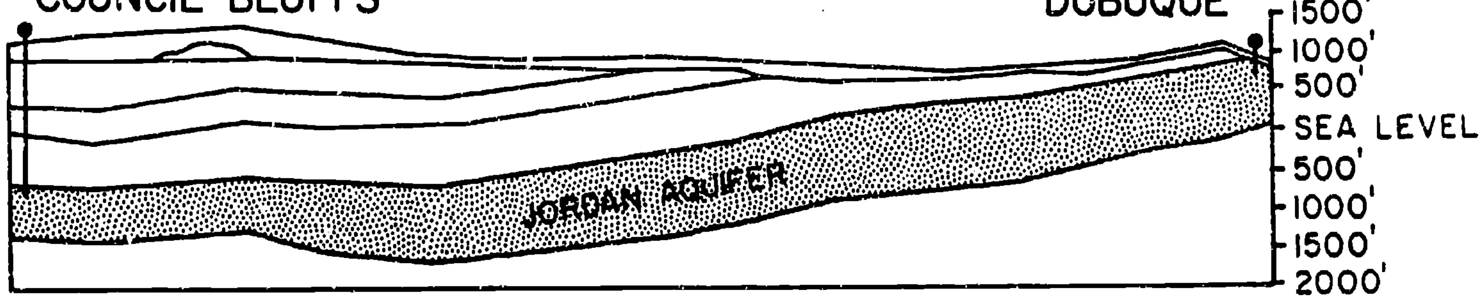
Figure I-2. Cross section of Jordan aquifer, a bedrock aquifer



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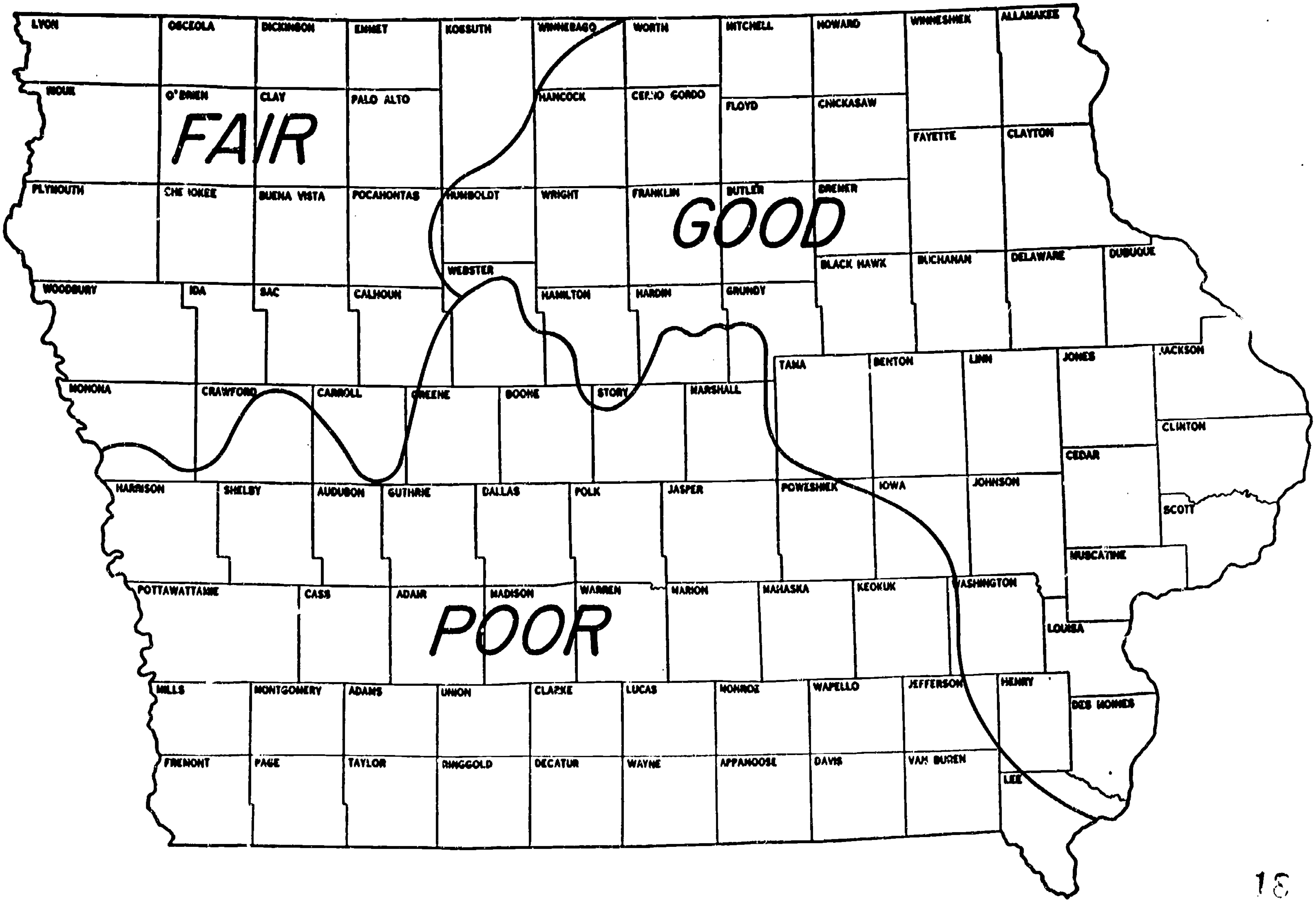

FIGURE I-3 NATURAL OCCURRING WATER QUALITY IN IOWA'S BEDROCK AQUIFERS.

Soil does not filter all contaminants. Chemical contaminants from a variety of landuse activities have been found in various aquifer settings. Thick layers of soil can filter disease-causing bacteria and silt which are often problems in surface water supplies. Contaminants are "filtered" in basically two ways: (1) decomposing and (2) sticking to certain soil particles (called adsorption). Soil type and natural bacteria affect how water is filtered as it moves to aquifers below. Bacteria in humus-rich topsoil may break down some contaminants if the water stays in the topsoil long enough. Clay-rich soils provide a better barrier to the infiltration of contaminants than porous sandy or gravelly soils.

Water Uses

Table I-3 shows that most of Iowa's water used for drinking and industrial purposes is from groundwater. (This excludes water for power generation, most of which is returned to rivers for future use.)

After excluding the water withdrawn for power generation, it was estimated that for each person in Iowa during 1985, 330 gpd (gallons per day) were withdrawn from surface water and groundwater sources for all uses, including both home and business uses. Iowa homes use an estimated 85 gpd per person.

About 80% of Iowa's population drinks groundwater.

Figure I-4 shows the estimated total groundwater use by category. Public water suppliers used the most groundwater: 38.5% of the total; livestock used 20.1% of the groundwater, followed by self-supplied industrial, self-supplied domestic, irrigation, mining, self-supplied commercial, and power generation.

We depend on groundwater.

Refer also to the teacher information in Investigating Water Use in Iowa on page I-39.

Water Treatment

Public drinking water is usually treated before use. However, private rural wells usually have not required treatment. Treatment practices used in Iowa vary widely. The four most common methods of water treatment are described in the outline below, followed by other methods.

I. Most common methods of water treatment.

A. Remove the "big stuff".

1. Intake screens can remove large things like sticks, fish and dirt from surface water. In groundwater, large items are naturally screened as the water moves through earth materials.

2. Other processes in public water treatment, such as coagulation and flocculation, can remove dirt and other solids. Chemicals are added to the water which cling to impurities (coagulation) and form larger, heavier particles called floc. The floc and sediment drop to the bottom of a settling tank and are eventually removed as sludge.

B. Remove "germs".

Adding chlorine to water is the most common method of killing disease-causing organisms. Bacteria are present in most of Iowa's surface water, and may be present in groundwater if wells are old or poorly constructed.

Table I-3. Percentage of uses supplied by Iowa groundwater

Category of Use	Percent of Category Supplied by Groundwater
Public water supplies	74
Self-supplied domestic	100
Livestock	79
Irrigation	78
Self-supplied industrial	36
Self-supplied commercial	76
Mining	80
Power generation	1

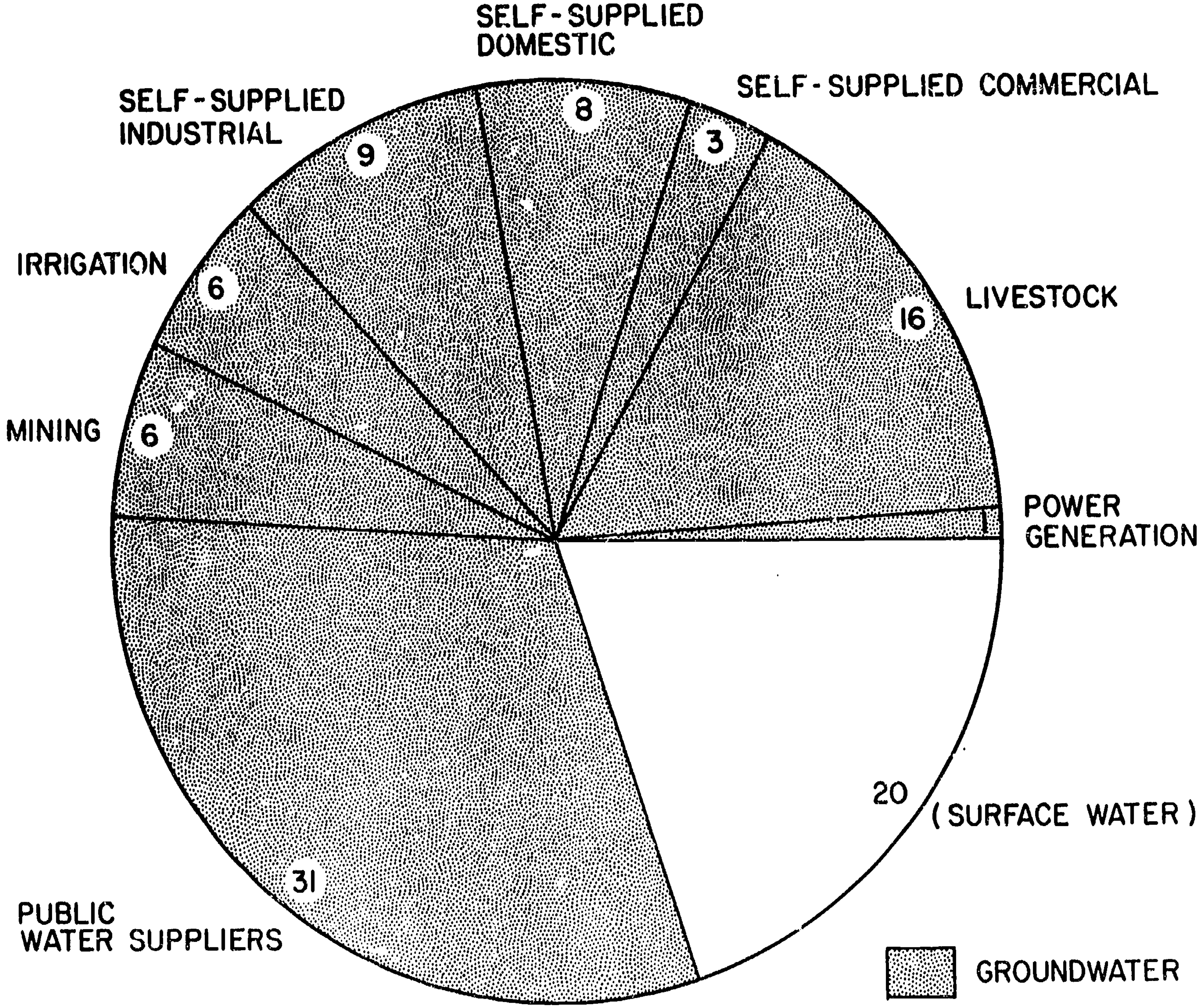

FIGURE I-4 ESTIMATED TOTAL USE BY CATEGORY (%)

C. Control taste, odor, color, and corrosion.
Different treatment methods can be used to remove minerals such as iron or manganese. Activated carbon filters or aeration are often used to remove the rotten egg odor of hydrogen sulfide.

D. Remove hardness.
Water softeners or other methods can be used to remove calcium and magnesium which cause water hardness problems.

II. Other potential treatment functions.

A. Add fluoride.
Fluoride is added to most municipal treatment facilities to help prevent tooth decay.

B. Remove chemicals with health risks.
Chemical contaminants such as nitrates, pesticides, or gasoline/organic solvents are generally very expensive to remove. Many people with this problem find it cheaper to find another water source than to remove these chemicals. Preventing contamination at its source is generally cheaper and more effective than water treatment for these chemicals.

For more information on home treatment systems, refer to Home Treatment Systems for Drinking Water Quality, published by the Hygienic Laboratory, The University of Iowa, Oakdale Campus, Iowa City, IA 52242; phone (319) 335-4500. Table I-4 Drinking Water Quality Problems in Iowa is from this booklet.

Iowa Aquifers From Bottom To Top

The geologic history of Iowa has determined the type of material, depth, extent, and productivity of each of the state's aquifer systems. Underlying the entire state is a thick stack of layered bedrock which was deposited hundreds of millions of years ago when all or parts of Iowa were covered by shallow seas. These bedrock layers are composed mostly of limestone, sandstone, shale, and dolostone, and in general they are inclined in a southwesterly direction. They are like tilted layers in a cake. On top of the bedrock are other layers of younger, softer, loose material deposited by glaciers, rivers, and wind during the last two million years. These surficial layers are like frosting on a cake, and they are composed mostly of a mixture of boulders and clay (glacial drift); water-sorted gravel, sand, silt, and clay (alluvium); and wind-blown silt (loess).

There are five major bedrock aquifers beneath Iowa. From bottom to top they are called the Dresbach, Jordan (Cambrian-Ordovician), Silurian-Devonian, Mississippian, and Dakota (or Cretaceous) aquifers.

The **Dresbach aquifer** is the oldest, made of rock which formed about 600 million years ago during the Cambrian period. It is composed mostly of porous sandstone. It is used only in a few eastern counties of the state. A common well yield is about 500 gallons per minute (gpm), but the wells are deep and the water is highly mineralized.

The **Jordan aquifer** underlies most of the state. It is sometimes called the Cambrian-Ordovician aquifer which also includes the Prairie du Chien Formation. It is exposed at the surface in extreme northeastern Iowa, but in southwestern Iowa it is more than 3000 feet deep. Most of the aquifer is composed of porous sandstone. This aquifer is Iowa's most widespread, dependable groundwater source, and it is utilized by a large number of communities and industries. The common well yield varies from 100-1000 gpm from southwestern to northeastern Iowa. The

Table I-4

Drinking Water Quality Problems in Iowa

I. Problems That May Threaten Health

Contaminant	A. Coliform Bacteria	B. Nitrate	C. Pesticide	D. Lead	E. Gasoline/Organic Solvents
Possible health effect (varies with exposure, compound, and susceptibility)	Intestinal illnesses; taste or odor	methemoglobinemia (blue baby disease)	Acute: vomiting, weakness, etc. Chronic: cancer, genetic or birth defect risks	Chronic: adverse effects on blood, nervous and kidney systems	Chronic: cancer risks; taste or odor
Possible Source	Surface or shallow subsurface water or wastewater	Fertilizer, manure septic system, etc.	Improper use, disposal, spills or back-siphoning accident	corrosion of lead pipes or lead solder	Leaking storage tanks, spills, improper use or disposal
Suggested Treatment	Eliminate source; correct defects of well or supply, shock chlorinate, then recheck for safety	Eliminate source; correct defects of well or supply, anion exchange, reverse osmosis, distillation	Eliminate source, purge system; depending on type of pesticide, treatment units may be available (consult manufacturer)	Reduce corrosion, (see below), lead pipe/solder replacement, reverse osmosis; distillation	Eliminate source, purge system; activated carbon filter in series; vented distillation

II. Problems That Usually Do Not Threaten Health

Contaminant	F. Iron or Manganese	G. Hardness	H. Iron Bacteria	I. Corrosion	J. Taste/Odor
Complaint	Rusty water; rust stains on sink or clothes; deposition inside pipes	Scale, soap scums, deposition inside pipes	Oily film on water; slime growth in water tanks or toilets	Metallic taste; greenish stains on faucets, sinks, leaking pipes	Rotten egg odor
Possible Source	Corrosion of iron pipes or these elements may be naturally present in aquifer	Dissolved calcium and magnesium from soil and/or aquifer	Present in iron-rich aquifer; introduced by contaminated drilling equipment	Corrosive water present in aquifer; "softened" water; incompatible metals in plumbing; aggressive water	Hydrogen sulfide gives water this odor; corrosion; sulfur bacteria NOTE: make sure odor is not due to Coliform bacteria problem (see I.A.)
Suggested Treatment	Water softeners for soluble (ferrous) iron; Iron removal units (green sand filter); reverse osmosis; distillation	Water softener (ion exchange); reverse osmosis; distillation	Shock chlorination; continuous chlorination to retard regrowth	Add corrosion control chemicals or sacrificial metal	Shock chlorination; green-sand iron filter; activated charcoal filters

natural water quality is best in the northeastern part of the state. Since the 1880's water levels associated with this aquifer have dropped about 150-200 feet in parts of the state. Within major pumping centers a yearly decline of 4-6 feet is common.

The **Silurian-Devonian aquifer** underlies most of the state. It is a productive aquifer composed of creviced and fractured limestone and dolostone. It is heavily utilized in a narrow zone along the Cedar River valley from Charles City to Waterloo, where it supplies as much as 4000 gpm and is in direct contact with overlying alluvial material. The common public-supply well yield varies from 100-400 gpm. This aquifer is not a significant producer in the central and southern parts of the state because of high concentrations of sulfate ions resulting from the presence of gypsum in the rock. Sinkholes in northeastern Iowa (karst regions) are often developed in the top of this bedrock aquifer, and they provide easy and direct entry of contaminants into the aquifer.

The **Mississippian aquifer** underlies about 60% of the state and is utilized primarily in the north-central and southeastern parts of Iowa. It is composed mostly of fractured limestone and dolostone. The common well yields range from 10-500 gpm, depending on location. The water quality and quantity decrease towards the southwest.

The **Dakota aquifer** underlies most of northwestern Iowa. It is composed mostly of sandstone with common well yields ranging from 50-100 gpm. In some areas, such as Sioux City, the yields are in excess of 1500 gpm. The Dakota aquifer is being utilized for municipal, rural, and irrigation needs.

The three types of surficial aquifers are : alluvial, drift, and buried channel.

Alluvial aquifers are composed mostly of shallow deposits of sand and gravel along present-day river valleys. The deposits along the Missouri and Mississippi Rivers store and transmit very large quantities of water, as evidenced by many wells pumping in excess of 2000 gpm for municipal, industry, and irrigation purposes. Many of Iowa's smaller interior river and stream valleys also contain alluvial aquifers. They are generally less productive, but Cedar Rapids and Des Moines pump about 15 and 20 million gallons per day, respectively, from the alluvial aquifers along the Cedar and Raccoon Rivers. Alluvial aquifers occur at shallow depths and are productive, but they are also highly vulnerable to contamination from the land surface.

The **drift aquifers** are generally random, isolated bodies of sand and gravel enclosed within the clay-rich glacial drift. They usually serve only as a source for small private rural water supplies, because they typically have low yields, often less than 10 gpm, and low storage capacity. They are especially important in southern and western Iowa where other water sources are too deep and yield water with poor natural quality.

Buried channels form a third type of surficial aquifer. They are generally located at the bedrock surface beneath the glacial drift in valleys formed by glacial or preglacial rivers. They may occasionally be connected to overlying alluvial aquifers along present-day streams and rivers. They typically yield from 10-100 gpm, but may occasionally provide in excess of 500 gpm. The most productive examples are found in central and eastern Iowa.

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Investigating Iowa's Water Cycle

Earth/Life Science 15-20 minutes

Quick Summary: Students will develop a model of the water cycle for Iowa based on the annual average precipitation (32"). The completed model will show the a unts of water which enter various parts of the water cycle.

Objectives: Upon completion students will be able to:
1. Draw a diagram of the major parts of Iowa's water cycle.
2. Estimate how much water enters each part of Iowa's water cycle.
3. Relate the importance of groundwater to the total amount of water that falls on Iowa.

Materials: None

Printed/AV Materials:
Overhead/Worksheet: Iowa's Water Cycle

Teacher Information:
See hydrogeology background information.

Procedure:
1. Have students develop the water cycle and then study the worksheet: Iowa's Water Cycle. (This can be done in small groups or as a class discussion.)

2. In groups of two or three, discuss the cycle and try to determine how much of the total annual average precipitation (32") should be listed (in inches) at each position.

3. As a class, discuss the numbers that each group used for each part of the cycle and come to an agreement. Compare the class' numbers with the facts:

Precipitation: 32"
Falls on plants: 2"-3"
Runoff: 3"-4"
Infiltration: 26"-27"
Evapotranspiration: 24"-25"

4. Answer the following questions and statements.

a. What three places might the precipitation go? (Fall on plants, runoff to lakes and streams, or infiltrate the ground. These three should add up to 32".)

b. Where might the water go that infiltrates the ground? (Stay temporarily as soil moisture, move down to groundwater, taken up by plants, or eventually go the the air through transpiration and evaporation.)

c. Where does groundwater go? (Although groundwater usually moves very slowly (inches or feet per day) it eventually discharges to surface water (lakes and streams) or wells. Keep in mind that there is much more water underground than at the surface, although much of it may not be usable due to naturally high mineral content.)

d. About what percentage of the total average annual precipitation (32") is groundwater: 1%, 7%, 15%, 25%, 50%? (7-8%. Because most Iowans use groundwater for drin g and business purposes, this is a very precious resource.)

e. What fraction of the total average annual precipitation (32") returns to the atmosphere as a result of evaporation and transpiration (evapotranspiration): 1/4, 1/2, 2/3, or 3/4? (3/4)

f. Does any of the water in Iowa's water cycle leave the state or enter it from other states? (Yes). How? (Most of the water leaving Iowa is through the Mississippi or Missouri River systems. Air masses with clouds often move in from other states. However, because of Iowa's geologic features, most of Iowa's groundwater is recharged by precipitation within the state and is discharged within the state.)

g. How much water is "lost" in the world's water cycle? (None.)

Alternative:
Show the overhead, Iowa's Water Cycle, to the students and discuss it.

Extensions:
a. Write a poem or a song describing Iowa's water cycle.
b. Develop a board or card game emphasizing Iowa's water cycle.

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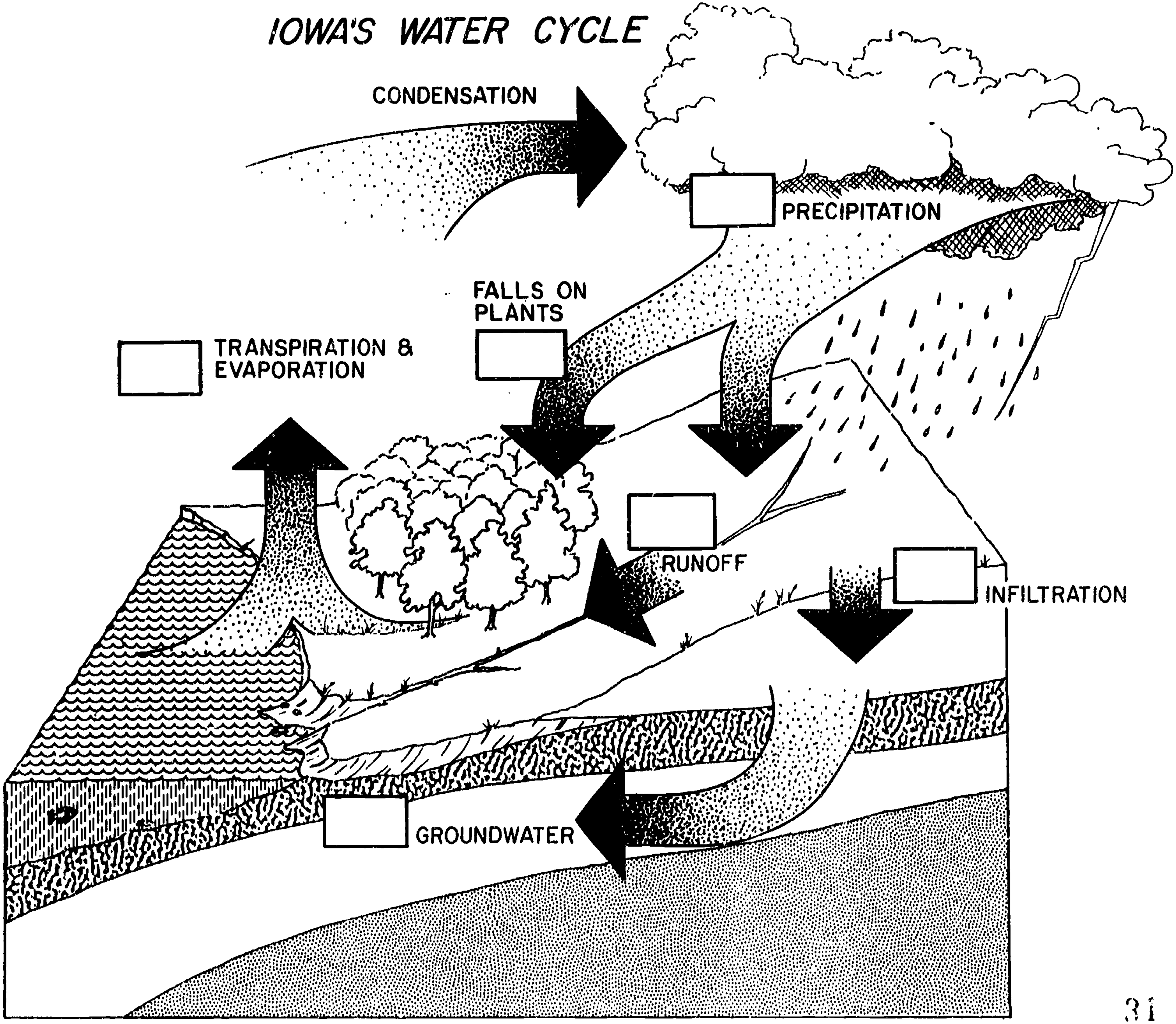
IOWA'S WATER CYCLE



Investigating the Porosity and Permeability of Sediments

Earth Science 1 class period

Quick Summary:
Students will determine the porosity and permeability of some common sediments.

Objectives: Upon completion, students will be able to:
1. Define porosity and permeability.
2. Calculate the percentage of pore space in several types of materials.
3. Compare the porosity and permeability of several types of materials.
4. Identify some variables that affect porosity and permeability.
5. Generalize from their data about the relationship between particle size and shape and porosity and permeability.

Materials: For each team of 2-4 students: 400 ml beaker; 100 ml graduated cylinder; paper cups; thumbtack; strong tape (duct tape); nylon filter material (old pantyhose cut to size--slightly larger than the bottom of a cup); water; sediment samples: pea gravel or aquarium gravel, sand, clay or clay-rich soil, soil, a mixture of each of the above.

Printed/AV Materials:
Student worksheet (2 pages)

Teacher Information:
Iowa's surficial aquifers (alluvial, buried channel, drift) are composed of sediments such as sand and gravel. Porosity is the ratio of the volume of pore spaces between particles to the total volume of a sample of material. In this investigation, students will be able to determine the porosity of several materials by using the following formula:

Porosity (%) = Volume of water/Volume of material X 100.

Permeability is the ability of a material to transmit water.

Sediments are classified by the size of the grains. From smallest to largest they are: clay, silt, sand, and gravel.

Clays and some clay-rich or organic soils can have very high porosities. Organic materials do not pack very closely because of their irregular shapes.

Porosity Ranges for Sediments	
Well-sorted sand or gravel	25-50%
Sand and gravel, mixed	20-35%
Glacial till	10-20%
Silt	35-50%
Clay	33-60%

Procedure:
1. Discuss porosity and permeability. (Refer to background information.)

2. Divide the class into teams of 2-4 students.

3. Hand out student worksheets and materials and highlight any necessary directions.

4. Ask students to predict the porosity and permeability of each material before starting the investigation.

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5. Have teams perform the investigation. Depending on available time, teams may investigate all materials or each team may investigate one material and evaluate data compiled for the whole class.

6. Discuss results and answers.

a. Porosity is the ratio of the volume of pore spaces between particles to the total volume of a sample of material.

b. Permeability is the ability of a material to transmit water.

c. The bigger the particle, generally the greater the porosity and permeability. Generally, rounder particles will pack more tightly and have less porosity than particles of other shapes.

d. Most porous: gravel (the material that had the most water to cover it.)

e. Least porous: will depend on specific samples used--see teacher information.

f. Most permeable: gravel (the fastest to drain)

g. Least permeable: clay

h. Yield the most water: gravel

i. Yield the least waterr: clay

Alternative: Do the investigation as a demonstration and have students answer the questions.

Extensions: Students may wish to test other materials for porosity and permeability. Some students may wish to research the porosity and permeability of the aquifer beneath their local communities by contacting their local water treatment plant.

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Investigating the Porosity and Permeability of Sediments
Student Worksheet

Name________________

Setup
1. Punch 8-10 holes in the bottom of a paper cup with a thumbtack. Put a piece of duct tape over these holes on the outside of the cup.

2. Put a piece of nylon material in the bottom of the cup for a filter. Measure and pour 200 ml of gravel into a paper cup. Tap the cup gently to settle the particles. Record the 200 ml on your data table under the heading "Volume of material." Also record the name of the material (in this case, "gravel") in that column.

Porosity
3. Next you will need to find how much water is needed to cover the gravel or other sediments. Put 100 ml of water in the graduated cylinder and pour the water slowly into the cup until the particles are just covered. If more than 100 ml of water is required to cover the material, refill the graduated cylinder and continue.

4. Determine to the nearest ml how much water was added to the cup and record the number on your data table under the heading "Volume of water."

5. Use the following formula to calculate the porosity of each kind of material and record it under the heading "Porosity."

$$\text{Porosity (\%)} = \frac{\text{Volume of water (ml)}}{\text{Volume of material (ml)}} \times 100$$

For example:

$$\text{Porosity (\%)} = \frac{100\text{ ml}}{200\text{ ml}} \times 100 = 50\%$$

Permeability
6. Now add enough water to the cup to make a total of 200 ml. For example, if you used 100 ml to cover the gravel, add 100 ml more to make 200 ml.

7. Several people cooperate in this step. One person holds the cup over the beaker and removes the tape on the bottom of the cup. Another person times how long it takes for the 200 ml of water to drain out of the cup and into the beaker. Stop timing when the water begins to drip. Record the time under the heading "Amount of time". (NOTE: Clay may require too much time, so stop after a reasonable time.) Empty the cup and beaker.

Repeat
8. Repeat steps 2-7 with the other materials (sand, clay, soil, mixture).

Data Table For Porosity and Permeability
Student Worksheet p.2

NAME OF MATERIAL	VOLUME OF MATERIAL	VOLUME OF WATER TO COVER THE MATERIAL	POROSITY %	AMOUNT OF TIME FOR WATER TO DRAIN
1				
2				
3				
4				
5				

Answer the following:
a. Define porosity.

b. Define permeability.

c. How does particle shape or size or both affect porosity?

d. Which material is most porous?

e. Which is least porous?

f. Which material is most permeable?

g. Which is least permeable?

h. If an aquifer were made of these materials, which kind would yield the most water?

I. Which would yield the least water?

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Investigating Porosity in Rocks

Earth Science

15 minutes on one day and
15 minutes several days later

Quick Summary: Students will conduct an investigation to test how much water various types of rocks can absorb.

Objectives: Upon completion, students will be able to:
1. Predict which kind of common rocks will be most porous.
2. Gather data on the porosity of common rocks.
3. Differentiate between porous rocks and nonporous rocks.
4. Generalize from their data which kinds of common rocks are most porous and would make good or poor aquifers.
5. Identify several variables that may influence porosity.

Materials: For each team of 2-4 students: Several egg-sized or smaller pieces of various kinds of common rocks, such as sandstone, shale, limestone, granite, (students may also bring samples from their own surroundings); water; 3 or 4 beakers or other containers; balance.

Printed/AV Materials:
Student worksheet

Teacher Information:
See background information at the beginning of this unit.

SAFETY If any samples of rocks need to be broken, supply safety goggles.

Procedure:
1. Review porosity. (Refer to background information at the beginning of this unit.)

2. Divide the class into teams of 2-4 students.

3. Hand out student worksheets and materials and outline any necessary directions. Try to get at least 4 types of common rocks, and have students in each team work with about equal sizes of each rock type.

4. Have students in each team predict which rocks will be most porous and which will be least porous before beginning the measuring process.

5. It may require several days for water to enter the pore spaces in some rocks, so the investigation may have to be extended.

6. Discuss results and answers.

a. Answers may vary, but sandstone probably will be most porous.

b. Answers will vary, but shale probably will be least porous.

c. Answers will vary for yielding the most water.

d. Answers will vary for yielding the least water.

e. Cracks or fractures in the rocks are important factors which would increase the porosity.

f. Factors that could influence the porosity of rocks will vary. Examples include: cementation, size of rock, time soaking, shape of particle, size of pores, etc.

Alternative:
Do the investigation as a demonstration.

Extension:
Students could investigate the porosity of other kinds of rocks that are not as common, such as lava, obsidian, gneiss, marble, gypsum, coal, etc., to compare their potential use as an aquifer.

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Investigating Porosity in Rocks
Student Worksheet

Name________________________

1. Measure and record the mass of all the pieces of each kind of rock.

2. Place the samples of each rock type in separate beakers and label the beakers with the name of the rock type. For example, put several pieces of sandstone in a beaker, several pieces of limestone in another beaker, etc.

3. Put enough water in each beaker to cover the samples.

4. Let the rocks soak in the water for several days.

5. Remove the rocks from the water, dry them, and measure and record the mass of each sample of each kind of rock.

6. Record the difference between the mass before soaking and mass after soaking.

Data Table for Investigating Porosity in Rocks

KIND OF ROCK	MASS BEFORE SOAKING	MASS AFTER SOAKING	DIFFERENCE
1			
2			
3			
4			

Answer the following:

a. Which kind of rock tested was most porous?

b. Which kind of rock tested was least porous?

c. If an aquifer were made of one these rocks, which kind would yield the most water?

d. Which would yield the least water?

e. How would cracks or fractures in the rocks affect porosity?

f. Identify several factors or variables that could influence the porosity of different kinds of rocks.

Constructing a Groundwater Model

Earth Science 1 class period

Quick Summary: Students will construct a groundwater model, analyze how it works, and infer how a real aquifer works.

Objectives: Upon completion, students will be able to:
1. Construct a groundwater model.
2. Relate the different parts of the aquifer model to the flow of water through the aquifer.
3. Analyze how their model aquifer stores and transports water.
4. Infer how a real aquifer works.
5. Compare and contrast porous and nonporous, permeable and impermeable layers.
6. Discover how a pumped water well and artesian system work.

Materials: For each group of 3-5 students: groundwater model; fine- to medium-sized aquarium gravel, foam or other impermeable material; water; paper cups; graduated cylinder; pumps from lotion or some similar product; plastic straws; strong tape (duct tape).

Teacher Information:
See background information at the beginning of this unit and in Appendix A. GREAT Ways to Use the Groundwater Model.

Procedure:
1. Collect materials for the model. Aquarium gravel works well because it is clean. If quarry sand or gravel is used, be sure to flush water through it several times to remove floating "debris" so the model will not get so messy.

2. Divide students into groups of 3-5.

3. Hand out student worksheets and materials and outline any necessary directions.

4. After students experiment with the groundwater models, discuss their results and answers.

   a. The gravel aquifer is most porous and most permeable.

   b. The foam confining layer is least porous and most impermeable.

   c. The water table lowers as water is pumped out of the aquifer.

   d. Water must be added at the same (or faster) rate as water is being pumped out of the aquifer in order for the water table to remain at (or above) the same level.

   e. The model had to be tipped so the straw was lower than the water table to make water flow out of the drinking straw, creating an artesian well.

Alternatives:
1. Do the activity as a demonstration.
2. Steps 2-4 on the student worksheet may be eliminated by doing that procedure as part of the porosity and permeability experiment. This eliminates the need to start with dry gravel each time.

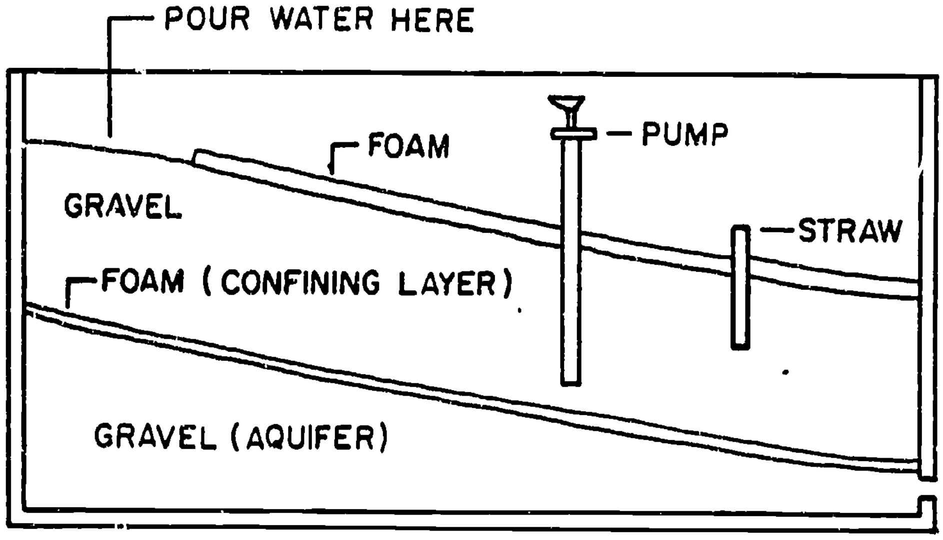
Extensions:
1. Obtain a map of the local aquifer from the Geological Survey Bureau. (See Appendix J.) Locate any wells that are in the local area on it. Locate and visit any artesian wells in the area.
2. Write a newspaper article about the groundwater and aquifer under your local community.
3. Produce a video or slide set about groundwater in your community or farmstead.
4. Design and make a bumper sticker that increases the public awareness of groundwater and groundwater contamination.

Constructing a Groundwater Model

Student worksheet

Name______________________________

1. Set up the groundwater model as shown.



2. Set a cup at the end to catch water coming out of the hole. Pour water (be ready to measure this) into the model until it begins draining from the hole. Put a piece of tape over the hole. One person can use a nonpermanent marker to draw on the side the path of water as it flows into and through the gravel and mark the water table. Record the amount of water added. ____________________ ml

3. Untape the hole and let the water drain and compare the amount collected to the amount poured in. Measure and record the amount of water drained from the model. ____________________ ml

4. How does the amount collected compare with the amount poured in?

5. Put tape over the hole again. Pour in more water until the water table is above the level of the bottom of the pump. Pump some water out of the aquifer. Experiment with putting in water (recharging the aquifer) faster than water is being pumped out, simulating abundant precipitation. Record your observations:

6. Experiment with pumping water out of the aquifer faster than water is poured in, simulating drought conditions. Record your observations:

7. Add water until it is just below the bottom of the drinking straw. Experiment with the position of the model to make water flow out of the drinking straw without pumping to simulate an artesian well.
Observe and record your results:

8. Clean up and return equipment.

9. Answer the following:
a. Which material is most porous? ________________________ Permeable?________________
b. Which material is least porous?______________________ Impermeable?________________
c. What happens to the level of the water table when water is pumped out of the aquifer?

d. What must happen for the water table to remain at or above the same level as water is being pumped out of the aquifer?

e. How did the position of the model have to be changed to make water flow out of the drinking straw? Name and define this type of well.

Where's the Water? Investigating Iowa's Aquifers

Earth Science 15-20 minutes

Quick Summary:
Students will label a simplified cross-section of Iowa along Highway 20 showing the aquifers and confining layers and use it to answer interpretive questions.

Objectives: Upon completion, students will be able to:
1. Distinguish between the major aquifers available to Iowans.
2. Interpret a cross-section showing Iowa's major aquifers.

Materials:
Colored pencils

Printed/AV Materials:
Overhead: Iowa's Major Aquifers
Worksheets: Iowa's Major Aquifers
Investigating Iowa's Aquifers

Teacher Information:
The simplified cross-section is not to scale. Also refer to the hydrogeology background information.

Procedure:
1. Have students complete the worksheet.

2. Use the overhead on Iowa's Major Aquifers to discuss their answers.
a. Students should see the tilting and great depth of the layers. Answers will vary.

b. Iowa's six major aquifers from the surface downward are: surficial, Dakota (Cretaceous), Mississippian, Silurian-Devonian, Cambrian-Ordovician (Jordan), and Dresbach.

c. Confining layers are impermeable layers that confine the water in an aquifer.

d. Aquifers used by the following cities are:

	Pictured	Also Used
Sioux City:	Dakota	alluvial aquifer
Fort Dodge:	Jordan	Silurian-Devonian & Missippian
Iowa Falls:	Mississippian	
Waterloo-Cedar Falls:	alluvial aquifer	Silurian-Devonian
Dubuque:	Dresbach	Cambrian-Ordovician

e. The depth of the wells, to the nearest number printed on the diagram, are:
Sioux City: 300'
Fort Dodge: 2,250'
Iowa Falls: 200'
Waterloo-Cedar Falls: 100'
Dubuque: 1,750'

f. Waterloo/Cedar Fall's well is most susceptible to contamination by people because it is the closest to the surface.

g. Fort Dodge's well is most likely to have problems with dissolved minerals because it is the deepest; therefore, the water has had more time to dissolve minerals from the bedrock. There are, however, exceptions to this generality. You may want to take this opportunity to outline major types of water treatment which are described in the background information for this unit.

Alternative:
Show the overhead "Iowa's Major Aquifers." Have students discuss it.

Extensions:
1. Students may obtain a record of the layers in their own community by visiting the local water department. They may want to research what type of aquifer their town well taps, its depth, how much water is pumped in a minute/day/year, the water quality and/or what treatment methods are used.
2. Write an editorial for the local newspaper about groundwater in your community.
3. Design and produce a pamphlet about groundwater in Iowa or your local community.
4. Draw a cartoon character and produce a comic strip or editorial cartoon about groundwater in Iowa.

Investigating Iowa's Aquifers
Student Worksheet

Name_______________________

1. On the diagram of Iowa's Major Aquifers label the layers of rock in order from the surface to the bottom of the cross section: A: Surficial Aquifer; B: Dakota (Cretaceous) Aquifer); C: Confining Layer; D: Mississippian Aquifer; E: Confining Layer; F: Silurian-Devonian Aquifer; G: Confining Layer; H: Cambrian-Ordovician Aquifer (Jordan); I: Confining Layer; J: Dresbach Aquifer; K: Precambrian Basement Rock (mostly igneous and metamorphic).

2. Use colored pencils to color the aquifers different colors. Do not color confining layers.

3. Answer or discuss the following:

a. Describe the arrangement and shape of the layers shown.

b. List Iowa's six major aquifers from the surface downward.

c. What are confining layers and what is their function?

d. Cities often get their water from several sources. The diagram shows one of the wells for each city. Name the aquifer shown from which each of the following cities pump their water.

Sioux City:

Waterloo-Cedar Falls:

Ft. Dodge:

Dubuque:

Iowa Falls:

e. Use the scale on the left margin to estimate the depth of the wells at these communities:

Sioux City:

Waterloo-Cedar Falls:

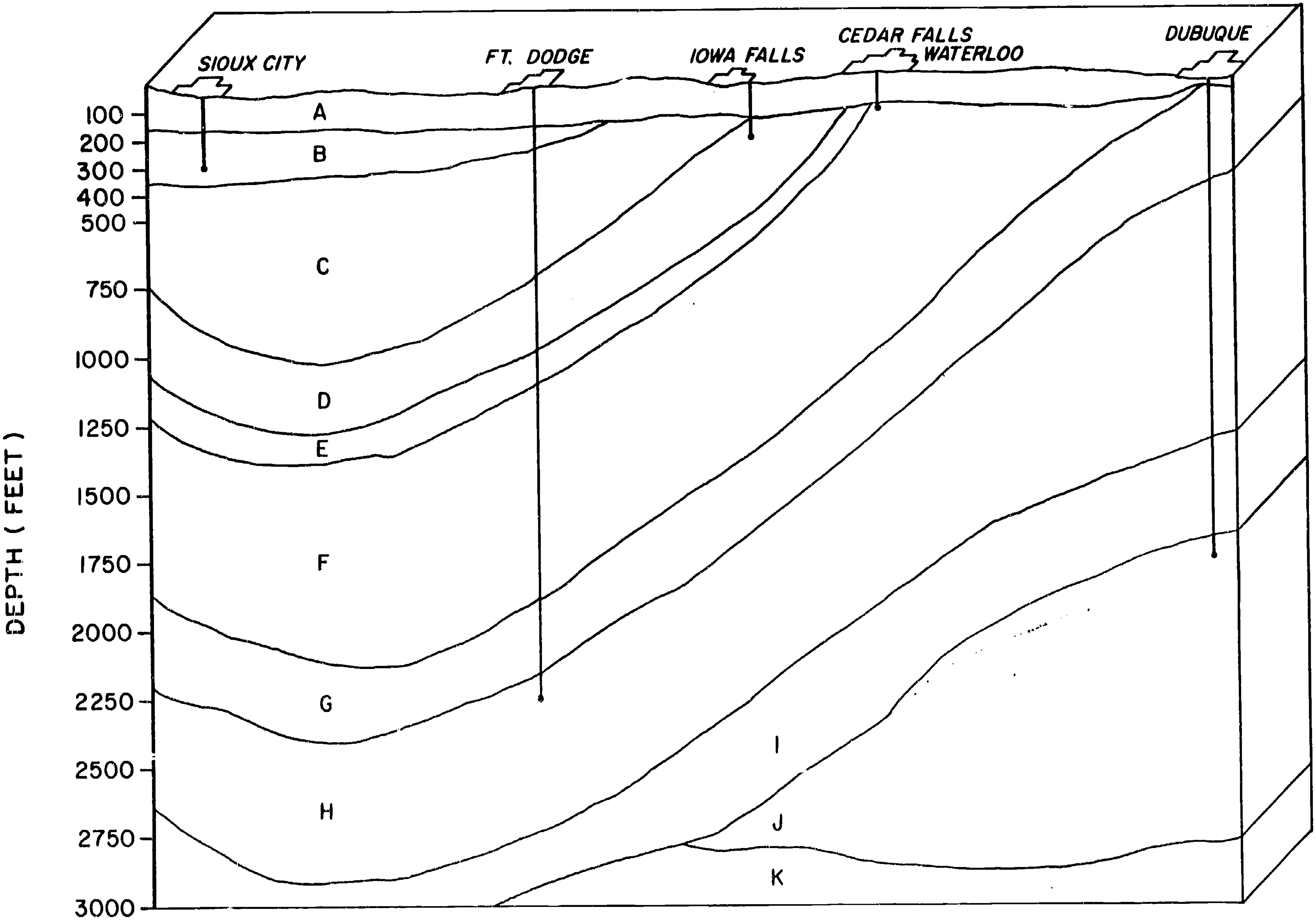
Ft. Dodge:

Dubuque:

Iowa Falls:

f. According to the diagram, which city's well might be most susceptible to contamination from people's activities? Why?

g. Water that has been in bedrock a long time often has many dissolved minerals in it. Although it is not a health hazard, this water may need softening or other treatment to improve its taste, odor, or color. According to the diagram, which well is most likely to have the biggest problem with dissolved minerals? Why?



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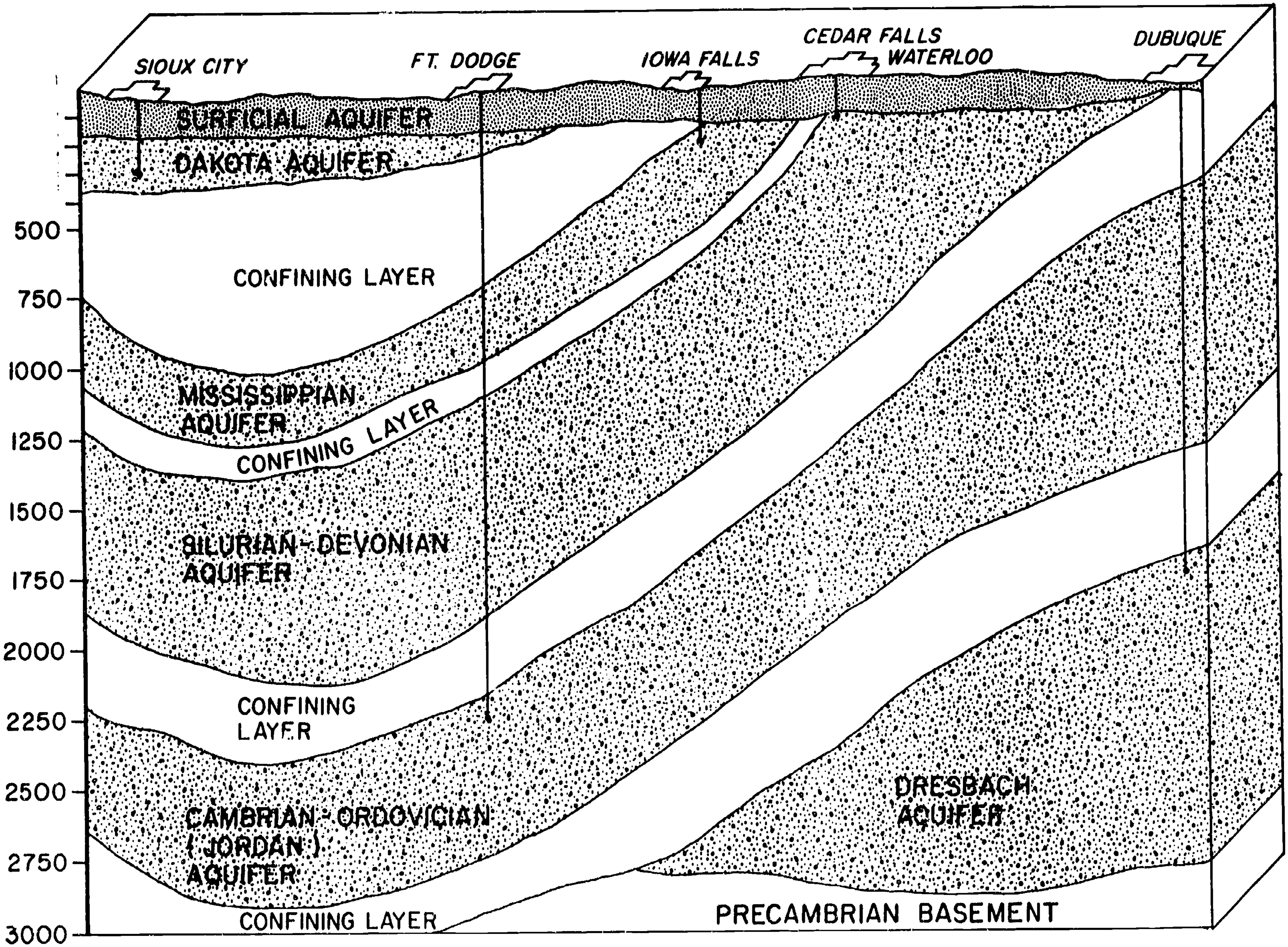
IOWA'S MAJOR AQUIFERS - worksheet



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IOWA'S MAJOR AQUIFERS - overhead

Investigating Water Use in Iowa

Earth/Life Science 1/2 class period

Quick Summary: Students will use a map of Iowa showing the total estimated water use (surface and groundwater) in 1985 and a pie graph of water use categories to answer questions.

Objectives: Upon completion, students will be able to:
1. Formulate conclusions on data about water use.
2. Interpret a map showing water use in Iowa.
3. Discuss critically the relationship between surface and groundwater use in Iowa.
4. De' mine how much water is being used in their county.
5. Compare water use in various counties in Iowa.

Materials:
Colored pencils.

Printed/AV Materials:
Teacher background: Table I-5. Estimated total water use (2 pages)
Figure I-5. Estimated total consumptive water use by category
Overhead: Estimated total water use by category in 1985 (answers)
Worksheets: Investigating Water Use in Iowa
Estimated total water use by category in 1985

Teacher Information:
Most Iowans depend on groundwater for drinking and many business uses. During 1985, a total of 1,010,000 million gallons (Mgal) of water was estimated to have been withdrawn from Iowa. Power generation for electricity accounted for 66% of the total withdrawals, nearly all of it from surface water. Nearly 80% of the surface water used in Iowa was by power generation plants on the border rivers. About 3% of the water used for cooling purposes in thermoelectric power plants was estimated to be consumed through evaporation. The other 97% was returned to the rivers. The worksheet shows the estimated total water use by county and by category.

Total consumptive use was estimated to be 178,000 Mgal. Consumptive water use is considered to be that part of the water withdrawn that is no longer available for future use. See Figure I-5 for the percentages of consumptive water use by category.

The water used for livestock and irrigation was considered to be 100% consumed and accounted for 49% of the estimated total consumptive water use. More than two thirds of Iowa's irrigation withdrawals occurred in the counties along the western border.

Domestic users were estimated to consume 40% of withdrawals. The public water supply category is the second largest use of water in Iowa. This category includes cities, towns, mobile home parks, housing associations, and rural water associations. Self-supplied domestic includes water used for household activities such as drinking, food preparation, washing, and watering lawns. About 26% of Iowa's population uses self-supplied water.

Commercial and industrial consumptive use was estimated to be about 13% of withdrawals. Self-supplied industry used water for manufacturing, processing, washing, conveying, condenser cooling, air conditioning, and sanitation. Although not included in these figures, public water supplies provided about one-fourth of industries' water needs. A few major users accounted for most of the water withdrawal in the self-supplied industrial category. The self-supplied commercial category includes hotels and other lodging places, recreational and amusement services, educational institutions, hospitals and governmental agencies.

The water consumed for mining processes is negligible.

Refer also to the hydrogeology background and Appendix D. Water Quantity Considerations in Iowa.

Procedure:

1. Have students complete the worksheets. More time should be spent interpreting the map in this activity than coloring the counties. Have students use the side of the colored pencil lead rather than the point to make the coloring process more efficient.

2. Discuss answers.

(1) After power generation, the next three highest water users are public water suppliers, self-supplied industrial, and livestock. (You may want to take this opportunity to compare these total withdrawals to consumptive water use by category shown in Figure I-5.)

(3)a. Answers will vary about the pattern of Iowa's water use. For example, the most use occurs along the border rivers and in highly populated areas. Rural areas such as south-central Iowa use the least.

b. Differences in counties' water usage are due to differences in population, sites of power plants, presence of industries or livestock yards, whether irrigation is needed, and other municipal or commercial uses.

c. Refer to the map to find how many million gallons of groundwater your county used in 1985.

d. Black Hawk County used the most groundwater in 1985.

e. Davis County used the least groundwater in 1985. Most of the groundwater used in this county was for rural homes (self-supplied domestic), and agricultural uses.

f. Woodbury County used the most water (combined surface and groundwater); largely due to power generation (95%), public water supplies (2%), industrial (1%), irrigation (1%), and livestock (9.5%).

Alternative:
Show the map of Iowa as an overhead and discuss it.

Extensions:
1. Students may be able to obtain the data about water use for their own community or well and compare it to the overall number. Interview a person in your local water treatment plant and present the interview to the class.
2. Students can see how much their household uses per day by checking their water meter or water bill.

4(

Table I-5. Estimated total water use
(All values are in million gallons;--value less than 0.01 million gallons.)

County	Agricultural	Self-supplied domestic	Self-supplied commercial	Self-supplied industrial	Irrigation	Mining	Power	Public-water supply	Total
	WATER USE CATEGORY								
Adair	745	150	--	--	--	40.2	--	175	1,110
Adams	394	98.6	--	--	--	51.1	--	110	654
Allamakee	912	256	--	117	--	--	73,200	453	74,900
Appanoose	303	266	--	--	--	21.9	--	1,170	1,760
Audubon	708	124	--	--	36.5	54.8	--	184	1,090
Benton	759	299	--	--	22.0	7.4	--	518	1,610
Black Hawk	460	270	3,670	3,440	190	2,760	285	6,240	17,300
Boone	480	266	3.7	--	7.3	--	--	861	1,600
Bremer	445	292	3.7	29.2	65.7	219	--	675	1,730
Buchanan	785	332	139	47.5	36.5	146	--	537	2,020
Buena Vista	756	190	--	--	98.6	14.6	--	1,700	2,760
Butler	678	230	475	--	94.9	840	--	358	2,680
Calhoun	417	146	--	--	54.8	3.7	--	321	943
Carroll	1,120	212	91.3	237	69.4	292	--	712	2,730
Cass	624	157	--	--	190	205	--	529	1,710
Cedar	792	256	--	11.0	3.7	58.4	--	398	1,520
Cerro Gordo	467	245	--	11.0	182	1,310	--	2,180	4,400
Cherokee	901	179	3.7	--	29.2	84.0	--	697	1,890
Chickasaw	540	226	--	76.7	285	14.6	--	409	1,550
Clarke	329	124	--	--	--	36.5	--	295	785
Clay	471	168	--	84.0	292	25.6	29.2	584	1,650
Clayton	1,380	336	--	183	--	14.6	--	378	2,290
Clinton	918	332	--	4,440	32.9	102	54,500	2,000	62,300
Crawford	974	230	--	237	69.4	69.4	--	697	2,280
Dallas	350	318	62.1	212	165	25.6	--	1,280	2,390
Davis	420	193	--	--	51.2	--	--	62.1	726
Decatur	378	142	--	--	--	54.8	--	161	734
Delaware	1,720	325	--	--	3.7	21.9	--	398	2,470
Des Moines	303	332	--	18.3	65.7	347	43,500	1,940	48,500
Dickinson	362	153	--	--	--	7.3	--	785	1,310
Dubuque	1,440	686	204	5,120	25.6	18.3	17,700	3,110	28,300
Emmet	277	113	11.0	11.0	54.8	25.6	--	391	883
Fayette	1,070	307	11.0	47.5	76.7	518	--	602	2,630
Floyd	384	212	21.9	774	139	3.7	--	701	2,220
Franklin	554	179	--	--	117	424	--	234	1,510
Fremont	299	117	1,420	40.2	756	--	--	223	2,860
Greene	376	131	--	--	241	73.0	--	383	1,200
Grundy	529	186	--	--	--	--	--	266	981
Guthrie	555	153	--	--	80.4	--	--	303	1,090
Hamilton	595	146	139	7.3	25.6	562	--	485	1,970
Hancock	511	186	51.1	168	102	172	--	303	1,490
Hardin	822	215	--	588	43.9	460	--	613	2,740
Harrison	402	219	--	--	3,630	332	--	445	5,030
Henry	482	215	--	--	--	14.6	--	584	1,300
Howard	500	172	--	--	14.7	646	--	183	1,520
Humboldt	284	120	--	--	29.2	920	985	295	2,630
Ida	648	110	3.7	--	32.9	69.4	--	245	1,110
Iowa	865	256	11.0	186	47.5	7.3	--	10,700	12,100
Jackson	883	318	--	21.9	14.7	76.7	--	507	1,820
Jasper	825	387	--	--	139	387	--	1,440	3,180

Table I-5. Estimated total water use *(cont.)*
(All values are in million gallons;--value less than 0.01 million gallons.)

County	Agricultural	Self-supplied domestic	Self-supplied commercial	Self-supplied industrial	Irrigation	Mining	Power	Public-water supply	Total
	WATER USE CATEGORY								
Jefferson	417	186	--	--	62.1	551	--	510	1,730
Johnson	967	489	204	7.3	32.9	1,070	13,100	4,400	20,300
Jones	883	281	--	197	14.7	25.6	--	365	1,770
Keokuk	876	175	--	--	7.3	139	--	252	1,450
Kossuth	945	292	--	292	110	40.2	--	540	2,220
Lee	613	409	3.7	44,600	186	362	--	2,770	48,900
Linn	555	704	--	1,980	150	205	37,600	9,650	50,800
Louisa	264	197	--	128	511	25.6	1,480	186	2,810
Lucas	252	146	7.3	--	--	--	--	518	923
Lyon	821	193	--	--	310	7.3	--	343	1,670
Madison	522	212	--	--	32.9	58.5	--	179	1,000
Mahaska	993	277	40.2	--	54.8	496	--	1,260	3,120
Marion	686	292	465	--	32.9	317	--	1,070	2,880
Marshall	529	281	270	--	25.6	1,430	263	1,840	4,640
Mills	321	161	--	--	715	--	--	292	1,490
Mitchell	624	186	--	--	124	95.0	--	230	1,260
Monona	460	146	73.0	--	6,730	54.8	--	314	7,780
Monroe	402	150	--	51.1	--	14.7	--	164	782
Montgomery	445	124	--	--	--	11.0	--	522	1,100
Muscatine	457	343	--	4,140	438	657	51,100	6,750	63,900
O'Brien	891	172	--	--	69.4	365	--	511	2,010
Osceola	417	117	--	--	347	62.1	--	193	1,140
Page	810	161	--	--	218	135	--	625	1,750
Palo Alto	464	142	--	--	883	157	--	343	1,990
Plymouth	1,370	321	--	--	452	215	--	799	3,160
Pocahontas	445	164	--	--	29.2	18.3	--	230	887
Polk	193	730	51.2	270	259	890	1,210	14,500	18,100
Pottawattamie	866	526	5,080	325	646	135	171,000	3,350	182,000
Poweshiek	733	204	--	--	22.0	274	--	617	1,850
Ringgold	465	106	--	--	14.7	--	--	512	1,120
Sac	858	168	--	--	179	98.6	--	372	1,680
Scott	536	507	11.0	299	25.6	511	4,270	7,160	13,300
Shelby	818	193	--	29.2	58.5	69.4	--	456	1,620
Sioux	1,790	350	--	21.9	1,360	135	--	1,170	4,830
Story	398	241	98.6	91.3	153	832	--	3,570	5,380
Tama	686	256	391	628	--	--	--	442	2,400
Taylor	474	117	--	--	--	7.3	--	178	776
Union	427	131	--	--	--	11.0	--	412	981
Van Buren	376	168	--	11.0	--	282	--	131	968
Wapello	336	292	--	14.6	--	--	1,470	1,850	3,960
Warren	482	485	29.2	--	76.7	--	--	613	1,690
Washington	953	245	--	--	14.7	131	--	493	1,840
Wayne	430	139	7.3	--	--	--	--	139	715
Webster	417	310	--	650	58.5	464	--	2,070	3,970
Winnebago	262	124	91.3	--	80.4	--	--	460	1,020
Winneshiek	1,250	343	--	18.3	22.0	47.5	--	496	2,180
Woodbury	1,040	248	318	2,040	2,420	110	190,000	4,420	201,000
Worth	208	146	--	--	73.0	873	--	139	1,440
Wright	314	135	405	142	36.5	18.3	--	518	1,570
Total	62,700	23,800	13,900	72[illegible]	24,600	22,900	662,000	128,000	1,010,000

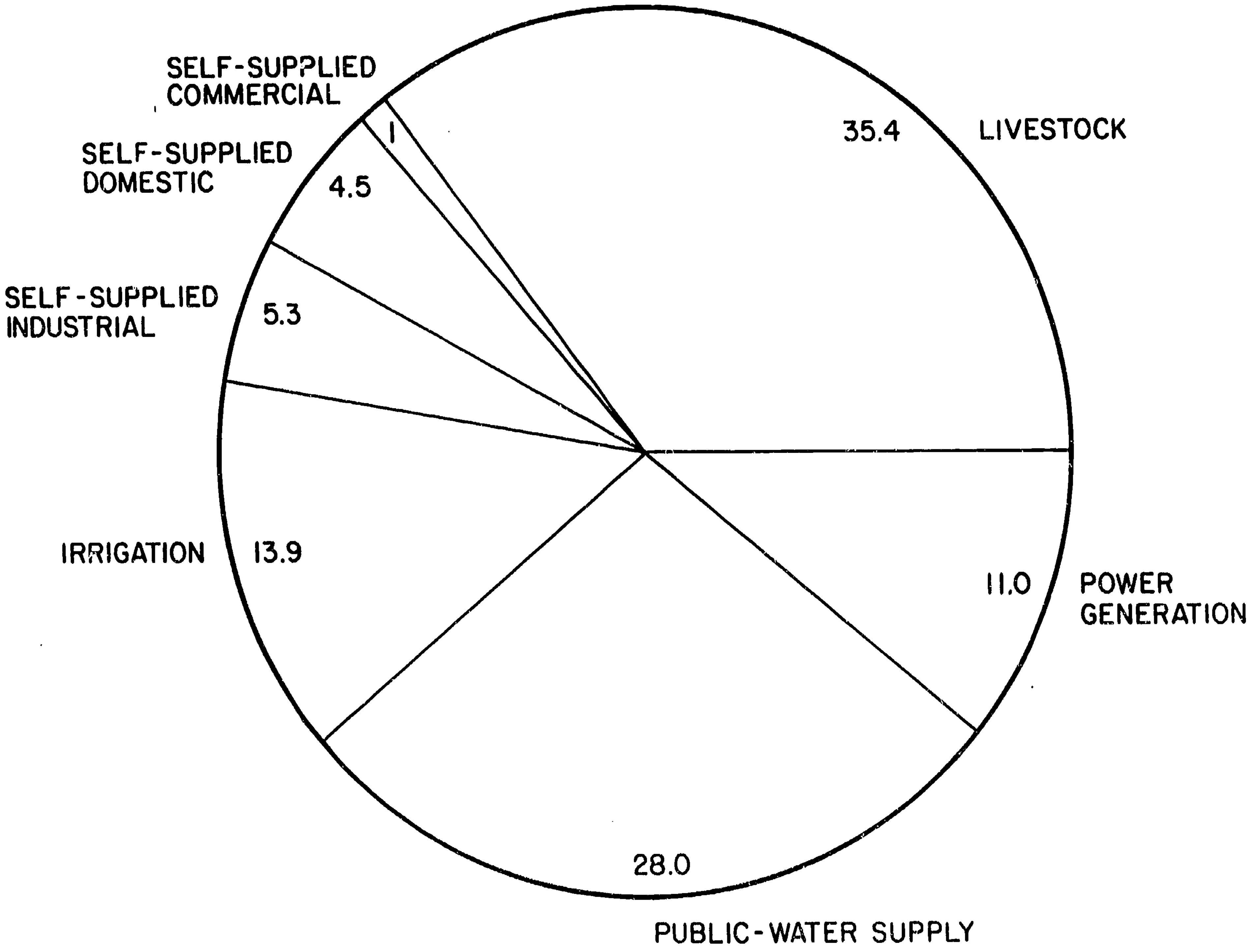
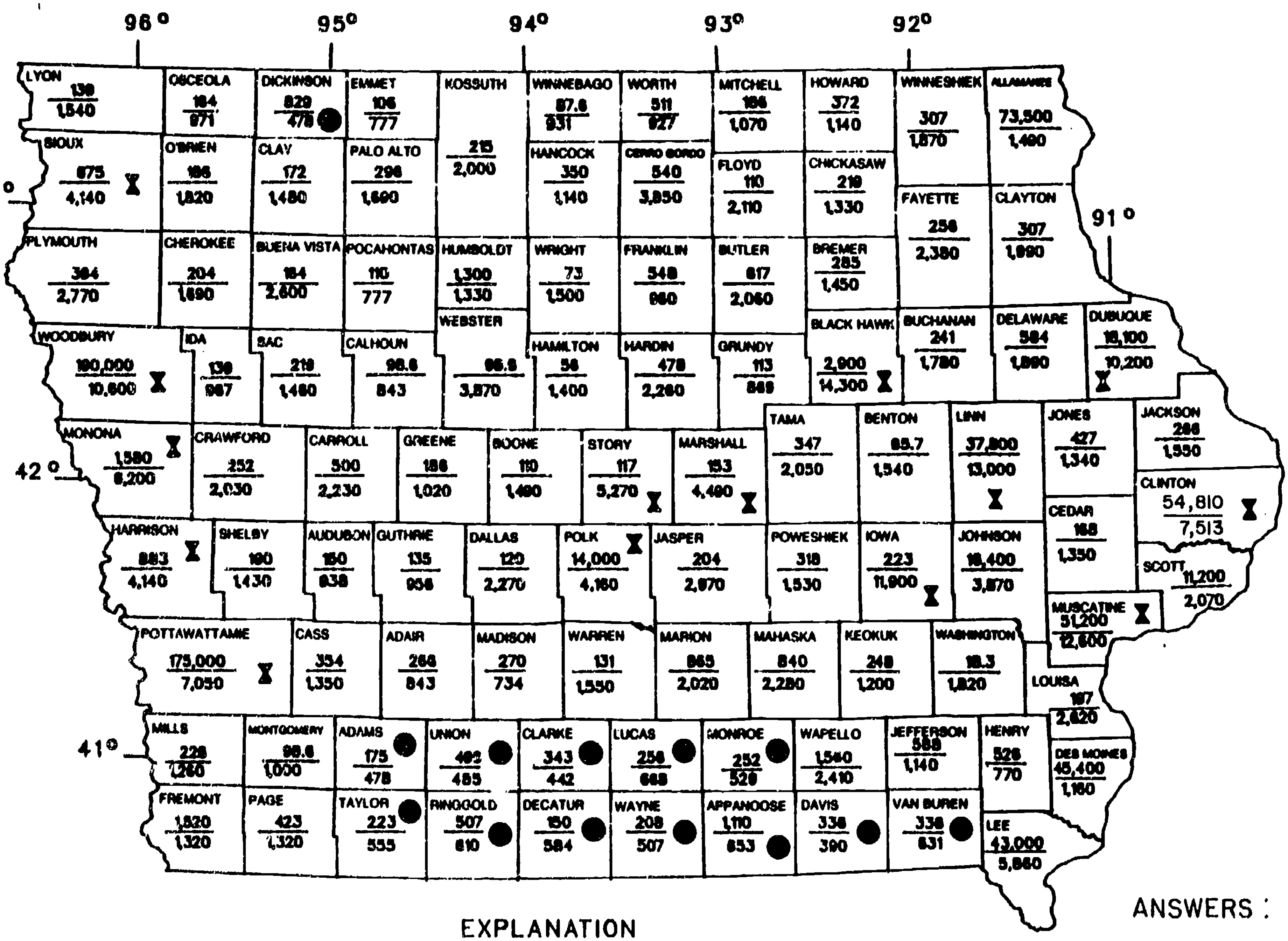


FIGURE 1-5 ESTIMATED TOTAL CONSUMPTIVE WATER USE BY CATEGORY (%)



ANSWERS :

EXPLANATION

1,520 SURFACE-WATER USE IN MILLION GALLONS
1,320 GROUND-WATER USE IN MILLION GALLONS

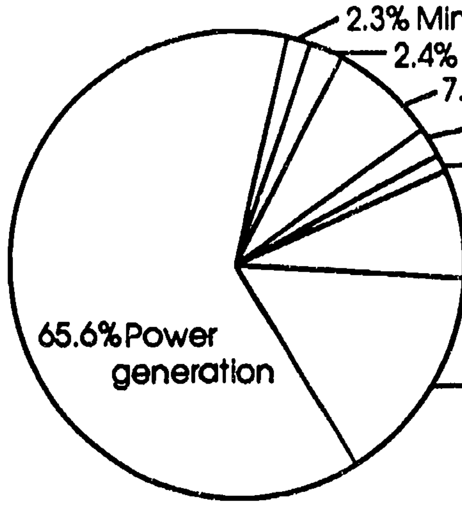
⧗ > 4000 Mgal Groundwater
● < 700 Mgal Groundwater

Overhead--Estimated total water use by county in 1985

Investigating Water Use in Iowa

Student Worksheet

Name________________________



Estimated Total Water Use By Category

1. Refer to the pie graph above. Power generation withdraws the most water of any category in Iowa. However, 97% of this water is returned to rivers for future use. What are the next three highest water use categories (in order)?

2. Refer to the map of Iowa showing water use in each county.
   a. Color the counties yellow that used more than 4000 Mgal of groundwater (the bottom number) in 1985.
   b. Color the counties green that used less than 700 Mgal of groundwater in 1985.

3. Answer the following:
   a. Describe the arrangement or pattern of water use in Iowa.

   b. Why are there such great differences in water usage from county to county?

   c. How many million gallons of groundwater did your county use in 1985?

   d. Which county used the most groundwater in 1985?

   e. Which county used the least groundwater in 1985?

      How was most of the groundwater probably used in this county?

   f. Compare the groundwater use to surface water use. Which county uses the most water (combined surface and groundwater)?

      Why do you suppose its water use is so high?

5?

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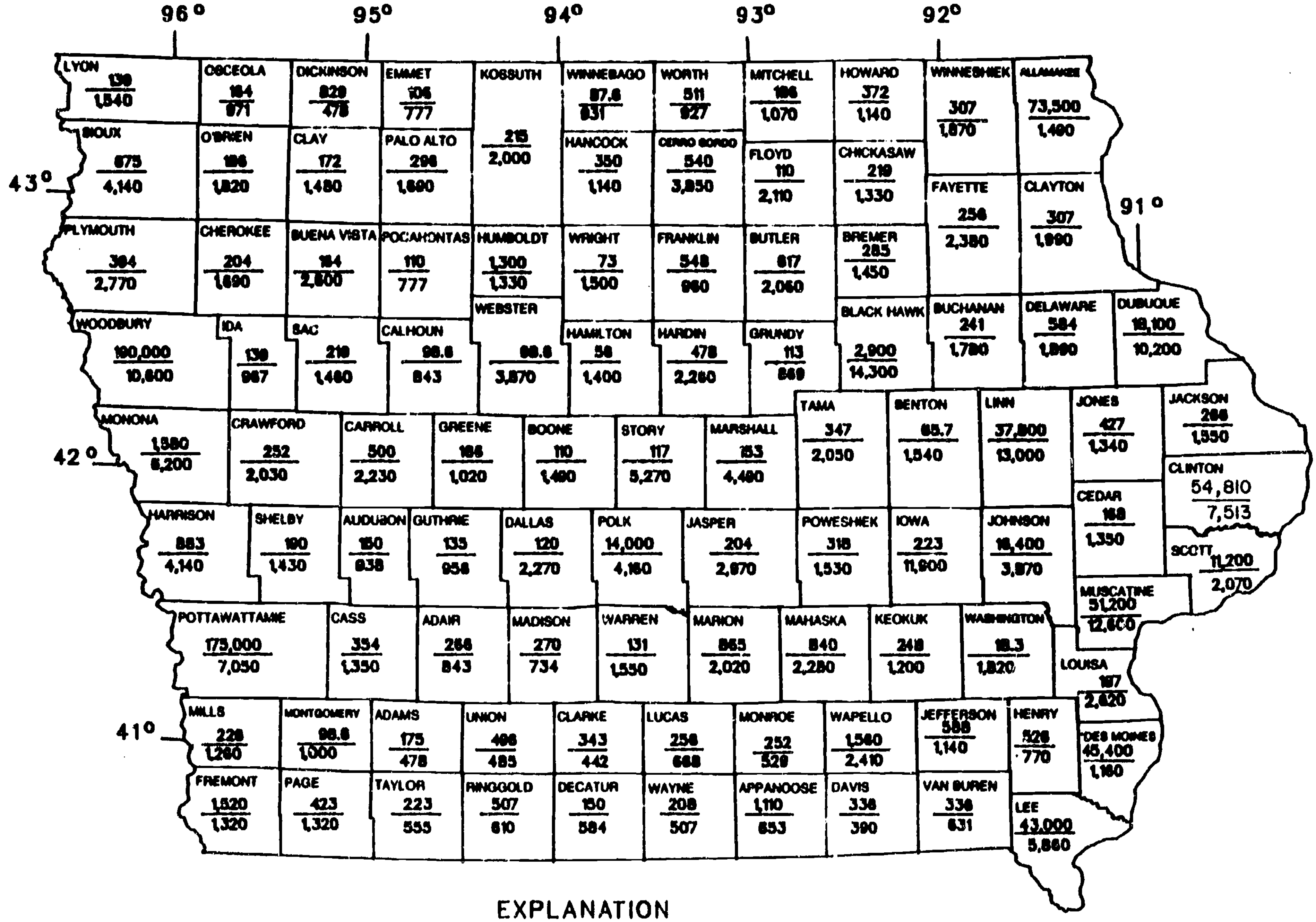


EXPLANATION

1,520	SURFACE–WATER USE IN MILLION GALLONS
1,320	GROUND–WATER USE IN MILLION GALLONS

Worksheet—Estimated total water use by county in 1985

Figure II-1. Agricultural use of nitrogen fertilizers

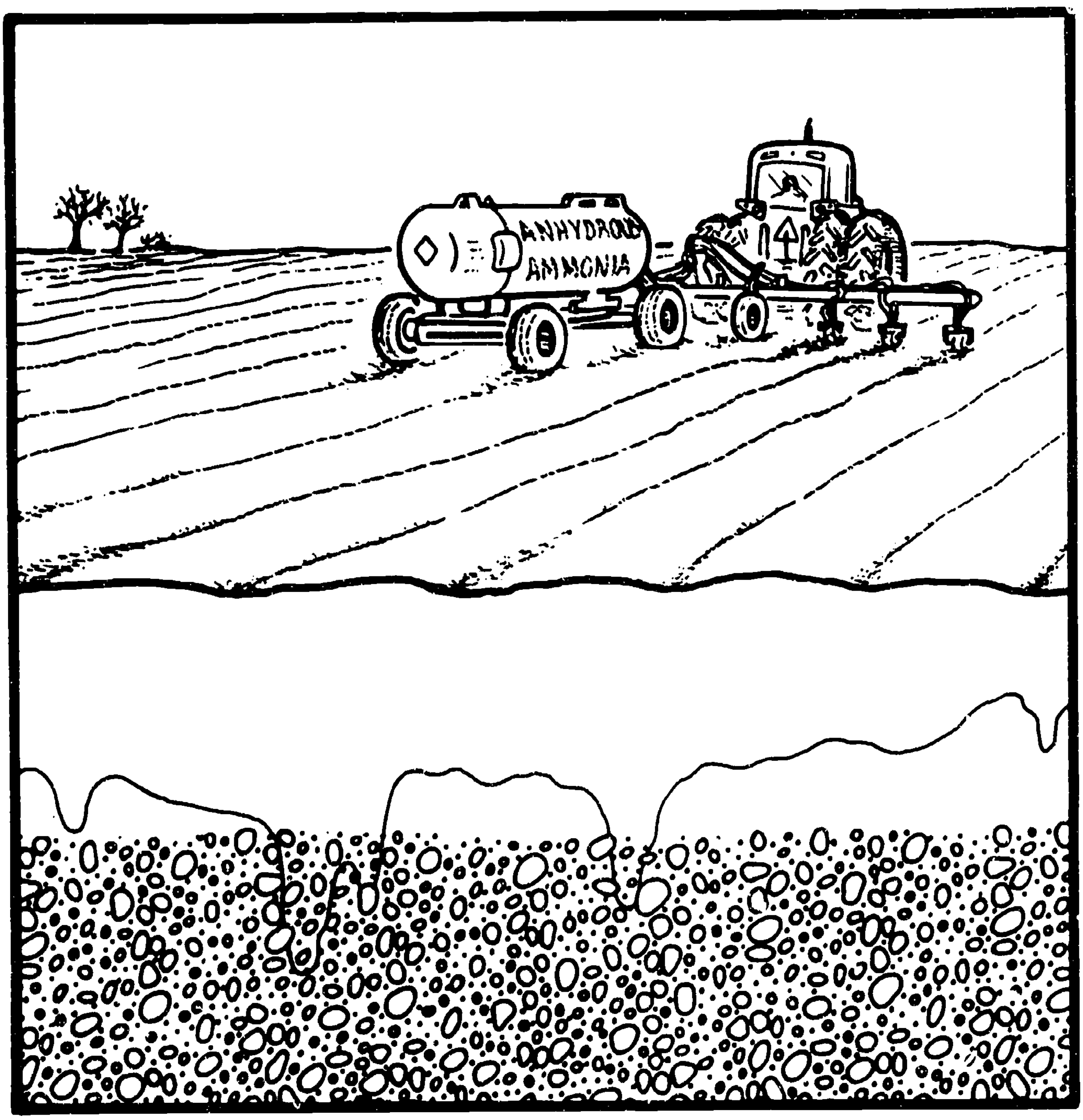


Figure II-2. Agricultural use of pesticides

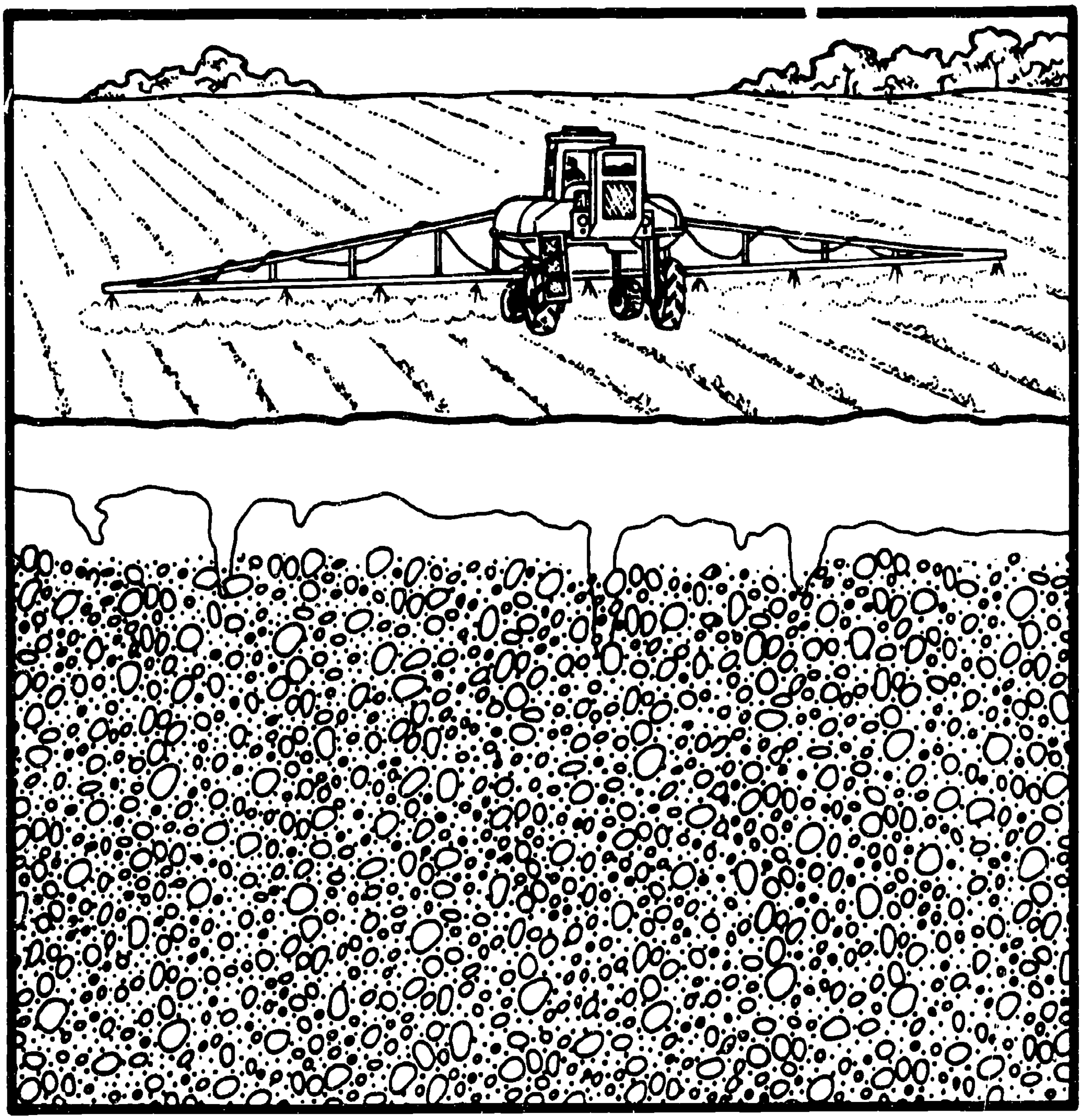
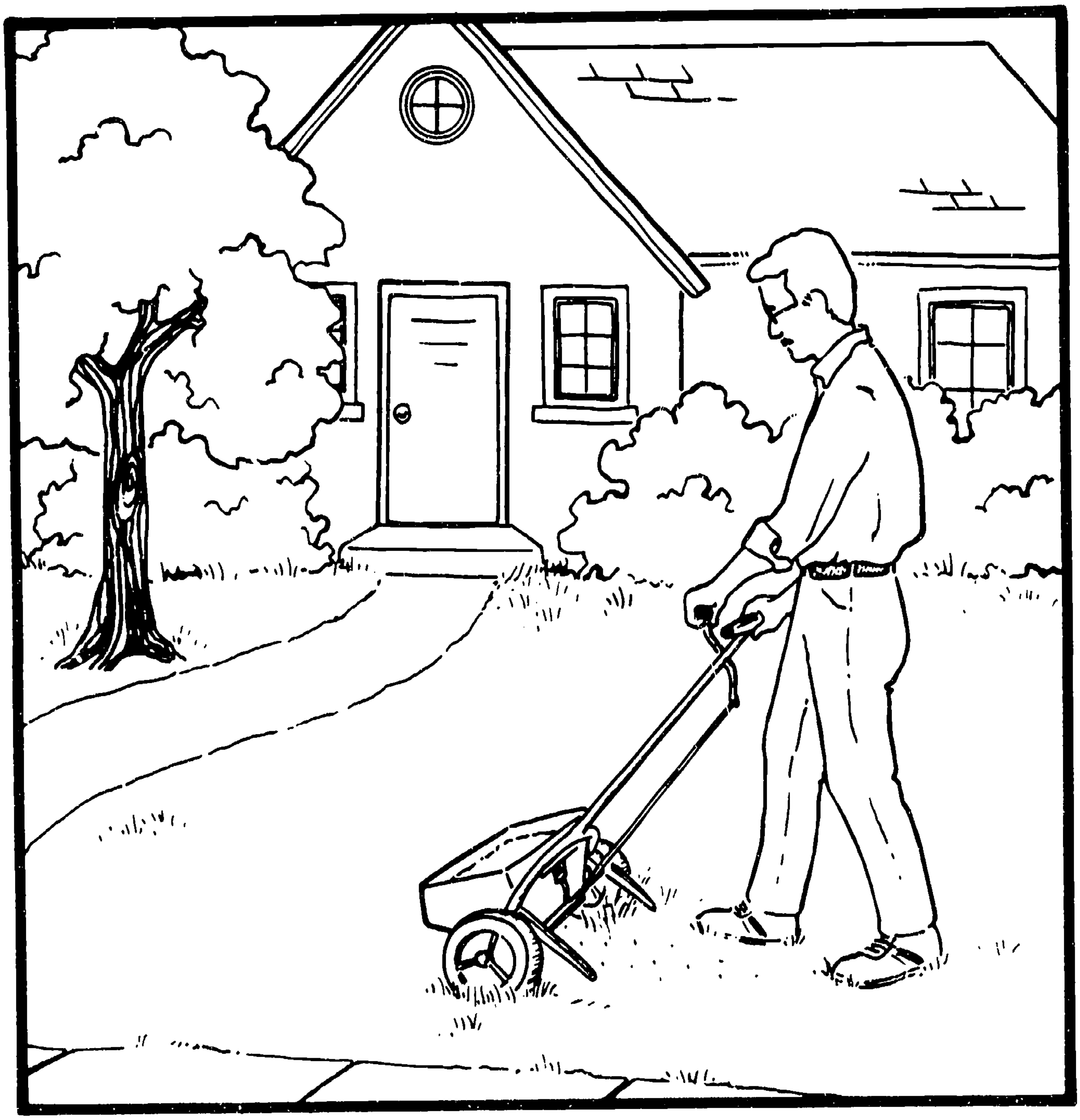


Figure II-3. Urban use of fertilizers and pesticides



II. CHEM: Fertilizers And Pesticides

OBJECTIVES

Upon completion, students will be able to:

1. Describe the current use and benefits of using nitrogen fertilizers and pesticides.
2. Analyze trends in ag-chemical use and the presence of ag-chemicals in groundwater over the past 40 years.
3. Describe health effects of drinking water contaminated with nitrates or pesticides.
4. Evaluate practices that could reduce the amount of ag-chemicals in groundwater and save money and energy.
5. Compare the agricultural and urban use of fertilizers and pesticides.

BACKGROUND INFORMATION

The routine use of agricultural chemicals on 60% of Iowa's land has resulted in increased contamination of shallow groundwater resources. This problem is not like pollution from hazardous waste sites or dumps which generally come from local, identifiable sites, or **point sources.** Although nitrates and pesticides can contaminate groundwater from a single point source (such as from spills, abandoned wells, agricultural drainage wells or sinkholes), Iowa studies show that individual on-site problems play a minor role. Ag-chemicals affect such broad areas that cleanup is impossible. The only efficient way to deal with these diffuse, **nonpoint source** pollution problems is prevention.

Although most contamination is now found in shallow aquifers, it is possible that deep aquifers could also become contaminated. Because ag-chemicals have been used extensively for only about twenty years, there has not been enough time for them to reach some of the deeper aquifers.

Iowa Research

> Groundwater contamination is a draining problem.

Ongoing groundwater studies in Iowa have become nationally recognized. The Big Spring Basin, a 100 square-mile site in northeast Iowa near Elkader, offers a unique opportunity as an outdoor laboratory. Nearly all of the groundwater from the basin comes out at the Big Spring. Therefore, the amount of groundwater and chemicals moving through the region can be measured. Also, all of the basin's land use is agricultural, and the results are not complicated by other sources, such as municipal or industrial wastes. The Big Spring Basin is not unique, however, in its severity of contamination. Ag-chemicals are contaminating groundwater throughout Iowa and much of the country.

Energy Considerations

Reducing the use of fertilizers and pesticides has many benefits for energy conservation. Natural gas is used in the production of nitrogen fertilizers, and pesticides are made from petroleum-based products. Much energy is used in producing, packaging, transporting and applying agricultural chemicals. Less tractor fuel is used with fewer ag-chemical applications.

The costs of energy and energy-consumptive materials such as fertilizers and pesticides are the largest non-land variable costs in grain production in Iowa. Tillage, harvest and grain drying procedures account for the greatest on-farm energy consumption. However, fertilizer (from production through application) accounts for the largest single component of energy consumption in grain production, amounting to 35 to 40 percent of direct energy used. Tillage operations account for

12 to 15 percent and pesticides for 5 to 10 percent of energy consumed. In relation to production costs, fertilizer accounts for approximately 20 percent, fuel 18 percent, and pesticides 5 to 10 percent of non-land costs.

A variety of practices can be used to reduce energy costs of fertilizer and pesticide use. Even now, for example, it is reasonable to expect that we can reduce fertilizer-nitrogen losses by 10 to 20 percent, resulting in savings of at least an equivalent of 25 to 50 million gallons of diesel fuel.

Nitrates

While private farm wells are the most susceptible to nitrate problems, public water supplies also are affected. In 1987 about 50 of Iowa's 2000 public water supplies exceeded the maximum contaminant limit for nitrate in drinking water. Many others have had to blend water from different sources in order to meet health standards.

Data from the Big Spring Basin show that **nitrates in groundwater have increased in direct proportion to the increased use of nitrogen (N) fertilizers.** This trend is seen throughout the state where 28% of all samples tested by the University Hygienic Laboratory exceeded the maximum contaminant level for public water supplies. In northwest Iowa, however, 40 to 70% of the samples exceeded this limit. Potential sources of nitrogen in groundwater (and their relative contributions) are shown in Figure II-4. Commercial fertilizers supply much more nitrogen to groundwater than municipal sludge, manure, septic tanks, legumes, or rainfall. This increase is further magnified by the fact that commercial fertilizer is used on more acres than other sources of nitrogen.

Between 1/3 and 1/2 of N-fertilizer applied to crops is lost. This loss is substantial - amounting to about $200 million in Iowa annually. Although not all of this lost fertilizer goes to groundwater, over-application of fertilizer has been a significant economic loss to Iowans.

Iowa's economic loss from excessive use of commercial fertilizers is compounded when **energy factors** are considered. Iowa imports nearly all of its energy which means that millions of Iowa dollars are exported each year. Using less fertilizer results in less energy used in manufacturing. Because natural gas is used in the production of nitrogen fertilizer, this nonrenewable energy source can be conserved. Also, with fewer applications of fertilizer, less fuel is used by tractors.

Short-term (acute) health hazards from nitrates in drinking water are restricted to "blue baby" syndrome (methemoglobinemia). This affects young infants whose formulas are prepared with nitrate-contaminated drinking water. Nitrates cause a reaction which reduces the blood's ability to carry oxygen which causes the baby's skin to turn blue. This disease, if undiagnosed, can be fatal, but is easily corrected once identified.

Long-term (chronic) effects of nitrate in drinking water are less well-understood. Experimental studies with laboratory animals have suggested relationships between nitrate consumption and the following: mutations in cells, certain cancers, and birth defects.

Note: The maximum contaminant level for nitrates in public water supplies may be expressed in two ways:

–45 mg/l NO_3 (total nitrate) or

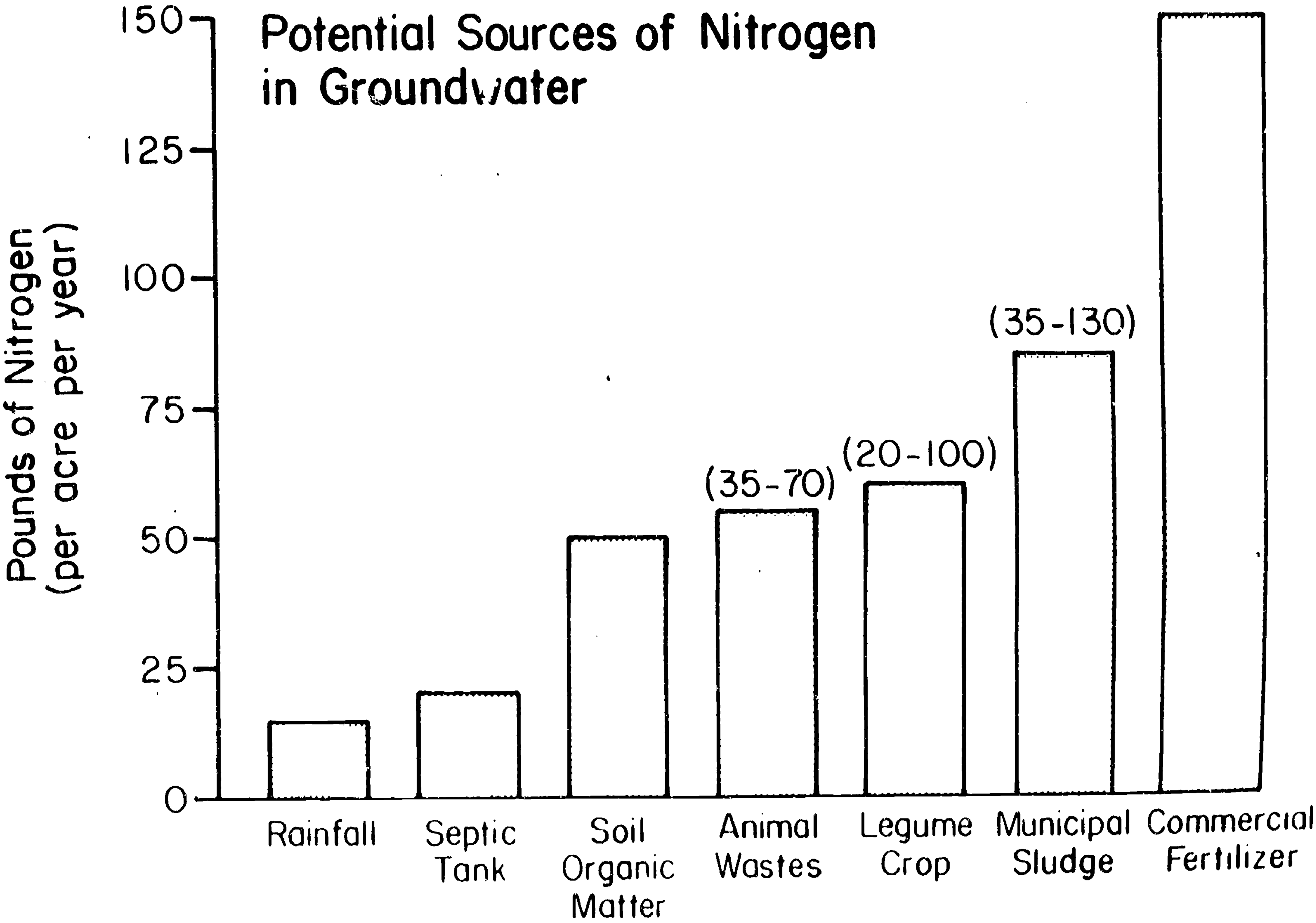
–10 mg/l NO_3-N (nitrogen <u>in</u> nitrate).

Also, milligrams per liter (mg/l) is the same as parts per million (ppm).

Pesticides

Pesticides are chemicals used to destroy, control or repel unwanted plants or animals. Pesticides include herbicides (to kill weeds) and insecticides (to kill insects) as well as chemicals to control fungi, rodents and algae.

Figure II - 4.



Potential Sources of Nitrogen in Groundwater
Pounds of Nitrogen (per acre per year)
150
125
100
75
50
25
0
(35-70)
(20-100)
(35-130)
Rainfall
Septic Tank
Soil Organic Matter
Animal Wastes
Legume Crop
Municipal Sludge
Commercial Fertilizer

The **use of pesticides** to control both plant and animal pests has increased greatly in the past few decades. Iowa uses more pesticides than any other state in the country. While losses of pesticides to groundwater are small in comparison to nitrate loss, the financial loss still amounts to several million dollars annually. Of potentially greater concern are the health effects which may be associated with long-term exposure to small quantities of pesticides in drinking water. Also unknown are the synergistic effects of several pesticides.

> Each day Americans produce 4 million pounds of pesticide; 2.7 million pounds a day is spread on this country.

Pesticide contamination is present in many shallow wells and some municipal wells. At least 72% of the state's population consumes low concentrations of pesticides in their drinking water at some time during the year. By far the greatest risk is shared by farmers and commercial workers who supervise and apply these chemicals. Current programs provide education and certification for these workers to assure that pesticides are managed and applied in the safest possible ways.

Longer-term effects of exposure to low levels of pesticides in groundwater are not so clearly understood. Studies have suggested potential links between pesticide exposure and the following:

--cancer
--genetic effects
--birth defects
--infertility

More research is certainly called for to clarify the long-term effects of these chemicals. Meanwhile, because these chemicals are made to kill living things, common sense suggests that exposure to any pesticide should be as limited as possible.

Agricultural vs. Urban Use

Urban households use only 2% of the pesticides used in Iowa, although the urban application frequency may be greater. The greatest risk in urban areas may be due to direct contact with pesticides by children and pets in lawns where sprays have not dried thoroughly. Another problem is that homeowners are generally the least prepared to use pesticides. Farmers and commercial lawn care applicators must be licensed to use some pesticides, and they receive annual training.

Best Management Practices

Refer to the information sheet after the references.

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In addition to protecting groundwater from contamination, best management practices must consider several other factors, including: economics, soil erosion, labor use, risk, level and skill of the manager, and government programs. There is no simple answer that will solve the problem for all farms. It will take a combination of practices tailored to each farm.

1. Some Ways to Reduce Use of Commercial Nitrogen Fertilizer and Maximize Profit

A. Set realistic yield goals based on county soil surveys. By setting yield goals based on how much each soil is able to produce instead of what a farmer hopes for, less fertilizer will be wasted. Both the type of soil and amount of erosion affect crop yields. Soil surveys are available in the Soil Conservation Service (SCS) office in each county.*

B. Credit other sources of nitrogen, such as manure, legumes (bean crops and forages like alfalfa that have been used in crop rotation) and sewage sludges. When these contributions are considered, less commercial fertilizer is needed. For example, a corn crop planted after alfalfa may need no extra fertilizer.*

C. Do not apply nitrogen fertilizer in the fall. Farmers often like to put fertilizer on the fields in the fall in case it is too wet to apply it in time in the spring. However, much of the fall-applied nitrogen often leaches away from the plants before it can be used. (If nitrogen is applied long before the crops can use it, applying it in ammonium forms, such as anhydrous ammonia, can help reduce losses. Because ammonium fertilizers tend to stick to clay particles in the soil, the risk of leaching is reduced.)

D. Sidedress nitrogen (instead of preplant). By putting the nitrogen along the side of each row after the plants have come up, less is needed than when nitrogen is spread on the whole field before crops are planted. It is available when the plants need it, and where they need it--only along the row instead of spread over the whole field. However, there are energy costs in having to make another trip over the fields.

*(For actual recommendations for amounts of nitrogen, refer to the following publications available from Iowa Cooperative Extension Service, Iowa State University, Ames, Iowa 50010: (1) Best Management Practices to Improve Groundwater Quality in Iowa, (2) Establishing Realistic Yield Goals (Pm-1268), (3) Crop Rotations: Effect on Yields and Response to Nitrogen (Pm-905), and (4) Animal Manure: A Source of Crop Nutrients (Pm-1164).

> "Clean farming, to be sure, aspires to rebuild the soil, but it employs to this end only imported plants, animals and fertilizers. It sees no need for the native flora and fauna that built the soil in the first place. Can stability be synthesized out of imported plants and animals? Is fertility that comes in sacks sufficient? These are the questions at issue."
>
> Aldo Leopold

2. Some Ways to Protect Groundwater from Pesticides and Maximize Profit

A. Reduce pesticide use and nonpoint pollution. Putting less pesticides on fields means less chemicals will move through the soil and into groundwater. Using less pesticide also means saving money. Some farmers are finding they can make a bigger profit with less chemical application and with the same or slightly smaller yields. "Nonpoint" means that the pollution does not come from only one source but is from a widespread area.

1. Band pesticides. Applying pesticides in a narrow band along a row uses less chemical than broadcasting it over a whole field. This also puts the chemical where it is needed most and works well with a ridge till system.

2. Ridge till. This method of farming involves making a ridge of soil for each row of crops. Pesticides placed in a band on top of the ridge may be less susceptible to leaching and more available for decomposing.

3. Cultivate weeds on level ground. Tearing up weeds in between the rows (cultivation) often works well alone or with banding pesticides. However, this is not a good alternative on slopes where erosion could be a problem.

4. Rotate crops. Changing crops from year to year results in better insect, weed, and disease control. Other benefits include improved soil, supply of legume nitrogen for other crops, better water infiltration and less erosion, less economic risk due to diversity and better labor distribution. Rotations best control pests that must live in a specific plant and cannot go dormant for a long time.

5. Check for pests. Integrated Pest Management (IPM) scouting techniques can be used to see what kind of "bugs" are in the field and if there are enough to warrant paying for pesticides. Then pesticides are only used if needed.

6. Calibrate sprayers accurately. To avoid wasting pesticides and to apply them evenly, calculations must be made carefully for things like flow rate of the sprayer nozzle, ground speed of application equipment, and amounts of pesticide and water.

7. Read and follow label directions. This involves finding the right product to use in the right place and at the proper rate. Groundwater warning statements are required on labels of pesticides that have been frequently found in groundwater. These products are moderately soluble in water and do not stick to soil very well. The label warns against using them on sandy soils when the groundwater is close to the surface. Products which have groundwater label warnings include atrazine, Bladex, Princep, Lexone/Sencor, Lasso, Furadan, Temik, and Tordon.

B. Control pollution through direct routes. To prevent chemicals from going directly into wells, ag-drainage wells or sinkholes, careful handling and other practices are needed.

1. Use anti-backsiphon devices. Backsiphoning can occur when filling sprayers or when applying chemicals through irrigation systems. If the chemical flow is accidently reversed, it can go directly into the aquifer and never be totally removed.

2. Construct dikes and pads. These are required for bulk storage of pesticides and fertilizers and/or where pesticides are mixed and loaded (which includes most commercial pesticide dealers and custom applicators and some farmers). They are recommended for all farms to prevent spills and rinsate from contaminating groundwater and to allow reuse of the spilled product.

3. Do not mix or store chemicals near wells.

4. Dispose of pesticides and containers safely. Empty pesticide containers should be triple rinsed and taken to a sanitary landfill. Rinsate should be applied to fields. Rinsate and extra pesticides should not just be dumped on the ground, especially near wells.

5. Grass filter strips around sinkholes or ag-drainage wells can trap pesticides to reduce contamination of groundwater. Similar strips along field edges can prevent surface water contamination.

3. Urban Agrichemical Use (Best Management Practices, continued)
(from "Cutting Back on Pesticides and Fertilizers: What You Can Do," Journal of Freshwater 1988, page 32)

A. Prevent Weeds and Pests

1. The most effective way to control weeds in your lawn is to develop a dense grass cover. The way you mow and water your lawn will affect the number of weeds in your yard.
2. Soaking your soil occasionally to a depth of 4-6 inches will result in deep-rooted grass.
3. To control weeds, mow grass carefully but leave grass as high as three inches or more. Grass left high will keep weeds and crabgrass out by robbing them of sunlight.
4. Never cut more than one-third of the total length of the grass at one time.
5. To avoid household pests, remove food and water sources from your home.
6. Avoid leaky faucets and standing water in trays under houseplants, which can attract pests.
7. Keep flour, cereals and grains in tightly sealed plastic or glass containers.

B. Consider Safer Alternatives

1. Instead of using pesticides in your garden, consider hand-picking pests from plants, or spray with warm soapy water to wash insects off plants.
2. To keep pests away from your plants, surround them with "collars" made of stiff paper, heavy plastic or tar paper.
3. To protect seedings from chewing insects, use fine netting such as cheesecloth.
4. Alternatives to insect sprays include fly swatters, flypaper and window screens.
5. Use boric acid to control cockroaches, which are often resistant to pesticides.
6. Remove and destroy insect and rodent nests.
7. Use caulk to seal cracks and crevices.
8. When mowing, leave the clippings on the grass. Clippings add nutrients to the soil, serving as a natural fertilizer.

C. Buy with Care

1. Choose the least-toxic product that will achieve the results you want, and buy only as much as you need.
2. Contact a University Extension Service or the Department of Agriculture for more information about specific products.
3. Avoid buying pesticide and fertilizer combinations. You probably don't need all of the chemicals in the mixture.
4. Before purchasing pesticides, determine what kind of pest is causing the problem and buy the appropriate chemical. An herbicide that will kill dandelions probably will be ineffective against crabgrass.
5. If you decide to hire a lawn care company, encourage the company to use chemical-free pest control measures and the least-toxic products available.

D. Use Chemicals Safely: More is Not Better

1. For pesticides, follow the directions on the label and do not overapply.
2. Apply pesticides only where pests can be seen.
3. Limit herbicide use to weedy areas of your lawn.
4. For fertilizers, have your soil tested to determine which nutrients are lacking, and fertilize according to test recommendations.
5. If possible, buy and use only low-phosphorus fertilizers.
6. Water your lawn after fertilizing, but do not allow the water to run into the street -- it eventually gets into the water.
7. Do not apply fertilizer near lakes and streams.
8. Never apply fertilizer on frozen ground.
9. When fertilizing a new seeding work the fertilizer into the soil during seedbed preparation.

E. Use Up Leftover Chemicals

1. Using up leftover chemicals is the safest way to dispose of them.
2. If you can't use them up, give them to someone who can.
3. Make sure you dispose of leftover pesticides properly. Do not throw pesticides into the trash, burn them or dump them on the ground or down a drain.
4. Bring leftover chemicals to a household hazardous waste collection site if your community has one. Otherwise, store the pesticide in a clearly labeled, sealed and secure container until your community holds a collection.

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Nitrates in Iowa's Groundwater

Earth/Life Science 1 Class Period

Quick Summary: Students will test water for nitrates, interpret graphs about nitrate contamination and discuss the problem of nitrates in Iowa's groundwater.

Objectives: Upon completion, students will be able to:
1. Analyze tr...ds in nitrogen fertilizer use and the presence of nitrates in groundwater over the past 40 years.

Materials: None

Printed/AV Materials:
Information: Drinking Water Analysis from Hygienic Laboratory
Worksheets: Nitrate Testing
Nitrates in the Big Spring Basin Study
Overhead: Map of High Incidence of Nitrate Contamination

Procedure:
1. Find out what the nitrate levels are for various local sources of drinking water (such as the school, municipal water, and private wells) by using one of the following methods, and have students complete the Nitrate Testing worksheet.

a. Have students test different sources of drinking water for nitrates. Simple Hach kits can be obtained from some AEA's or purchased from Hach Chemical Company.

b. Use the Request For a Water Sampling Kit form on a following page to have the University Hygienic Laboratory perform the water test.

c. Obtain data from your local county extension office or water treatment plant.

Answers:

a. (depends on test results)

b. No, if test is less than 45 ppm NO_3 (or 10 ppm NO_3 -N). If it is more than 45 ppm, infants under six months old could become "blue babies" (a condition called methemoglobinemia). A baby's stomach chemistry is different because it does not eat solid foods. That allows bacteria to be in the stomach that can change nitrate to nitrite which prevents the blood from picking up oxygen to carry to the body. Thus the baby's skin turns blue, just as if it couldn't breathe.

c. No, nitrate occurs naturally in clean water, but it does become dangerous in large amounts. However, some other chemicals (like lead) are toxic even in small amounts.

d. The nitrates not used by the corn plants, dissolve in the water, and can run off with rain or melting snow, or soak into the ground.

e. #2. Dry spring week is best. Most of the fertilizer applied in the fall is lost by the time crops are planted and ready to use it. Wet weather could carry some of the nitrate away before it could be used by the corn plants.

2. Have students complete the Nitrates in the Big Spring Basin Study worksheet and discuss the answers.

a. Nitrates in groundwater have increased dramatically over the past twenty years.

b. Nitrogen fertilizers are the probable source of the nitrate contamination in the groundwater because the slopes of the increase in fertilizer use and the increase in nitrate levels are very similar. The slope of the manure line shows relatively little variation by comparison. Refer also to Figure II-4 in the unit background information.

c. Some nitrate was present in the groundwater during years before the common use of fertilizers. This nitrate is probably from the soil, legumes, and manure. Although manure is not the primary cause of the total nitrate contamination, it does contribute to the problem.

d. This question leads students to the next activities in this unit. For specific ways to reduce nitrate contamination of the groundwater, refer to best management practices in the unit background information.

3. Discuss and review the nitrate contamination problem in Iowa, including benefits of using nitrate fertilizers and health effects of nitrates in drinking water. (Refer to the unit background information.) Use the overhead: Map of High Incidence of Nitrate Contamination to discuss the severity of the problem in Iowa. The map shows how widespread nitrate contamination is in Iowa and shows some areas with severe problems. Note that this data is for private wells that are less than 100 feet deep. There are many factors which affect nitrate levels in groundwater, but the most likely explanations for concentrations in northwest and southern Iowa are the types of wells and the surficial geology. Most of the wells in this area are shallow wells (often in alluvial aquifers). Also the soil in this area is a type which allows water-soluble nitrates to leach through more easily.

Extensions:

1. Show the last half of the 60-minute video tape, Riders of the St m, which features nitrate problems in Iowa and Nebraska. (The first half discusses nonpoint pollution problems in Chesapeake Bay.) This can be ordered for a small loan fee from Soil and Water Conservation Society, 7515 N.E. Ankeny Road, Ankeny, Iowa 50021. (515) 289-2331.
2. Find newspaper articles about local water quality problems.

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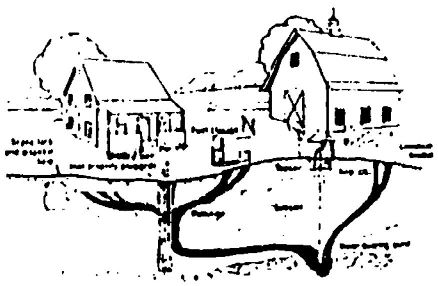
Private well owners can protect their drinking water supply by performing a routine maintenance check on the water system and correcting any structural defects that may allow surface or shallow subsurface contamination to enter. Assistance may be available from county health departments, extension services and reputable well drillers. Part of the routine maintenance check should include a yearly water test for coliform bacteria and nitrates.



Two Primary Tests for Drinking Water Safety

Coliform bacteria are a group of microorganisms that are normally found in the intestinal tract of humans and other warm-blooded animals and in surface water. The presence of coliforms in a drinking water supply indicates contamination from surface or shallow subsurface sources such as barnyard runoff, septic or cesspool leakage or other source. The presence of coliform bacteria also suggests that disease-causing (pathogenic) organisms may enter the drinking water supply in the same manner if preventive action is not taken. Drinking water should be free of coliforms. The coliform test is easily performed in a certified laboratory and is a reliable indicator of bacterial contamination.

Nitrates, when ingested in sufficient amounts, pose a health risk to infants under six months of age by reducing the oxygen-carrying capacity of the blood. The resulting life-threatening disease is called "blue baby" syndrome or methemoglobinemia. Nitrate concentrations exceeding the drinking water standard of 45 mg/L (as NO_3) are generally an indication of contamination from such sources as sewage disposal systems, animal manure, or nitrogen fertilizers, and are more likely to occur in shallow wells which are poorly located, constructed or maintained. At concentrations between 45 and 100 mg/L there may be some increased risk of methemoglobinemia. A *significant* risk exists when nitrate levels exceed 100 mg/L and alternative water sources should be used for infant consumption. Boiling the water will concentrate the nitrate present thus *increasing* the danger to infants. (Ref: Ia. Tox. Advis. Comm. 11/85)

Other Tests for Water Quality

Iron, hardness and iron bacteria levels in water primarily affect the aesthetic, rather than health-related, quality of water. Iron concentrations above 0.3 mg/L and iron bacteria can cause staining of plumbing fixtures and laundry. The hardness level is significant if water softening is being considered. High levels of any of these three parameters may result in the deposition of material on the inside of pipes, thereby gradually constricting and reducing the flow of water where pipe replacement may be necessary.

The **Hygienic Laboratory** offers other analyses on an individual basis. If you have need for a specific analysis not mentioned here, please contact the Laboratory (319/335-4500) for information.

Send for Water Sampling Kit

If you wish to have your water tested, please fill out the form, detach and mail to the **Hygienic Laboratory**, University of Iowa, Oakdale Hall, Iowa City, IA 52242. Instructions for collecting the sample, the appropriate laboratory report form and the current laboratory analytical rates will be included in the water sampling kit.

Request For Water Sampling Kit

1. We **MUST** know if your water supply is continuously treated with chlorine, bromine, or iodine in order to send you the appropriate container(s).

   PLEASE CHECK THE APPROPRIATE BOX:

   The water supply ☐ is ☐ is not CONTINUOUSLY treated with chlorine, bromine or iodine.

2. **TESTS DESIRED:**

   Drinking Water Safety Analyses

   Coliform Bacteria .... ☐
   Nitrate (Infant Consumption) .... ☐

   Miscellaneous Analyses

   Iron ☐ Hardness ☐ Iron Bacteria ☐

3. Number of water supplies to be tested ________
   (Maximum three)

FOR OTHER TESTS NOT MENTIONED HERE, OR IF MORE THAN THREE CONTAINERS ARE NEEDED, CONTACT THE LABORATORY FOR INFORMATION

4. Send sampling container(s) to:

Name ______________________

Address ______________________

City/State/Zip ______________________

Phone Number (________) ______________________

Comments ______________________

____

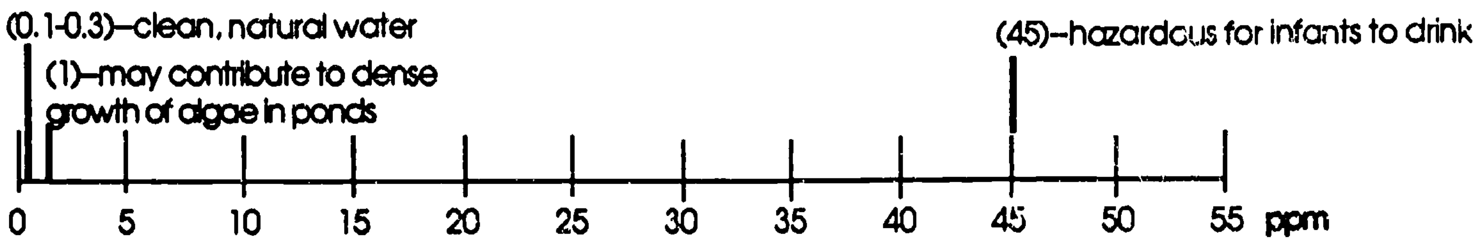
____

Testing of private drinking water for farm chemicals is relatively expensive and usually not necessary unless a spill or back-siphoning accident has occurred at or near the well site. Under normal circumstances, testing for coliform bacteria and nitrates are recommended which will provide a good indication of drinking water safety. If coliform bacteria and nitrate are not present, other surface or shallow sub-surface materials, such as farm chemicals, are not likely to be present in the supply.

If you wish to have your water supply tested for a specific pesticide or for the coliform and nitrate tests, please contact the Hygienic Laboratory for the proper container, collection procedure and current fees.

Nitrate Testing
Student Worksheet

Name_______________



a. Find the nitrate level for your water sample. Circle the number on the above scale that comes closest to your results.

b. According to your results, would this water make babies sick?

c. Look at the nitrate scale. Is nitrate poisonous in tiny amounts of less than 1 ppm?

d. Farmers often put nitrogen-enriched fertilizer on corn crops to help the corn grow. This changes into nitrate which dissolves easily in water. How could fertilizing cornfields affect the nitrate level in ponds, streams, or underground water which is the source of drinking water from wells?

e. Circle the condition for applying fertilizer which would contribute the least to nitrate pollution.

1. wet spring week

2. dry spring week

3. wet fall week

4. dry fall week

Nitrates in the Big Spring Basin Study
Student Worksheet

Name.________________

The Big Spring Basin is an important study area in our state. Special geologic conditions have resulted in a region which can easily and accurately be studied. The groundwater quality has been monitored for many years in this area. On the attached page, you will find three graphs showing part of the study data. Look over the three graphs carefully and then answer the following questions:

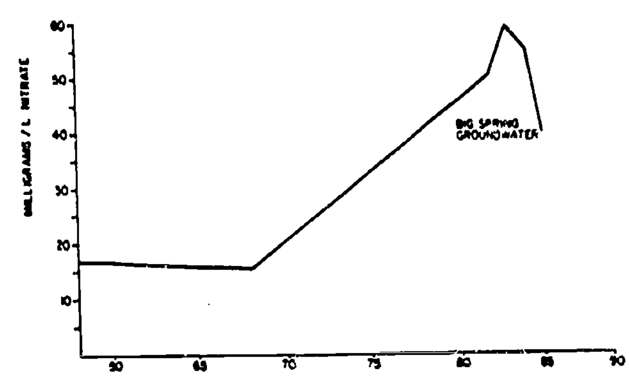
a. How have nitrate levels in groundwater changed over the last twenty years?

b. Sources of nitrate in groundwater include: commercial fertilizer, municipal sludge, legume crops, animal wastes, soil organic matter, septic tanks and rainfall. On the basis of the graphs, which source do you think has caused the nitrate levels in the groundwater to rise?

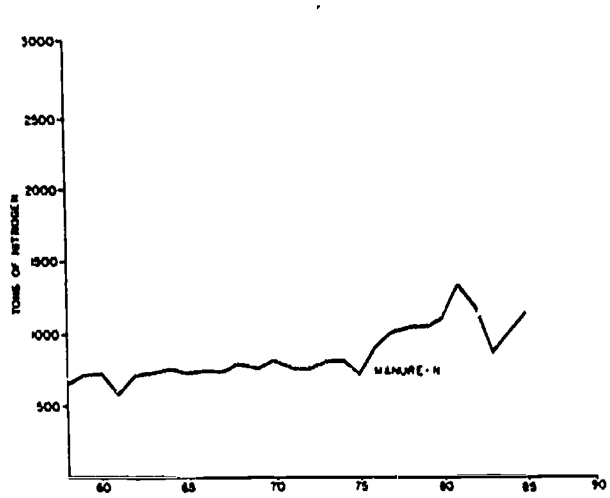
Explain your answer.

c. Why was nitrate present in the groundwater even when very little nitrogen fertilizer was used (1960 to 1970)?

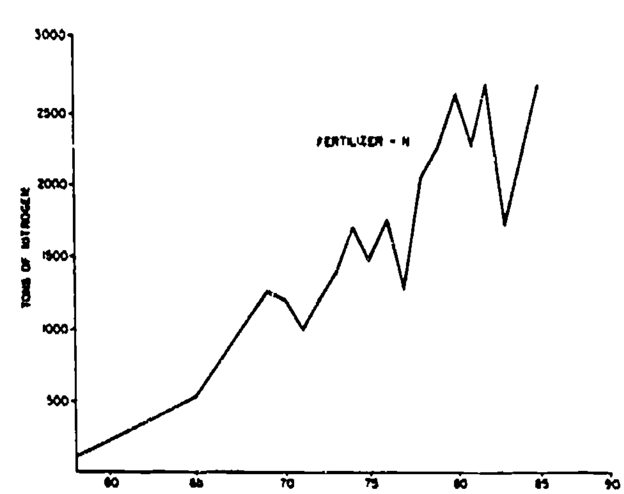
d. Suggest two ways that we might begin to go about reducing the amount of nitrate contamination in the Big Spring Basin groundwater.



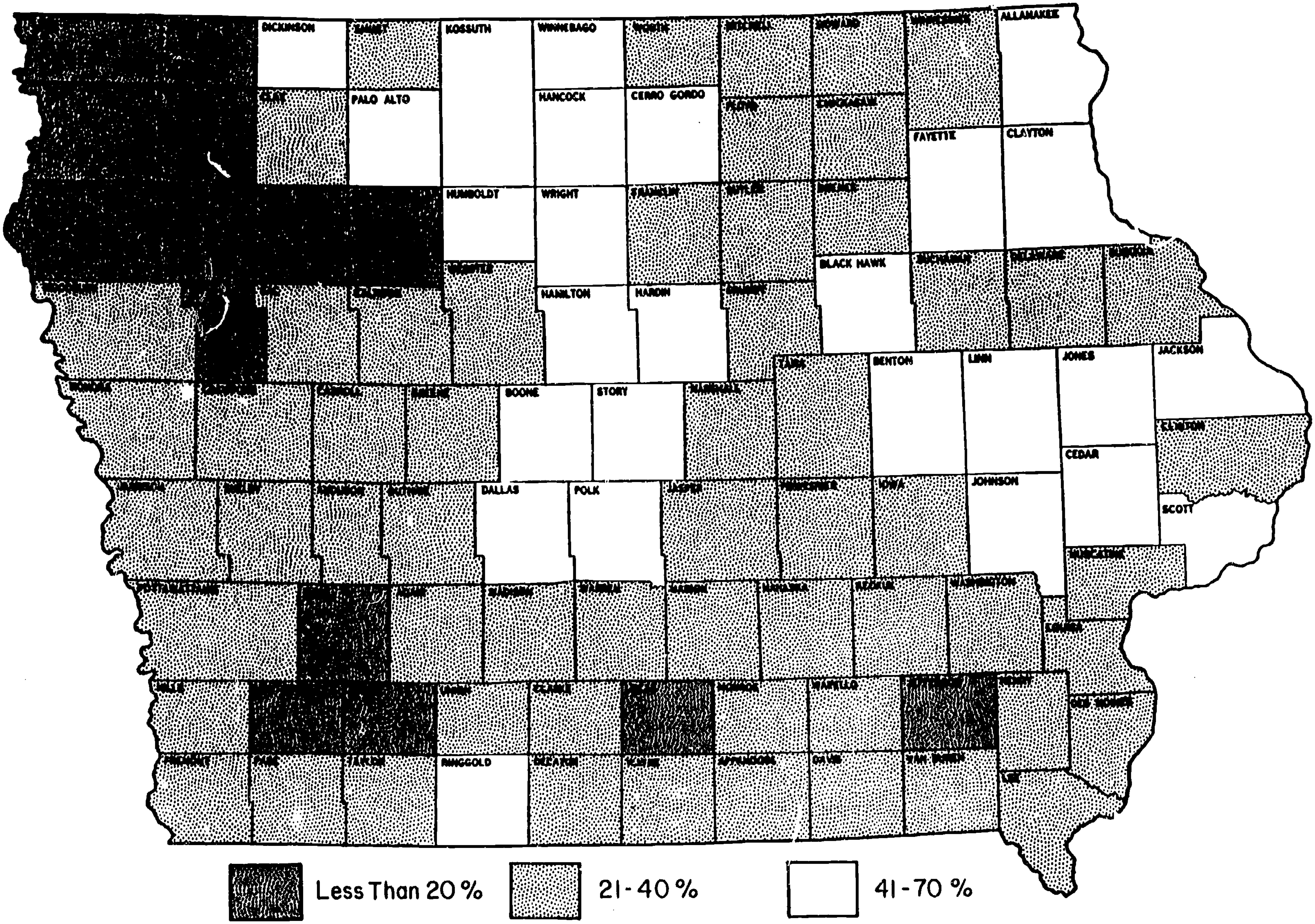
Nitrate Levels in Groundwater



Amount of Manure Used



Amount of Fertilizer Used



Map of High Incidence of Nitrate Contamination -- Overhead
(Data source: R. Splinter, University Hygienic Laboratory; from 13,625 wells less than 100 feet deep)

Understanding Pesticide Use and Contamination

Earth/Life Science | 1 Class Period

Quick Summary: Students consult some tables to answer questions related to pesticide use and contamination, and use a groundwater model to show how ag-chemicals can contaminate groundwater.

Objective: Upon completion, students will be able to:
1. Describe the current use, benefits and groundwater contamination status of pesticides.
2. Compare the agricultural and urban use of pesticides.

Materials: For each small group of students: groundwater model and supplies (Refer to Appendix A, Fig. 2)

Printed/AV Materials:
Worksheet (2 pages)

Procedure:
Have students use the groundwater model to demonstrate contamination from agricutural chemicals. (Refer to Figure 2 in Appendix A. Great Ways to Use the Groundwater Model.)
After students have completed the worksheet, discuss the following answers.

1. Atrazine and Lasso are the two most commonly used herbicides for corn. In 1986, 72% of all pesticide detections in Iowa groundwater were atrazine.

2. Sencor or Lexone is the most commonly used herbicide for soybeans.

3. Five of the pesticides in the table have exceeded EPA health advisory levels at least once: Atrazine, Lasso, Bladex, Dual, and Counter. However, most detections are not above health advisory levels.

4. Agricultural areas use more pesticides because row crops cover about 2/3 of Iowa's land area. In 1985, about 97% of the corn and soybean acreage (over 21 million acres) received at least one application of a herbicide, and insecticides were applied to about 43% of all corn acres. However, 88% of all corn-following-corn acreage was treated with an insecticide to control corn rootworm or black cutworm.

5. The farmer would lose 28 bushels of soybeans per acre due to the Pigweed.
(50 bu/acre - 22 bu/acre = 28 bu/acre)

6. The farmer would probably kill all the soybeans.

7. Lasso; Dual; Sencor-Lexone; Treflan; or Basagran could have been used.

8. Six foxtail per foot would reduce a yield from 91 bu/acre to 81 bu/acre.

9. Yes, it was a good decision. Spraying cost $16 per acre and resulted in an increased yield of 10 bu/acre which could be sold at $2.40 per bushel for a increased income (after spraying) of $8 per acre.

10. The farmer could cultivate between the rows and/or band the pesticide along the row to use less.

11. No. One plant/foot yields 85 bushels/acre. (91 - 85) bushels/acre X $2.40/bushel = $14.40/acre. More was spent for spraying ($16/acre) than was received in increased yield ($14.40/acre).

Alternative:
Teachers may wish to prepare overheads of the data tables and figures and project them.

Extensions:

Find out what pesticides are used by local farmers on their fields -- particularly any fields visible from school.

Have a local ag-extension person visit to discuss certification requirements and procedures for individuals who wish to apply their own pesticides.

Collect and study labels from products sold for use in home gardens.

Get Materials Safety Data Sheets for all pesticides used on the school grounds. The head of buildings and grounds would have access to these forms.

Understanding Pesticide Use and Contamination

Student Worksheet   Name ____________________

Pesticides are chemicals we use to kill unwanted plants and animals on croplands and at home. Pesticides used to kill plants are also called **herbicides**. Pesticides which kill insect pests are called **insecticides**.

In this activity, you will use a collection of tables and figures to help you answer questions about pesticide use in Iowa.

Table 1
Common Pesticides Used in the Corn Belt (from Minnesota Dept. of Agriculture, 1985)

Chemical Name	**Trade Name**	**Percentage of Crops Receiving Pesticide**		**Maximum Concentration Found in Iowa Groundwater * (ppb)**	**EPA Health Advisories (ppb)**
		Corn	**Soybeans**		
Atrazine		57%		19.0	3
Alachlor	Lasso	43%	36%	70.0	0.4
Cyanazine	Bladex	24%		13.0	10
Metolachlor	Dual	22%	14%	200.0	100
Butylate	Sutan	20%		.10	700
Metribuzin	Sencor-Lexone		50%	6.84	200
Trifluralin	Treflan		45%	.2	2
Bentazon	Basagran		20%	0.0	20
Chlorpyrifos	Dursban-Lorsban	14%		.03	unknown
Fonofos	Dyfonate	12%		.9	10
Terufos	Counter	12%		12.0	1
Carbofuran	Furadan	06%		1.2	40

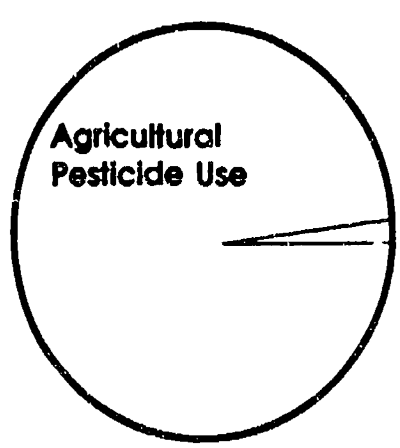
* from DNR data, 5 studies 1982-88

1. What are the two most commonly used herbicides for corn?

2. What is the most commonly used herbicide for soybeans?

3. How many of the above pestcides, found in Iowa's groundwater, have been detected over the EPA health advisory level at least once?

Figure A. Comparison of Urban and Agricultural Pesticide Usage in Iowa (from Iowa Groundwater Protection Strategy, 1987)



Estimated Urban Pesticide Use

4. Six times as many people live in urban areas of Iowa as live in rural (or agricultural) areas. Which uses more pestcides? Urban __________ Agricultural ______________ Why?

Table 3* Changes in Soybean Yield from Pigweed

	Bushels per Acre
No Pigweed	50
1 Plant / Foot	35
2 Plants / Foot	25
4 Plants / Foot	22
32 Plants / Foot	14

* from Crop Chemicals- Fundamentals of Machine Operation, John Deere Technical Services

5. Pigweed is a big problem in soybean fields. How much loss in soybean yield would result if a field was found to have four pigweed plants per foot of row?

6. A farmer made a mistake and sprayed the soybeans with Aatrex. What do you think happened?

7. Name a chemical that should have been used on the soybeans.

Table 2 * Changes in Corn Yield from Foxtail

	Bushels per Acre
No Foxtail	91
1 Plant / 2 Feet	86
1 Plant /Foot	85
6 Plants /Foot	81
12 Plants /Foot	76

* from Crop Chemicals- Fundamentals of Machine Operation, John Deere Technical Services

8. Foxtail is a problem in corn. A farmer uses a herbicide which kills foxtail. A small area was not sprayed and has six foxtail per foot of row. The farmer had a yield of 91 bushels per acre in the sprayed part of the field. What was the yield in the unsprayed portion?

9. If spraying cost $16 per acre and corn sold at $2.40 per bushel, was the decision to spray a good one (if based on immediate costs)?

Explain your answer.

10. If other factors (such as long-term costs for health care and groundwater quality) were considered, the farmer may have chosen an alternative to spraying the foxtail. Describe at least one alternative

11. If only one foxtail per foot of row were found in the above example would spraying pesticides be a good economic decision?

Choices & Chances

Earth/Life Science 1 class period

Quick Summary: Students use a game board and score sheet to take chances and make choices about farming practices. The object of the game is to get the fewest total negative points for groundwater quality and energy conservation while maintaining a profit (a positive score for farmer's money).

Objective: Upon completion, students will be able to:
1. Evaluate practices that could reduce the amount of ag-chemicals in groundwater and save money and energy.

Materials: Dice (for each team of 3-4 students), scissors

Printed/AV Materials:
Score sheet
Answer sheet
Worksheet/Overhead: Game board (for each small group)
Information sheet: Best Management Practices (from unit background information--optional)

Procedure:
1. Have students work in teams of 3-4 students. Distribute one game board sheet and dice to each team. The tractor on the game board sheet should be cut out to use as a playing piece to mark the position on the board (one per game). Distribute one score sheet to each person.

2. Explain the object of the game and directions (see score sheet), and let students play.

3. When they have reached the end, distribute score sheets for students to tally their results.

4. Discuss the choices that successful farmers made, and the effect of different chances. Discuss the difference between high yields and high profits. (By reducing input expenses like chemicals and tractor fuel, a farmer can make more money from the same size yields or slightly smaller yields.)

Alternative:
Use the game board as an overhead and have the whole class play one game, with students working on either individual or team score sheets.

Extensions:
1. Discuss the effects of the choices on other factors, such as the farmer's time and labor, surface water quality or soil erosion.

Choices & Chances
Score Sheet

Object of the Game:
To get the fewest total negative points for groundwater quality and energy conservation while maintaining a profit (a positive score for farmer's money).

Directions:
1. Put the tractor marker on the start space.

2. Everyone moves one space at a time.

3. On a **chance square**, roll the dice to see which selection to check on your score sheet. Then proceed to the next space.

4. On a **choice square**, check your selection on the score sheet. Remember: you are trying to maintain a profit with the least harmful effects on groundwater quality and using the least amount of energy. (You will find out the effects of your choices on money, groundwater and energy later.) Then proceed to the next space.

5. At the end, get an answer sheet to total your scores. Fill in the scores for each of the three columns for your choices and chances. If there is a negative score for the Farmer's Money, you lose. If there is a positive score for the Farmer's Money, you can be considered for the winner–the fewest total negative points for groundwater quality and energy conservation.

Abbreviations:
$ = Farmer's Money
GW = Groundwater Quality
E = Energy Conservation

	Effects		
	$	GW	E
Chance #1 General Expenses			
1,2: Land & Equipment–land payment due and major equipment must be purchased			
3,4: Land & operating expenses			
5,6: Operating expenses:			
Choice #1 Fall Plow			
a. Yes			
b. No			
Choice #2 Fall Fertilizer			
a. Yes			
b. No			
Chance #2 Weather–winter			
Odd: Snowy			
Even: Dry winter			

Effects		
$	GW	E

Chance #3 Advertising

Odd: Yes--Saw the pesticide commercials on TV during the basketball tournament, so stocked up on chemicals for the year and ended up with more than you needed.

Even: No--Went to the basketball tournament & missed the pesticide commercials on TV so didn't buy chemicals at this time.

Choice #3 Tillage

a. No-till

b. Ridge till

c. Traditional plowing

Choice #4 Planting

a. Continuous corn

b. Corn/soybeans rotation

c. Corn/oats/alfalfa rotation

Choice #5 Fertilizers

a. Extra--put on recommended amount plus a little more for safe measure

b. High yield--put on recommended amount for high yields

c. Credits--put on less than the recommended amount, giving credit for nitrogen from legumes; (must have chosen soybeans or alfalfa rotation in choice #4).

d. None

Choice #6 Herbicides

a. Broadcast--spray over whole field

b. Band--along rows

c. Spray where needed--checking for weeds first

d. No herbicides

Choice #7 Insecticides

a. Broadcast--spray over whole field

b. Band--along rows

c. Spray where needed--checking for insect pests first

d. No insecticides

Effects		
$	GW	E

Chance #4 Handling

Odd: Your operator left the water hose in the liquid in the mixing tank when the water was shut off, causing pesticides to back-siphon straight into the well.

Even: Your operator mixed chemicals carefully away from the well without spilling or back-siphoning.

Chance #5 Weather

1,2: Heavy rains–soon after chemical application, washing chemicals into the soil or off the fields, leaving no pesticides or fertilizers

3,4: Average rains–good crop yield expected

5,6: Drought–poor crop yield expected

Choice #8 Cultivation

a. Yes

b. No

Chance #6 Pests

1,2: Corn bug plague–conditions were right for the terrible eatummup bug

3,4: Slight infestation

5,6: No bugs–you're lucky this time

Chance #7 Weeds

1,2: Heavy weed pressure

3,4: Moderate weed pressure

5,6: Few weeds–you're lucky this time

Chance #8 Crop Prices

1,2: Great

3,4: OK

5,6: Poor

Harvest (Use answer sheet to complete.)

Total

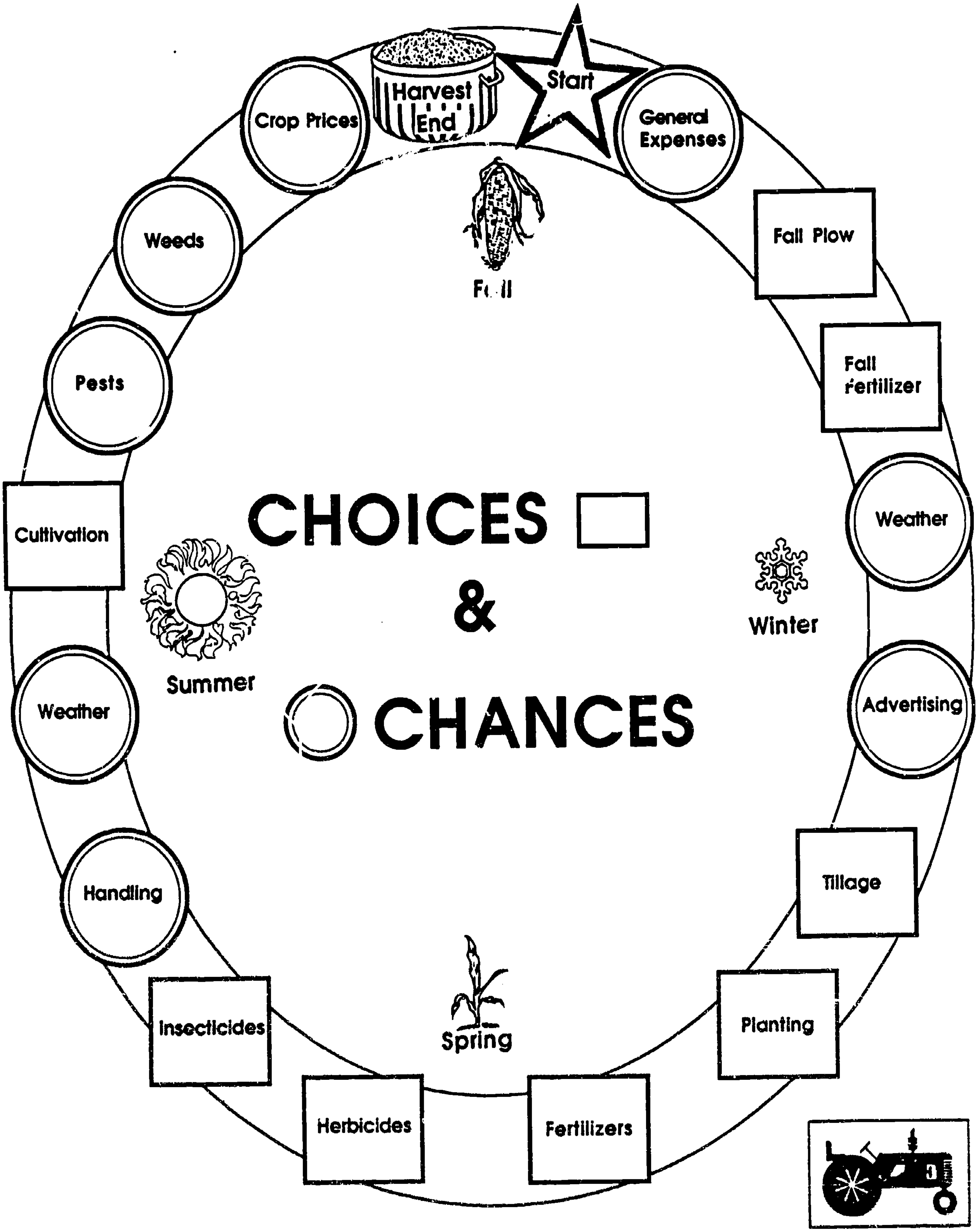
Choices & Chances
Answer Sheet

Abbreviations:
$ = Farmer's Money
GW= Groundwater Quality
E = Energy Conservation

Note: negative $ scores indicate input costs, positive $ scores indicate relative effects on yields

	Effects $	Effects GW	Effects E
Chance #1 General Expenses			
1,2: Land & Equipment–land payment due and major equipment must be purchased	-7		
3,4: Land & operating expenses	-5		
5,6: Operating expenses:	-3		
Choice #1 Fall Plow			
a. Yes	-1	0	-1
b. No	0	0	0
Choice #2 Fall Fertilizer			
a. Yes	-1	-1	-1
b. No	0	0	0
Chance #2 Weather–winter			
Odd: Snowy –if applied fertilizer	0	-1	0
–if no fertilizer	0	0	0
Even: Dry winter	0	0	0
Chance #3 Advertising			
Odd: Yes–Saw the pesticide commercials on TV during the basketball tournament, so stocked up on chemicals for the year., and ended up with more than you needed.	-1	-1	-1
Even: No–Went to the basketball tournament & missed the pesticide commercials on TV so didn't buy chemicals at this time.	0	0	0
Choice #3 Tillage			
a. No-till	0	0	0
b. Ridge till	-1	0	-1
c. Traditional plowing	-1	0	-1
Choice #4 Planting (will affect later scores)			
a. Continuous corn			
b. Corn/soybeans rotation			
c. Corn/oats/alfalfa rotation			
Choice #5 Fertilizers			
a. Extra–put on recommended amount plus a little more for safe measure	-3	-3	-3
b. High yield–put on recommended amount for high yields	-2	-2	-2
c. Credits–put on less than the standard amount, giving credit for nitrogen from legumes; (must have chosen soybeans or alfalfa rotation in choice #4).	-1	-1	-1
d. None	0	0	0
Choice #6 Herbicides			
a. Broadcast–spray over whole field	-2	-2	-2
b. Band–along rows	-1	-1	-1
c. Spray where needed–checking for weeds first	-1	-1	-1
d. No herbicides	0	0	0

	Effects		
	$	GW	E
Choice #7 Insecticides			
a. Broadcast–spray over whole field	-2	-2	-2
b. Band–along rows	-1	-1	-1
c. Spray where needed–checking for insects first	-1	-1	-1
d. No insecticides	0	0	0
Chance #4 Handling			
Odd: Your operator left the water hose in the liquid in the mixing tank when the water was shut off, causing pesticides to back-siphon straight into the well.			
–If any pesticides chosen earlier	-1	-9	-1
–If no pesticides chosen earlier:	0	0	0
Even: operator mixed chemicals carefully away from the well, without spilling or back-siphoning.	0	0	0
Chance #5 Weather			
1,2: Heavy rains–soon after chemical application, washing chemicals into the soil oroff the fields, leaving no pesticides or fertilizers	+1	-1	0
3,4: Average rains–good crop yield expected	+2	0	0
5,6: Drought–poor crop yield expected	+1	0	0
Choice #8 Cultivation			
a. Yes	-1	0	-1
b. No	0	0	0
Chance #6 Pests			
1,2: Corn bug plague–conditions were right for the terrible eatummup bug			
–If insecticide present	+6		
–If crop rotation used without insecticide	+3		
–If none of above used	0		
3,4: Slight infestation			
–If insecticide present	+6		
–If cultivation or crop rotation used	+6		
–If none of above used	+2		
5,6: No bugs–you're lucky this time	+6		
Chance #7 Weeds			
1,2: Heavy weed pressure			
–If herbicide present	+6		
–If cultivation or crop rotation used without insecticide	+3		
–If none of above used	0		
3,4: Moderate weed pressure			
–If herbicide present	+6		
–If cultivation or crop rotation used	+6		
–If none of above used	+2		
5,6: Few weeds–you're lucky this time	+6		
Chance #8 Crop Prices			
1,2: Great	+5		
3,4: OK	+3		
5,6: Poor	+1		
Harvest			
–If nitrogen was added from fertilizer (and if it has not washed away) or from legumes	+6		
Total			



Start
General Expenses
Fall Plow
Fall Fertilizer
Weather
Advertising
Tillage
Planting
Fertilizers
Herbicides
Insecticides
Handling
Weather
Cultivation
Pests
Weeds
Crop Prices
Harvest End
Fall
Winter
Spring
Summer
CHOICES
&
CHANCES

Letter to a Farmer

Earth and Life Science 1 class period

Quick Summary: Students will write a letter to someone who uses nitrogen fertilizer and/or pesticides. The letter will include questions about chemical use and explanations about benefits and disadvantages of reducing chemical use.

Objectives: Upon completion, students will be able to:
1. Analyze the advantages and disadvantages of reducing the use of nitrogen fertilizers and/or pesticides in a specific, real situation.

Materials: None

Printed/AV Materials:
Worksheet: Directions for Letter to a Farmer
Information: Best Management Practices (from unit background information)

Procedure:
1. Provide the students with adequate background information (such as through other activities in this unit).

2. Hand out the worksheet and discuss directions. You may want to give them suggestions for writing effective letters. For example, the letters should not be adversarial. Students should find out first what the farmer's situation is and share information on pros, cons, and specific how-to's.

3. Let students decide for themselves whether or not they actually want to send their letters. If some do, it might be interesting to discuss responses.

Alternative:
1. Invite one or more farmers into the classroom for a panel discussion or interview. Have the students generate a list of questions before they arrive.

2. Contact one of the following about demonstration farms in your area:

<u>Integrated Farm Management</u>
ISU Ag Experiment Station
Ames, Iowa 50011
515-294-4025 or
515-294-1923

<u>Resourceful Farming Demonstrations</u>
Iowa Natural Heritage Foundation
Insurance Exchange Building, Suite 830
505 Fifth Avenue
Des Moines, Iowa 50309
515-288-1846

<u>Farming With Fewer Chemicals: A Farmer-to-Farmer Directory</u>
Iowa Citizens for Community Improvement (Iowa CCI)
1607 E. Grand Ave.
Des Moines, Iowa 50316
515-266-5213

Directions for Letter to a Farmer

Student Worksheet Name____________________

Write a letter to someone who uses nitrogen fertilizer and/or pesticides. Think of a friend or relative who farms. (98% of these chemicals are used on farms.) If you cannot think of a farmer, find someone who uses these chemicals on their lawn or garden.

Your letter should include the following:

1. Ask questions about the farm (or lawn or garden) and their use of nitrogen fertilizers or pesticides.

2. Explain some of the dangers of using too much nitrogen fertilizer or pesticides, and the benefits of reducing the use of these chemicals. (For example, effects on groundwater, health, and energy.)

3. Ask questions about whether they are trying to reduce groundwater contamination from nitrates or pesticides. Use specific examples.

4. Ask about ways to reduce energy costs. Can they reduce the number of trips across the field and/or the amount of chemical used?

5. What would be the disadvantages of using less fertilizer or pesticides? (Would cost be a disadvantage? Remember: in order to survive, farmers must be able to maintain some kind of profit.) Share your opinions, and ask the farmers what they think.

III-1. Abandoned waste sites

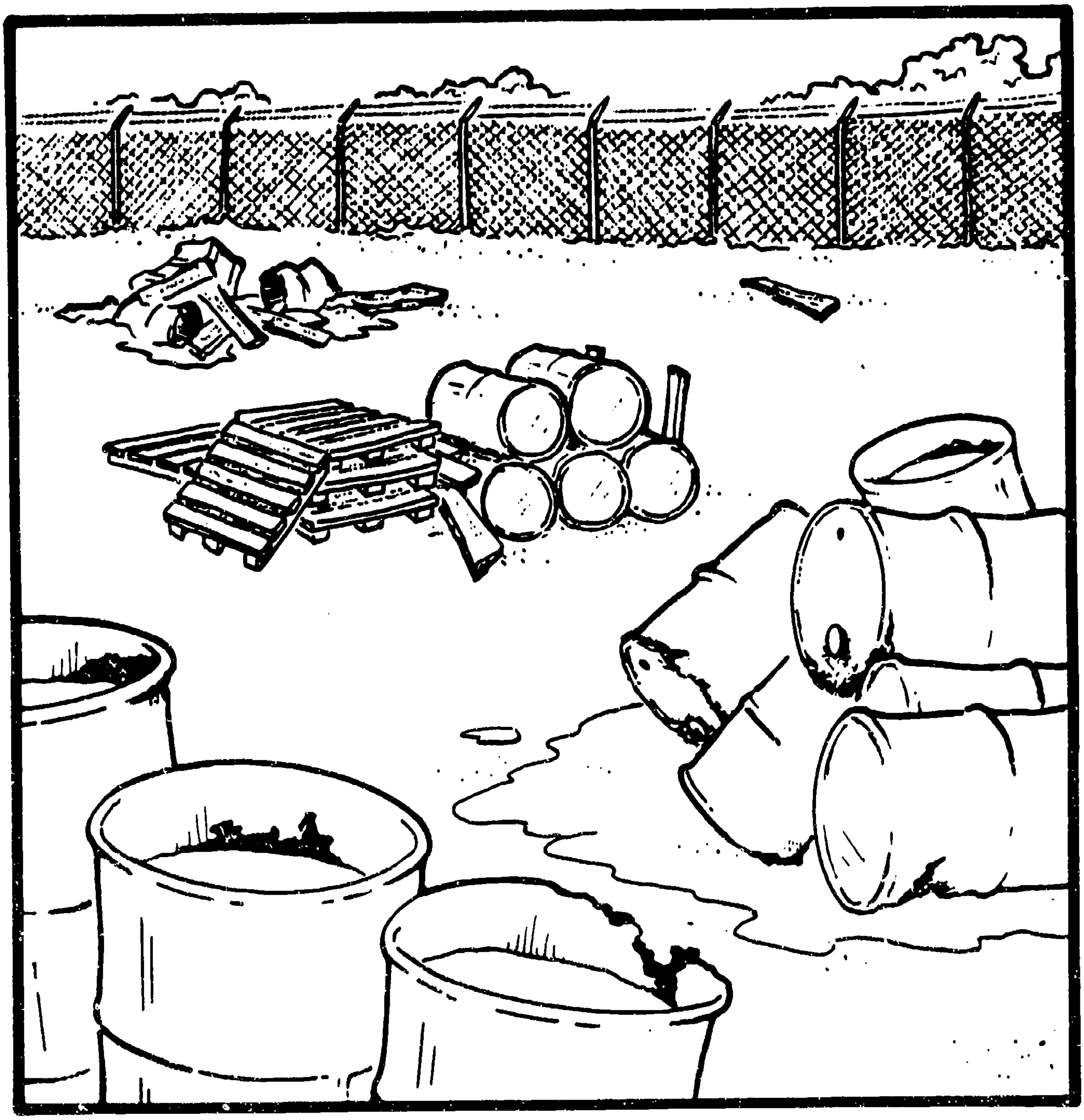
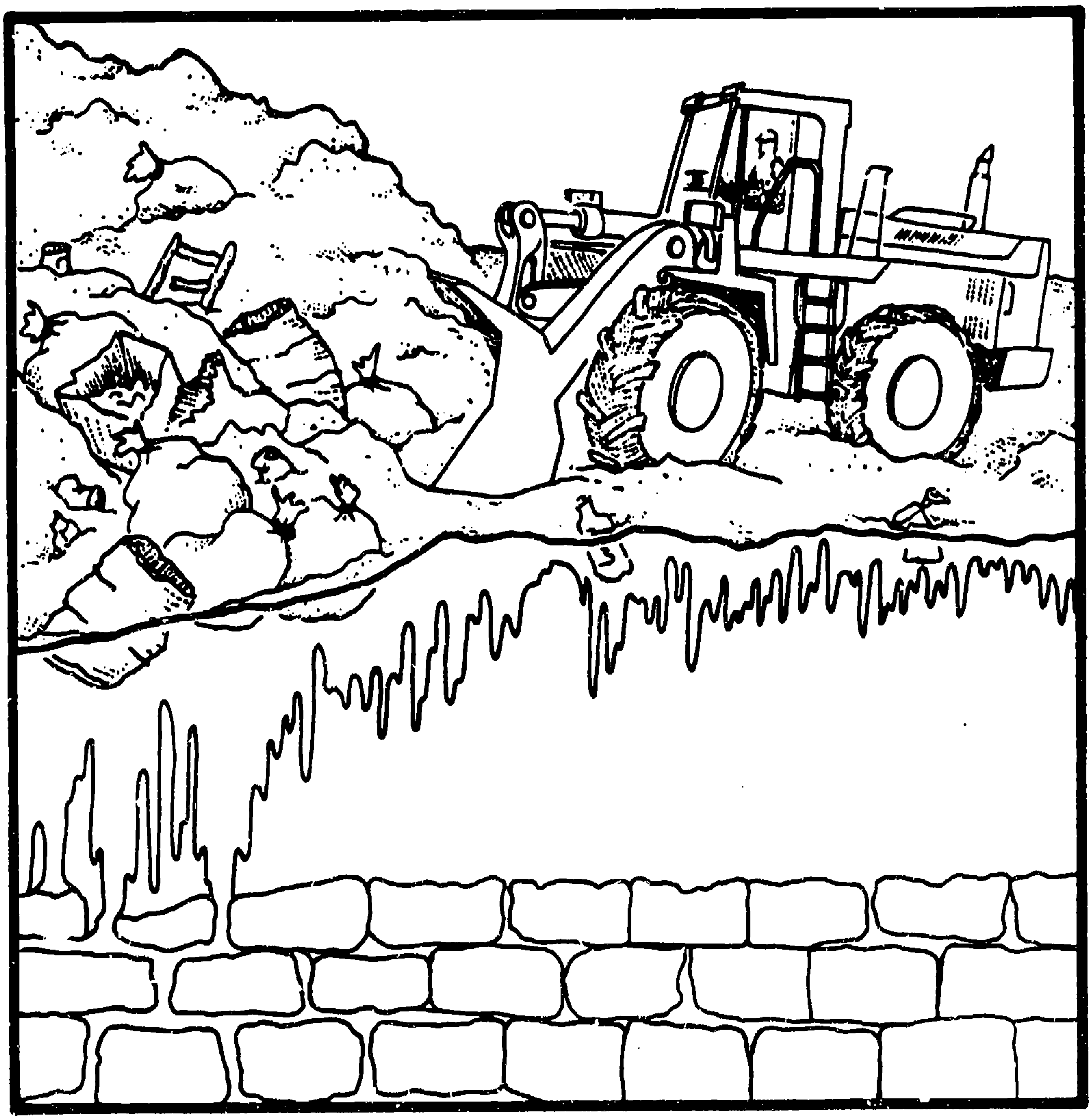


Figure III-2. Landfills



III. DUMP: ABANDONED WASTE SITES AND LANDFILLS

OBJECTIVES:

Upon completion, students will be able to:

1. Analyze the effect of solid waste disposal on the environment, especially on the groundwater.

2. Gather data and compare methods of community waste disposal.

3. Demonstrate how abandoned waste sites or landfills can contaminate groundwater, using a groundwater model.

4. Examine landfill alternatives which reduce solid waste while conserving energy and other natural resources.

5. Evaluate the dangers of using and disposing of hazardous products.

BACKGROUND INFORMATION

ABANDONED WASTE SITES

The Problem

In Iowa, abandoned hazardous waste sites have **contaminated** over 50 **drinking water wells** including some public supplies. These sites include abandoned dumps and industrial waste sites which used practices not allowed today.

Dumping wastes "out the back door" was a common practice. Although the land may have been owned or leased by the dumper, the hazardous waste poses potential safety problems for the general public.

Sometimes **big problems** have resulted such as the LaBounty site in Charles City (where arsenic was found in the Cedar River and other contaminants found in nearby alluvial aquifers) and Des Moines (where TCE was found in the water supply).

At other times, **smaller problems** have resulted which pose potential dangers and need to be cleaned up, but have less impact. Examples of smaller problems include: Land O Lakes north of Des Moines where a former employee reported buried farm chemicals, and several tons of soil and chemicals were removed; and Eginoire in Lorimor where an abandoned building had open bags of hazardous chemicals laying around.

Who Pays For Clean-up?

Clean-up is **expensive** ($250,000 to $9 million for each site in Iowa). Preventing contamination would have been cheaper and more effective than clean-up attempts. Officials try to make the **responsible party** pay for cleaning up their hazardous problems. However, the federal government tries to help with the worst sites through the **Superfund**, administered by the Environmental Protection Agency (EPA). The Superfund was authorized as a five-year program, first by CERCLA (Comprehensive Environmental Response, Compensation and Liability Act) in 1980, and then by SARA (Superfund Amendments and Reauthorization Act) in 1986.

To be eligible for Superfund money, a hazardous waste site must be on the National Priorities List (NPL). The site and contamination must be reported by an observer, and then officials evaluate the site. About 10% of the worst sites make the list, based on the extent of contamination, public health threat, and environmental impact. Fees on hazardous materials in Iowa are now used to pay the state's share (10%) of clean-up costs. To date, Iowa has paid for one site (Aidex) which cost about three times the annual budget for this program.

Another EPA program, **RCRA** (Resource Conservation Recovery Act), is in charge of the current management of hazardous materials (as opposed to abandoned waste sites), tracking the chemical from "cradle to grave" (production to disposal). RCRA is designed to prevent future problems that would require Superfund clean-up.

Iowa Sites

There are over 400 potential uncontrolled hazardous sites investigated in Iowa. Nearly half have not required any action. Table III-1 shows the National Priorities List sites in Iowa (as of July 1988); Table III-2 shows the proposed NPL sites in Iowa; and Table III-3 shows previously proposed NPL sites which are now under the management of RCRA.

Table III-1. NPL Hazardous Sites in Iowa, July 1988. Source: DNR.
Aidex Corp., Council Bluffs
Des Moines TCE, Des Moines
Dupont Landfill (Todtz Farm), Camanche
LaBounty Dump Site, Charles City
Midwest Manufacturing/North Farm, Kellogg
Vogel Paint and Wax Co., Maurice
Shaw Avenue Dump, Charles City

Table III-2. Proposed NPL Hazardous Sites in Iowa, July 1988. Source: DNR.
Red Oak Landfill (Union Carbide Disposal), Red Oak
Farmers Mutual Coop., Hospers
Northwestern States Portland Cement Co., Mason City
Lehigh Portland Cement Co., Mason City
Electro-Coatings, Cedar Rapids
Peoples Natural Gas, Dubuque
Fairfield Coal Gasification, Fairfield
E.I. Dupont West Point Sites, West Point
White Farm Equipment, Charles City
Mid-America Tanning, Sergeant Bluff
John Deere Ottumwa, Ottumwa

Table III-3. Previously Proposed NPL Sites, now under RCRA
Clinton, City of (Chemplex Co.), Clinton
Frit Industries, Humboldt
John Deere Dubuque, Dubuque
A.Y. McDonald, Dubuque
U.S. Nameplate Co., Newton

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LANDFILLS AND SOLID WASTE

The Problem

Leaking Landfills

Leaks from landfills (leachate) can contaminate groundwater. **Leachate** is liquid waste and can be formed when water mixes with buried waste. Leachate may contain a variety of hazardous materials, including **household hazardous wastes.**

Too Much Solid Waste

> Landfills become "land full."

Landfills are running out of room. Each Iowan generates 1200 pounds of waste per year. Each day Americans throw away 400 million pounds of food, junk 20,000 cars, and discard 18,000 TV's. The United States has 5% of the world's population, but produces 30% of the garbage. We each are a part of this throw-away society, and we each have a responsibility to help solve the problem.

Other Problems

Natural resources contained in wastes are growing more limited and more expensive. We can no longer afford to waste energy or to discard valuable resources that are still usable. Also, many of the materials buried are **nonbiodegradable** and will remain intact for centuries. Not only are the nonbiodegradables such as plastic unchanged, but the things they contain, even though biodegradable, cannot be acted upon by decomposers and will also remain essentially unchanged.

What Happens to Our Waste?

When we "throw away" something, it does not just "go away"--most of it goes into a landfill. A **sanitary landfill** is a site where solid waste is disposed of on land without creating public health or safety hazards, by confining refuse to the smallest practical area, reducing it to the smallest practical volume, and covering it with a layer of earth at the end of each day's operation or more frequently if necessary.

In the past, dumps were used which were simply piles of uncovered waste. They attracted rodents and insects, and were unsightly, smelly, and a health threat. By 1975, the 2000 dumps in Iowa were outlawed and replaced by landfills. However, it was not until 1981 that the burial of hazardous wastes in landfills was prohibited. As a result, 59 landfills in Iowa are on the national list for uncontrolled waste sites.

There are **now 125 permitted landfill sites** located in 83 counties in Iowa, occupying 10,000 acres of land. They must be constructed in areas where the possibility of contamination of groundwater will be minimal, with a series of pipes for monitoring laid below a clay liner. Garbage must be compacted and covered with six inches of soil daily, and land must be reclaimed as landfill operations are completed. Most are located in clay-rich glacial soil, but 12 are in abandoned coal mines and quarries, seven are near rivers and two are in karst areas. Thirty-seven of Iowa's landfills are within three miles of a city or town.

Goals for Solid Waste Management

To meet future solid waste needs, the 1987 Iowa Groundwater Protection Act mandated some big changes for landfills over a ten-year period, including better groundwater monitoring, a plan for landfill alternatives, and higher landfill fees to help pay for these changes. Solid waste alternatives (ranked in order of importance) are:

Landfills -- Don't dump your troubles on me!

1. **Volume reduction at the source:** (reducing the amount of waste before it goes to a landfill). This is something with which **everyone** can help. People can buy/use products that last longer. They can reuse things, or simply just buy/use less. **Businesses** can make products that use fewer resources, and reduce excessive packaging. (Simple compaction, although reducing volume, does not help with other environmental impacts, and so is neither encouraged nor discouraged.)

2. **Recycling/reuse:** (after it goes to the waste stream). Markets often exist or could be developed for programs to recycle: motor oil, car batteries, nickel and chrome batteries, plastics, newspaper, corrugated cardboard, textiles, office paper, construction materials (such as rock, concrete, lumber, paints and wire), aluminum and steel cans, colored and clear glass, yard clippings, animal wastes and other organic wastes. Composting yard waste, either at a central facility or in individual backyards, not only reduces volume but also makes a useful natural fertilizer.

3. **Incineration with energy recovery:** (burning waste to produce steam or electricity). Air pollution can sometimes be a problem, so pollution control devices may be needed on incinerators. There are two main types of facilities: mass burn and refuse-derived fuel (RDF). Refuse-derived fuel may be fluffy or densified into pellets (called densified refuse-derived fuel or d-RDF). The city of Ames has an example of a **mass burn facility**. In 1975 they were first in the nation to start a project that separates burnable refuse for use as boiler fuel and recovers as much of the nonburnable refuse as possible for recycling. **Densified refuse-derived fuel (d-RDF)** consists of three-inch pellets formed from solid waste or a mixture of paper and cardboard. D-RDF is being used at Dordt College and the high school at Sioux Center. Studies on d-RDF are being conducted at Cedar Rapids (jointly by the city and Iowa Electric Light and Power Company) and in a five-county region in southeast Iowa, focused in Keokuk.

4. **Incineration for volume reduction:** (simply burning waste). This is the second to the least preferred option, because it reduces volume only about 30-40 percent, does not make use of natural resources contained in the waste, and could have air pollution problems if not done correctly.

5. **Sanitary landfills:** Although high costs of future landfilling will make the other options more appealing, no system to date can operate without generating some waste, so landfills will still be needed. However, fewer local landfills may be needed, resulting in more regional landfills.

In 1989, the Iowa legislature passed a bill on waste volume reduction and recycling which set a goal to **reduce the amount of materials in the waste stream**, existing as of July 1, 1988, **25% by July 1, 1994, and 50% by July 1, 2000**. Other examples in the bill include:

Beginning Jan. 1, 1991, land disposal of **yard waste** is prohibited, except when the waste is separated and accepted by a sanitary landfill for composting. Cities and counties by July 1, 1990, shall require persons to separate yard waste.

Land disposal of **lead acid batteries** is prohibited beginning July 1, 1990. Retailers and wholesalers of lead acid batteries must accept used batteries for recycling.

Land disposal of whole waste **tires** is prohibited beginning July 1, 1991, unless the tire has been processed in a manner established by the DNR.

A sanitary landfill shall not accept **waste oil** for final disposal beginning July 1, 1990. Retailers selling oil must, at the point of sale, accept waste oil from customers or post notices of locations for waste oil disposal. They must also post a notice that disposing oil in landfills is unlawful.

Plastic foam packaging products or food service items manufactured with chlorofluorocarbons are prohibited beginning Jan. 1, 1990.

Effective July 1, 1992, land disposal of **nondegradable plastic** grocery bags or trash bags is prohibited, unless DNR determines that degradable plastic bags pose an environmental hazard.

Alternatives for Consumers

The Power of Choice in Buying

Buy with *care.*

Do you refuse to buy things that don't last? Do you take care of things to make them last longer? Can you reduce the number of disposable items you buy? Could you still be happy if you bought fewer things? If many of us bought things that lasted longer or were less wasteful, manufacturers would be forced to make things that last longer. Do you exert your buying power?

Recycling

At least fifty percent of the solid waste in landfills could have been recycled. Recycling is the process whereby the material is processed to be used again in its original form or in a similar form. Recycling not only reduces the amount of waste and conserves natural resources, but also saves energy and water, and reduces air/water pollution and mining wastes. Refer to Table III.1 below.

Table III.1 Energy Saved in Manufacturing With Recycled Material Instead of Raw Materials (Source: *Pennsylvania Energy.*)

	Percent Energy Saved
Aluminum	96
Copper	87
Iron/Steel	63
Lead	63
Paper	63
Rubber	71
Zinc	60
Glass	85

Americans throw away millions of tons of **paper** per year, which is about 40 percent of all our waste. For every ton of paper we recycle we save 17 trees which are renewable resources. Making paper from recycled paper uses 30 to 55 percent less energy than making paper from trees and reduces the air pollution involved in the paper-making process by 95 percent. The slick paper in magazines can technically be recycled (for example in Michigan). However, it is probably not yet practical to recycle magazines in Iowa.

About 70 percent of all **metal**, a nonrenewable resource, is used just once and then discarded. Aluminum costs enough that recycling is profitable, and aluminum is the most successfully recycled with 50% of aluminum cans returned. Iron, tin and copper are also routinely recycled. Did you know...?

* Throwing away an aluminum pop can wastes as much energy as pouring out a can half-filled with gasoline.

* Making aluminum from recycled aluminum uses 90 to 95 percent less energy than making aluminum from bauxite ore.

About 10% of our solid waste is **glass** and is all recyclable. Only one in 15 glass containers are crushed and made into something new. In order for glass to be recycled, all metal must be removed and it must be color sorted. Glass is made from silica, limestone, and soda, all of which are plentiful natural resources. Because of this, prices paid for waste glass (cullet) are low. Its weight and special equipment make transportation costly, so profits are minimal. Glass is not biodegradable.

Americans throw 100 million **tires** away per year. Although recycling tires is possible, it is difficult and virtually not done in the U.S. Tires are a problem in the landfill, because the rubber resists attempts to compact it, bouncing back and working its way to the surface.

The amount of **plastic** in landfills continues to increase as it replaces glass and paper. Plastic has been a problem to recycle because there are different kinds which do not stick together when remelted. There are few plastic recycling companies in the United States, but one of these is in Iowa Falls, Iowa.

Plastic has generally been considered nonbiodegradable because it takes hundreds of years to decompose. However, some new degradable plastics are now being researched. Some of these are made with corn starch which will decompose leaving dust-like particles of plastic; and other types of plastic are being developed which will decompose when exposed to light (photodegradable). Many questions remain about how safe these new plastics are for the environment.

Reuse

Many things that we just throw in the trash could be reused for the original or another purpose. Reuse saves natural resources (including energy) and reduces the size of landfills. Containers can be used for other purposes; and other items such as clothes, toys, furniture, and appliances, can be donated or sold to others for reuse. Disposable items should be avoided.

Composting

Yard waste accounts for the majority of waste after paper. In the past, farmers and gardeners often used compost for fertilizer and soil conditioning. Composting is collecting organic material such as lawn clippings, leaves, non-meat food scraps, and manure, and layering it to decompose into fertile humus. Compost is formed through the action of microbes that multiply when mixed with organic materials, sufficient air and moisture. These fungi and bacteria generate temperatures of 150° F, changing and sanitizing the material. The finished product looks like soil, is clean, and inexpensive. This natural recycling process is a good way to reduce the volume of solid wastes. See also Appendix M. Composting Your Yard Waste in a Holding Bin.

Household Hazardous Wastes

Household hazardous materials (HHM) are products used in the home that may be hazardous to human health or to the environment when improper disposal occurs. Some examples include: caustic household cleaners, drain openers, automotive products, pesticides, paint products, solvents, smoke alarms and outdated medicines. Although individual samples would probably cause little damage to the environment, when household wastes are concentrated in a landfill or sewage treatment plant, they may pollute water supplies.

Storing up trouble -- hazardous wastes.

Non-hazardous alternatives should be used whenever possible. (See the activity on Household Hazardous Materials.) Also "**use only what is needed**" should replace the philosophy of "more is better."

Retail stores are now required by law to display **shelf labels** which identify products that are considered hazardous. Brochures should also be available to explain how these materials are to be handled.

The **Toxic Cleanup Days** program provides funds (from HHM permits to retailers) for setting up a one-day collection site for HHM in cooperation with local groups. Collected wastes are properly disposed of at a hazardous waste facility or by incineration. Waste exchanges for reusable products such as paints and pesticides are encouraged in place of disposal.

Hazardous Waste Facility in Iowa

Presently, there are no long-term hazardous waste facilities in Iowa. Hazardous wastes are now shipped out of the state which is expensive. Iowa is in the process of studying a proposal to establish a regional facility with surrounding states to handle hazardous wastes. Meanwhile, ways to minimize hazardous wastes are being promoted.

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Superfund Case Study

Earth/Life Science 1 class period

Quick Summary:
Students will discuss solutions, and ideas about cleaning up a toxic waste site, using information concerning an actual site.

Objectives: Upon completion, the students will be able to:
1. Describe an actual toxic waste clean-up case.
2. Critically discuss the costs of prevention vs. cleaning up a toxic waste site.
3. Formulate a process for identifying the source of toxic waste which has contaminated groundwater.

Materials: Groundwater model (as shown in Figure 3 of Appendix A. Great Ways to Use the Groundwater Model) for each small group of students.

Printed/AV Materials:
Teacher Discussion Guide
Overhead: Map of Des Moines Groundwater TCE Concentrations - December '84.

Procedure:
1. Use the map and discussion guide provided to describe the toxic waste problem presented in the case study. Allow the class to offer their opinions about the answers to the questions. Stress the point that there are many possible answers to some of the questions and that what they think isn't necessarily wrong because it doesn't agree with what was actually done. They do not have all of the information and expertise required to arrive at the same conclusions that the authorities did.

2. Use the groundwater model to show how a pump (acting as a recovery well) can pull contaminated water towards itself for eventual removal.

Alternatives:
Case study information about several other sites is available from the Department of Natural Resources. Ask for the Annual Report on Abandoned or Uncontrolled Hazardous Waste Disposal Sites and Hazardous Waste Remedial Fund. This document contains case studies on hazardous waste sites throughout the state which you may adapt for this lesson.

Superfund Case Study: Des Moines TCE
Teacher Discussion Guide

The Des Moines Water Works which supplies the city of Des Moines and some of the surrounding towns with water is located on the Raccoon River in Des Moines. The Water Works gets its water from a combination of sources: the Raccoon and Des Moines Rivers (surface water) and a gallery (horizontal well) in an alluvial aquifer (groundwater) near and under the Raccoon River.

TCE (trichloroethylene) is a toxic but common industrial solvent. In late 1973, TCE was detected in Des Moines drinking water in sufficient concentration to cause concern. No one knew how the chemical had gotten into the water, where it had come from, or how serious the problem was.
Question 1: How would you go about discovering the source of the TCE in the water supply of Des Moines?
(**This is what they did:** Tested the water at short distances around the Water Works plant until you don't find any more TCE. Zero in on it that way.)

It was discovered that the source of the TCE contamination was the grounds of the Dico Manufacturing Plant across the river and less than one mile from the Water Works.
Question 2: How would you discover how the chemical got into the water supply from the manufacturing plant?
(**This is what they did:** Investigate how they use and handle the chemical, how they store it, and how they dispose of it. Test the soil around the plant.)

Investigators found that the TCE had been mixed with waste oil and spread on the gravel parking lot aroundithe plant to keep the dust down. The company claimed that they had no knowledge of the TCE in the oil and claimed that the problem wasn't their fault.
Question 3: How would you determine how far and how deep the TCE had spread from the parking lot?
(**This is what they did:** Soil tests and monitoring wells to determine the depth and spread of the chemical.)

Question 4: How would the TCE get from the parking lot to the Water Works?
(**This is how:** Soak into the ground and then enter the groundwater. The pumping of the Water Works gallery "pulled" the contaminated groundwater toward it.)

Federal, state, and local officials decided that the TCE contamination must be cleaned up to protect the health of the water users from this cancer-causing chemical. The Dico Company agreed to pay for much of the cost but did not admit responsibility for the problem.
Question 5: How would you go about cleaning the TCE out of the subsurface and the water supply?
(**This is what they are doing:** Pump from new recovery wells surrounding the area of contamination along the east side of the river which pull water away from the Water Works. Pump the water into a stripper tower which is filled with little plastic balls. The water drips through the tower, splashing against the balls and air which flows up from the bottom. This allows over 99% of the TCE to vaporize into the air.)

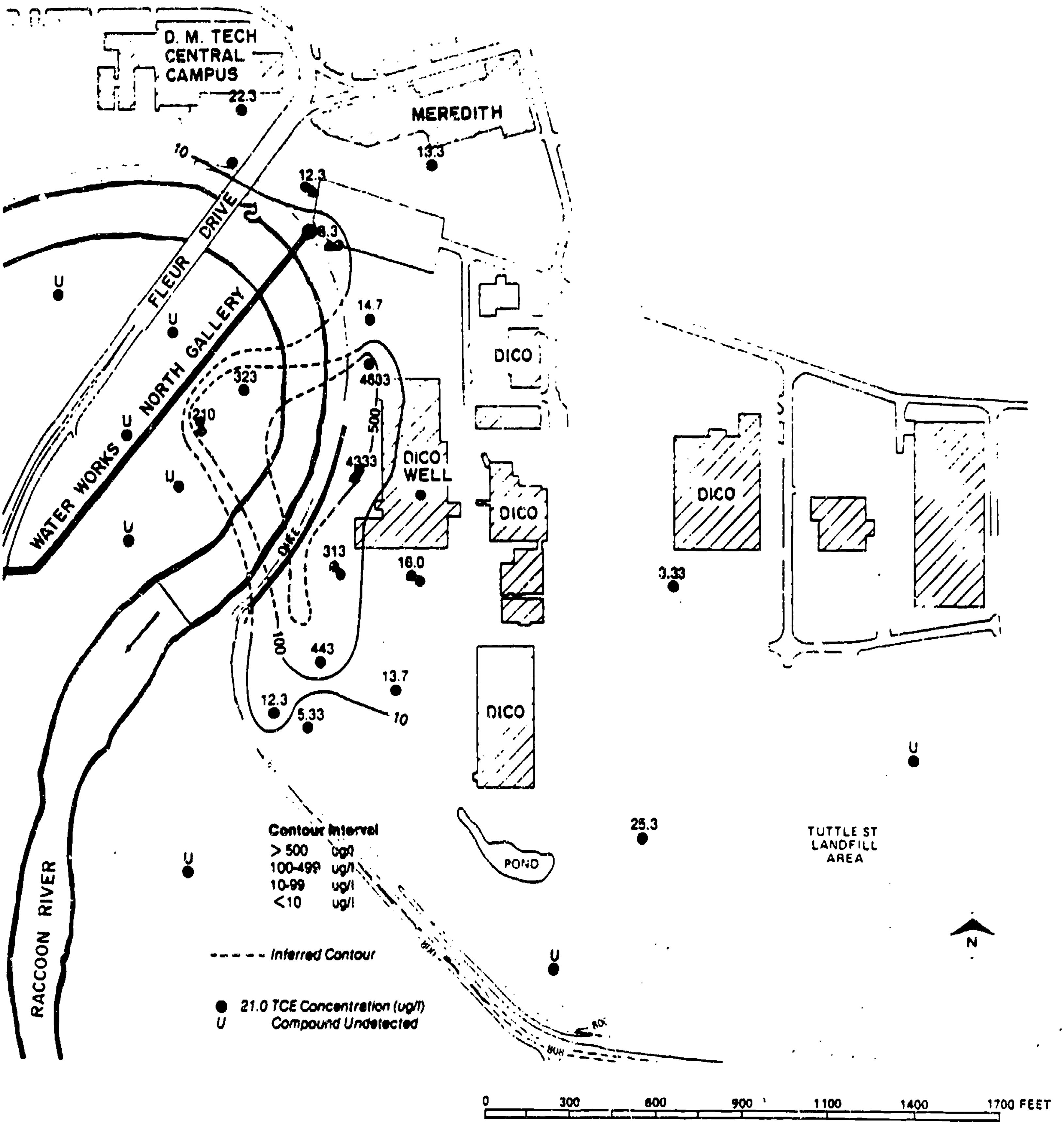
Question 6: How much do you think this entire cleanup including the testing and investigation would cost?
(**This is how much:** Almost $3 million total, including $1 million for testing and investigation and $1.5-$2 million for cleanup--paid by Dico.)

Epilogue: Another plume, called the north plume, was found in 1988 at the north end of the Flour Drive bridge. Contaminants are now being pulled out by a nearby recovery well, and investigations are currently underway to identify the source of this plume.

106

MAP OF DES MOINES

Groundwater TCE Concentrations - December '84



107

The Problem With Landfills

Earth/Life Science 1 class period

Quick Summary:
The students will be introduced to our solid waste crisis and some possible solutions using a quiz and discussion supported by overhead transparencies.

Objectives: Upon completion, the student will be able to:
1. State the problems in disposing solid waste.
2. Describe how waste disposal methods may lead to contamination of the groundwater.
3. Critically discuss waste disposal options.

Materials: For each group of 4-6 students: groundwater model and supplies (Refer to Appendix A.)

Printed/AV Materials:
Worksheet: Solid Waste Quiz.
Overhead: Running Out of Room
A Better Landfill
Solid Waste Alternatives

Procedure:
1. Have students take the "Solid Waste Quiz". Answers are: 1(a), 2(d), 3(c), 4(d), 5(a), 6(d), 7(d), 8(a), 9(d).

2. Using the overhead "Running Out of Room" and the items from the quiz, lead a brief discussion of our growing solid waste crisis.

3. Refer to the last question on the "Solid Waste Quiz" and discuss what is done with the trash in a landfill. Be sure to point out the difference between present landfills and dumps used in the past, and list the advantages of the landfill.

4. Discuss the disadvantages of landfill disposal including leakage to groundwater, limited space, waste of natural resources and inclusion of non-biodegradable materials.

5. Have students use the groundwater model to demonstrate a leaking landfill. (Refer to Figure 3 in Appendix A. GREAT Ways to Use the Groundwater Model.)

6. Use the overhead "A Better Landfill" to show inadequate and well-designed landfills. Good landfills in the future will also have a leachate collection system to pump leachate collected in the liner to be treated. Also when full, a final cover over the top will prevent water from entering the landfill and creating more leachate.

7. Lead the discussion toward alternatives to landfill disposal in light of the problems identified in #6. Use the overhead "Solid Waste Alternatives."

Extension:
Have students determine how and where their personal garbage is taken. On a county map, locate the nearest landfill and relate its location to their home.

Solid Waste Quiz
Student Worksheet

Name____________________

____1. Each person in Iowa produces _______ pounds of solid waste a year.
a) 1200 b) 800 c) 500 d) 100

____2. The number of beverage containers used by Americans increased from 15 million in 1967 to _______ in 1985.
a) 85 million b) 150 million c) 1.5 billion d) 12.5 billion

____3. Every American uses ______ pounds of aluminum a day.
a) 16 b) 36 c) 56 d) 96.

____4. Each American uses ______ pounds of paper per year.
a) 18 b) 98 c) 280 d) 580

____5. Each day Americans throw away ______ pounds of food.
a) 400,000,000 b) 4,000,000 c) 400,000 d) 4,000.

____6. Each day Americans junk _______ cars.
a) 1,000 b) 5,000 c) 10,000 d) 20,000.

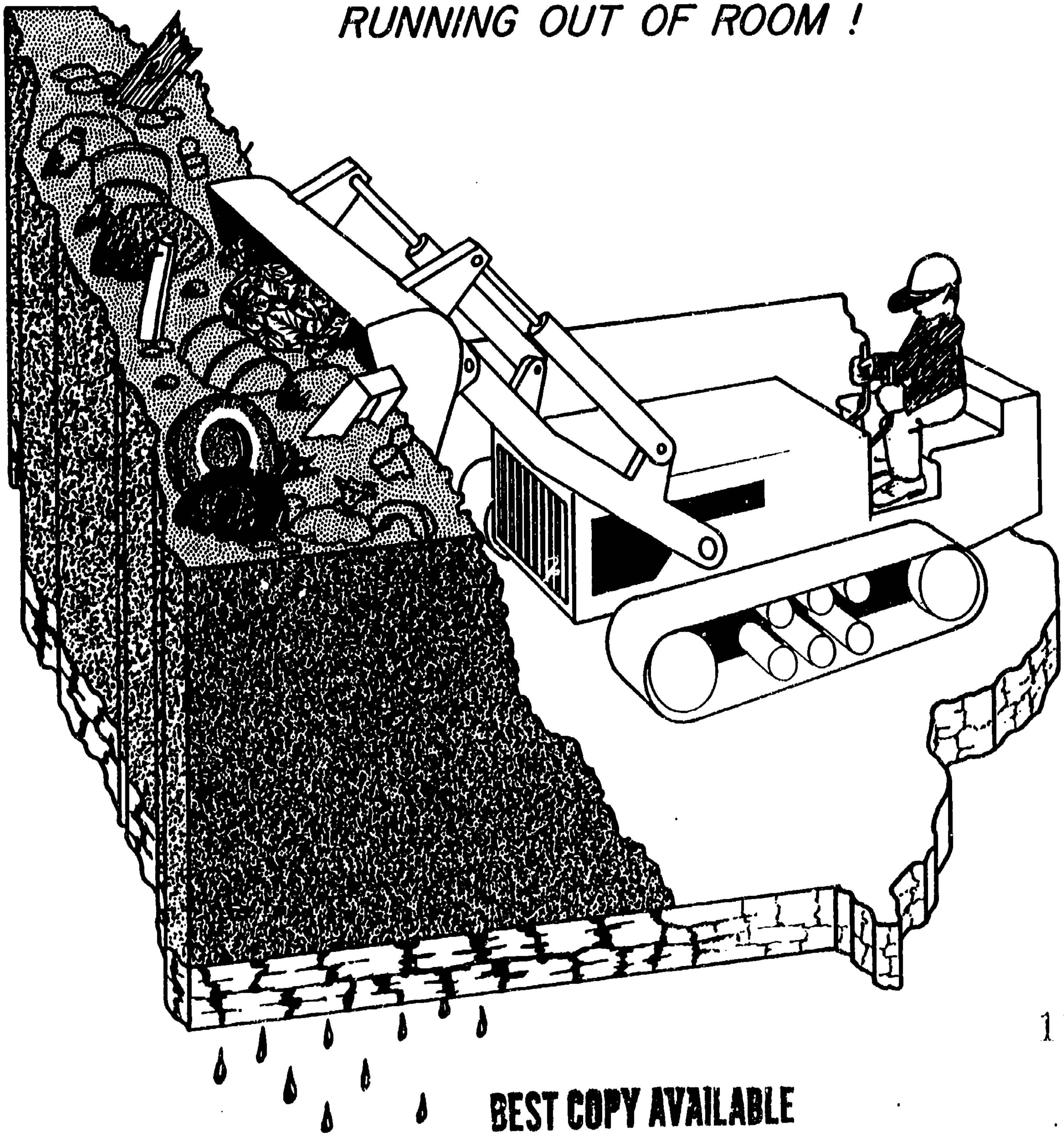
____7. Each day Americans discard _____ __ TV's.
a) 1,800 b) 3,800 c) 8,000 d) 18,000.

____8. What percentage of packaging (boxes, bags, and wrappers) is thrown out right away?
a) 90% b) 75% c) 50% d) 10%.

____9. Today, most solid waste is disposed of in....
a) a dump b) the sea c) an incinerator d) a landfill

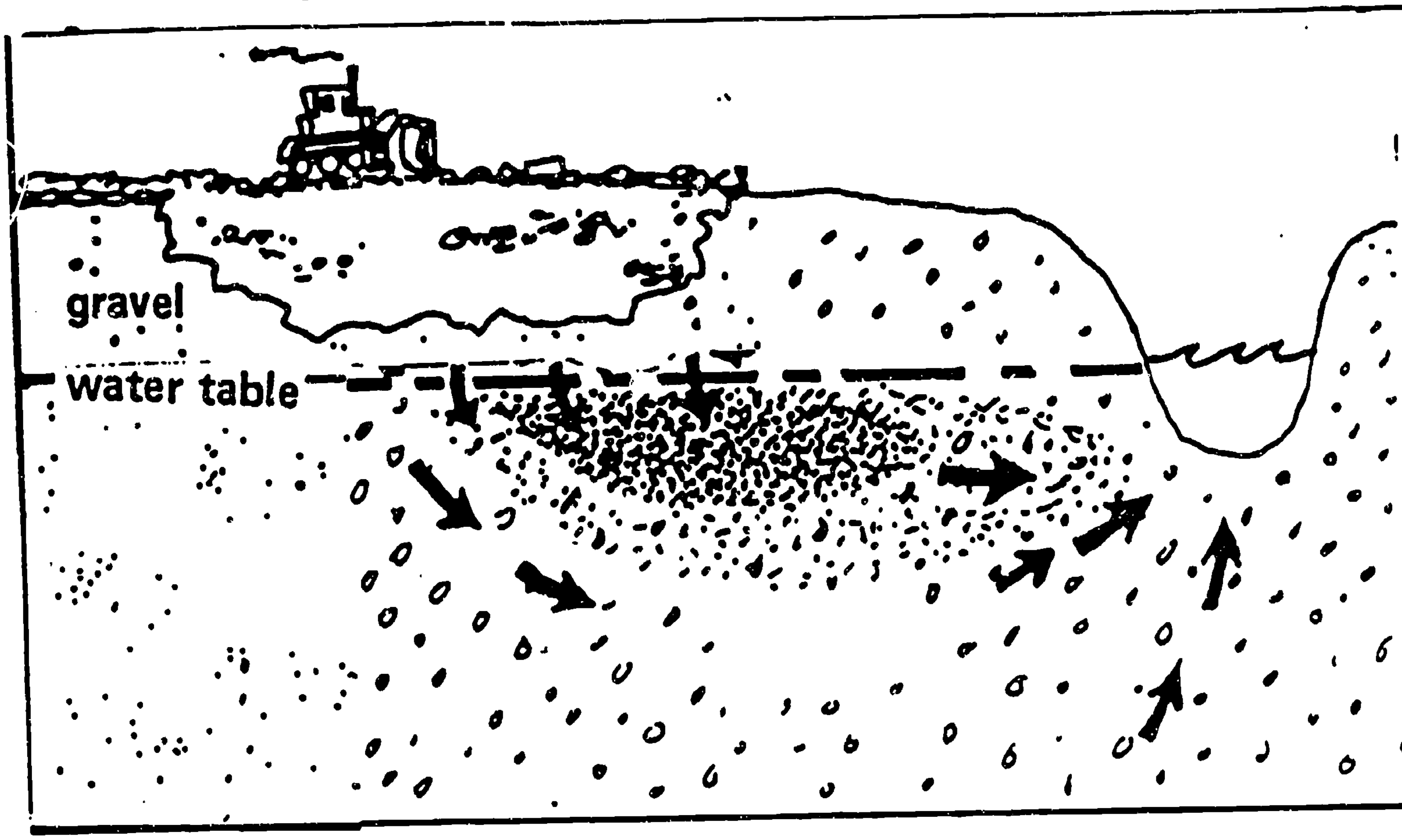
1[illegible]

RUNNING OUT OF ROOM !

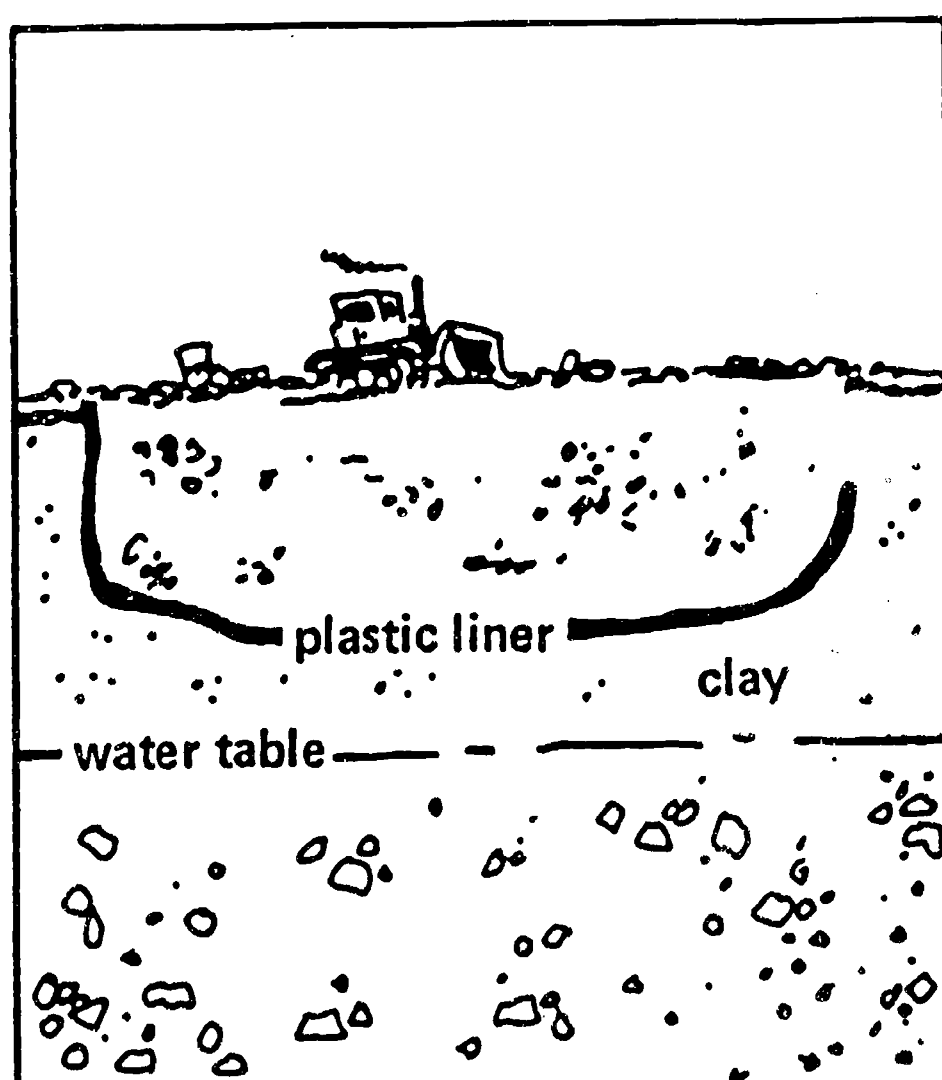


A Better Landfill

What's wrong with this landfill ?



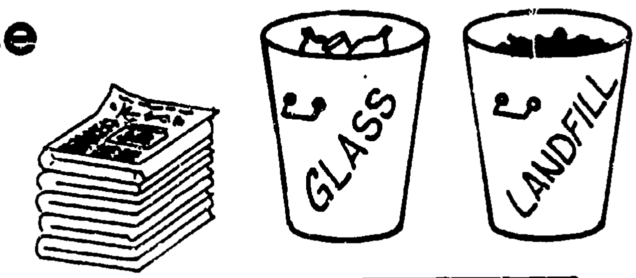
Why is this one better ?



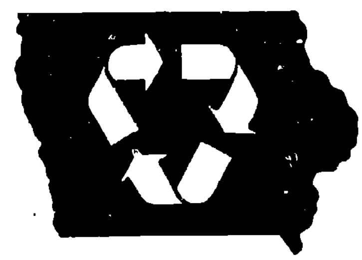
Solid Waste Alternatives

Overhead

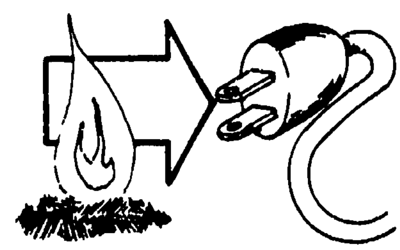
1. Volume Reduction at the Source



2. Recycling/Reuse

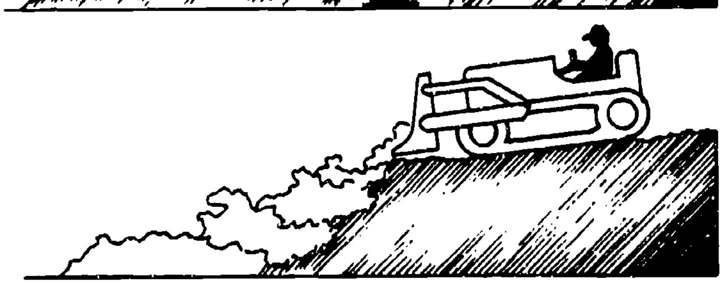


3. Incineration for Energy Recovery



4. Incineration for Volume Reduction

5. Landfills



Household Hazardous Materials

Earth/Life Science

2 Class Periods

Quick Summary:
Students will construct and use a Household Hazardous Waste Wheel to survey the hazardous materials in their homes as well as determine the harmful effects, proper disposal, and non-hazardous alternatives.

Objectives: Upon completion, students will be able to:
1. Construct the Household Hazardous Waste Wheel (HHWW) following a printed set of directions.
2. Use the HHWW to locate and identify hazardous materials in the home.
3. Identify ingredients from product labels and determine the health effects.
4. Compare label use and cautions to immediate hazard effects listed on the HHWW.
5. Compare label disposal directions to the type of disposal recommended on the HHWW.
6. List the appropriate safety measures to follow in storing and using hazardous products.
7. Evaluate the dangers of using and disposing of hazardous products in terms of a safe alternate use.
8. Describe the harmful effects of improper disposal on the environment.

Materials:
Glue
Manilla folders (2 per student)
Brads (1 per student)
Scissors (1 per student)

Printed/AV Materials:
Letter to the Parents
Worksheets: Household Hazardous Waste Wheel patterns and construction directions
Household Hazardous Materials Investigation
Household Hazardous Materials Inventory form
Overhead: How Toxicants Are Absorbed By The Body
Teacher Information:
See fact sheets: Toxicants In the Body
Household Hazardous Materials (2 pages)
Unsafe Hazardous Waste Disposal Practices
See Appendix G: Potential Hazards of Household Products Classified to Chemical Type

*****Safety*****
When students are doing the Household Hazardous Materials Inventory, parent or guardian supervision is recommended. Students should not open containers, should return containers to child-proof storage areas, and should wash their hands when finished handling the containers. If you did not send the letter to the parents at the beginning of this module, a letter at this time is recommended.

Procedure:
1. Distribute the HHWW patterns and directions along with materials needed to put the wheels together.

2. When the students have completed construction, demonstrate the proper use of the wheel. It would be helpful to have some samples of hazardous household products in the classroom.

3. Discuss terms used on the wheel such as toxic and corrosive and discuss how these products cause us harm. See fact sheet Toxicants In the Body. Use overhead How Toxicants Are Absorbed by the Body.

4. Distribute Household Hazardous Materials Investigation and Household Hazardous Materials Inventory form. To show students how to fill out the Inventory form at home, use a sample hazardous product and fill in the columns together using an overhead or chalkboard. As this is done,

discuss label requirements and precautions. Refer to fact sheets Household Hazardous Materials. Allow the students two to three days to complete the form at home.

5. On the inventory completion date, discuss some of the results. From discussion or access to Appendix H. Potential Hazards of Household Products Classified to Chemical Type, have students determine other health hazards. Warnings and precautions on the fact sheet may give students a clue to health hazards.

6. Discuss the feasibility of some of the alternatives in light of the health hazards of given products.

7. Close by finding out student ideas about what usually happens to the products when people no longer want them. How could such types of disposal harm the environment, especially groundwater? Refer to fact sheet Unsafe Hazardous Waste Disposal Practices.

Note--Inventory forms will be most effective if taken back to the student home for future family reference.

Alternate: Worksheet: What's in a Label?

Extensions:
1. Create a poster using an ad for a hazardous household product. Included on the poster should be the ad itself, how the product is harmful, what kind of advertising persuasion is used to appeal to the consumer, how the consumer can avoid or reduce the hazards, a description of a less toxic substitute, and information about proper disposal.
2. Create an ad for a safer substitute (T.V., newspaper, magazine, or radio).
3. Create a poster, brochure, or commercial to encourage proper use of hazardous materials, proper disposal of such hazardous products, and/or the use of safer substitutes.
4. Investigate how hazardous materials can enter our groundwater when poured down drains, toilets, sewers, and/or septic tanks. This may include a diagram of the path followed.

Reference:
Adapted from Household Hazardous Waste Wheel and Household Hazardous Waste Curriculum, Environmental Hazards Management Institute.

Dear Parent or Guardian:

Solid waste disposal is an important problem because of its implication for public health and its potential threat to groundwater supplies. As a part of our study of groundwater quality we will be conducting an inventory of hazardous materials found in the home.

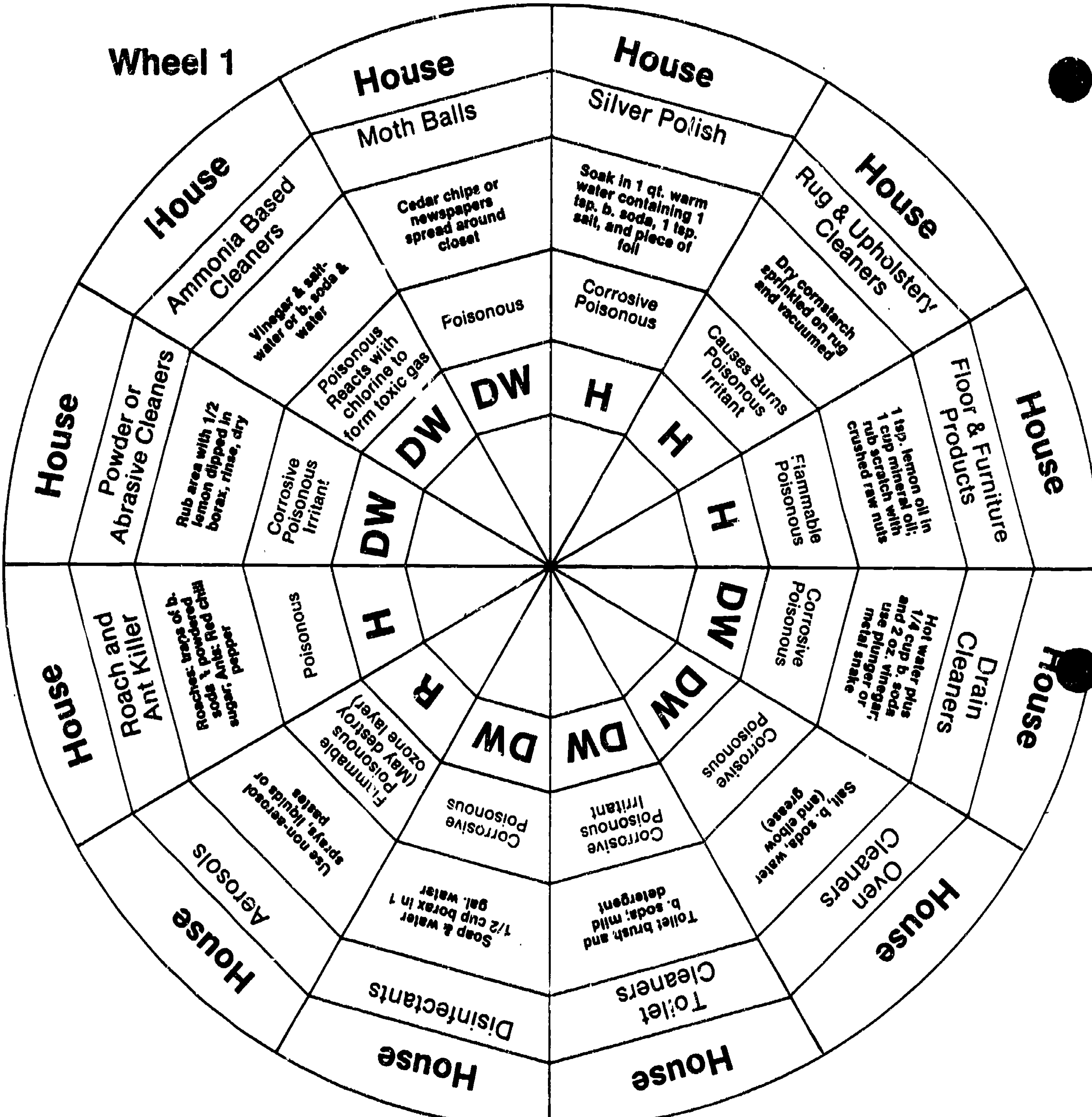
This activity should help each student recognize that they contribute to the solid waste problem. They will also learn to identify and use hazardous household products in a safe and effective manner. They will study solid waste management practices that will protect health and environment now and in the future.

We need your help in completing the home activities. The instructions are printed on the worksheets and can be easily followed by the student. We ask you to supervise the student for safety purposes.

Please make sure that all containers of hazardous products are securely closed and have been returned to a safe child-proof location after the necessary information is gathered for the worksheet.

Thank you for your help and cooperation.

Wheel 1

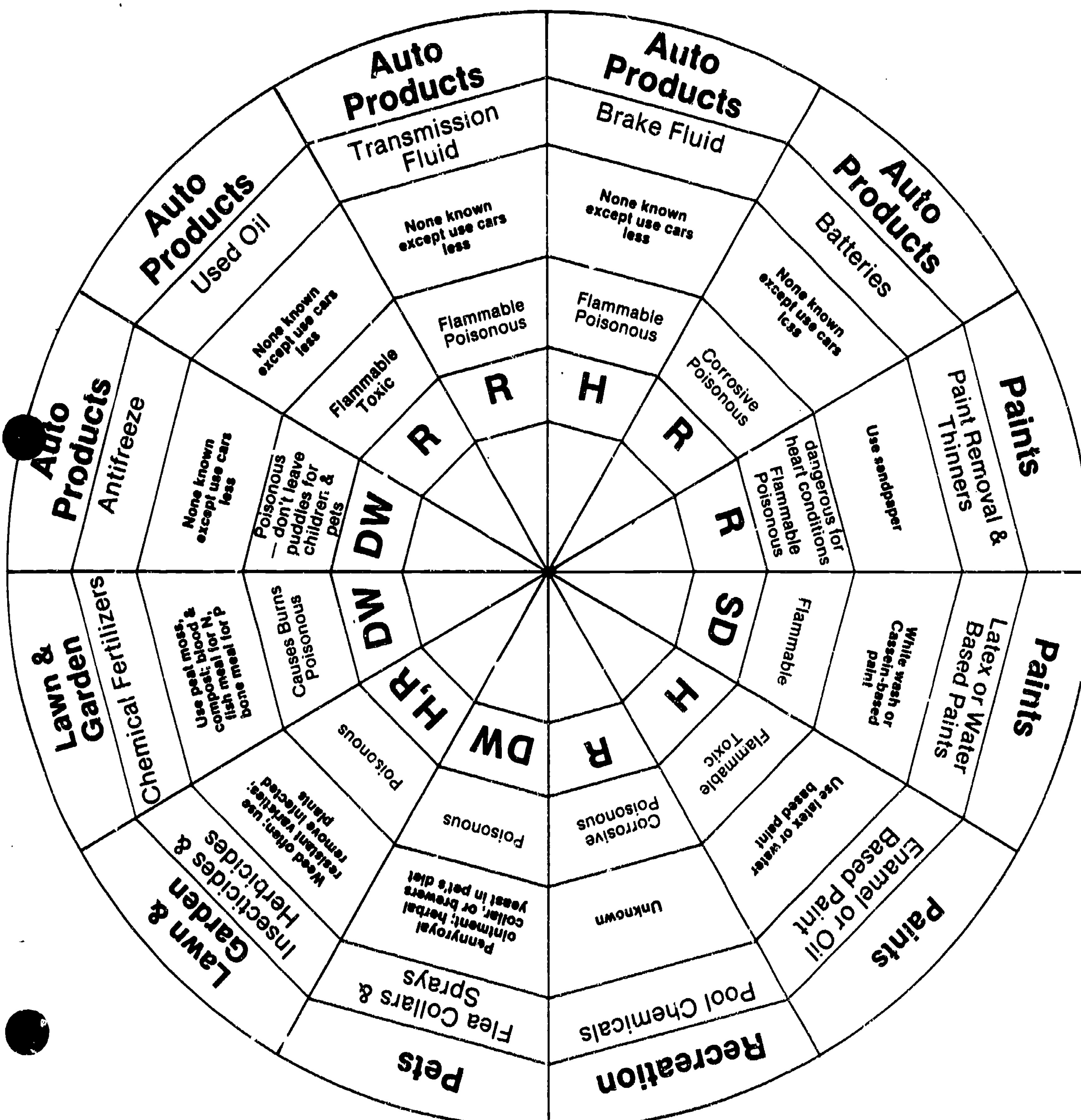


Directions for constructing the Household Hazardous Waste Wheel.

1. Cut a manilla folder in two pieces (cut along the fold).
2. Cut out wheel 1 found on this page.
3. Paste wheel 1 on one of the halves of the manilla folder.
4. With the wheel pasted to the folder, again cut out wheel 1.
5. Cut out wheel 2.
6. Paste wheel 2 on the back of wheel 1.

7. Make holder.

Wheel 2



Auto Products
Brake Fluid
None known except use cars less
Flammable Poisonous
H
Auto Products
Batteries
None known except use cars less
Corrosive Poisonous
R
Paints
Paint Removal & Thinners
Use sandpaper
dangerous for heart conditions Flammable Poisonous
R
Paints
Latex or Water Based Paints
White wash or Cassein-based paint
Flammable
SD
Paints
Enamel or Oil Based Paint
Use latex or water based paint
Flammable Toxic
H
Recreation
Pool Chemicals
Unknown
Corrosive Poisonous
R
Pets
Flea Collars & Sprays
Pennyroyal ointment; herbal collar, or brewers yeast in pet's diet
Poisonous
DW
Lawn & Garden
Insecticides & Herbicides
Weed often; use resistant varieties; remove infected plants
Poisonous
H,R
Lawn & Garden
Chemical Fertilizers
Use peat moss, compost; blood & fish meal for N, bone meal for P
Causes Burns Poisonous
DW
Auto Products
Antifreeze
None known except use cars less
Poisonous — don't leave puddles for children & pets
DW
Auto Products
Used Oil
None known except use cars less
Flammable Toxic
R
Auto Products
Transmission Fluid
None known except use cars less
Flammable Poisonous
R

1 1 ?

Holder 1

Waste Categories

Cut out this window

Products

Alternatives

Immediate Hazards

Waste Disposal

HOUSEHOLD HAZARDOUS WASTE WHEEL

This wheel simplifies a complex and controversial subject-the safe disposal of household wastes. For more detailed information contact 1-800-532-1114 in Iowa.

While proper use of hazardous substances may not pose a threat to the consumer, improper disposal may threaten groundwater quality.

The wheel provides information for proper waste management. A symbol identifies preferred options as follows:

Disposal Key

H-Hazardous waste program. Do not dispose. Keep safely stored until a hazardous waste collection/disposal program is held nearby.
DW-Dispose with Water. Fully use, rinse container, pour rinse water down drain that empties into a sanitary sewer with lots of water, or reuse according to label directions. Usually rinsed containers may then be deposited in landfill.
R-Recycle. Bring to a reclamation center or find someone who can use it.
SD-Special disposal. Air dry latex paints or aerosols in a cardboard box evaporate and solidify and discard empty containers and dry cardboard boxes.

Directions for making holder for Household Hazardous Waste Wheel.

1. Take another manilla folder and unfold it.
2. Place holder 1 on one side of the folder with the top along the fold.
3. Place holder 2 on the other side of the folder with the top along the fold.
4. The tops of the two holders should touch each other along the fold -- DO NOT CUT THIS FOLD.
5. Paste the holders to the manilla folder and cut them out, except for the top.
6. Place the wheel inside the holder; line up the center of each circle; and fasten with a brad.

Holder 2

Waste Categories

Products

Alternatives

Immediate Hazards

Waste Disposal

Cut out this window

HOUSEHOLD HAZARDOUS WASTE WHEEL

GENERAL SUGGESTIONS FOR THE STORAGE OF HOUSEHOLD HAZARDOUS WASTES

-Keep substances in the original container
-Keep a list of stored hazardous products which you maintain at home: include the name and the date of purchase
-Be sure label is securely affixed to the container
-Keep in a cool, dry place
-Keep substances out of reach of children and pets
-If the original container is leaking, enclose it in a larger container that is labeled appropriately
-Keep incompatible chemical products separated
-Periodically check containers for deterioration

PROPER USE OF PRODUCTS CONTAINING HAZARDOUS CHEMICALS

-Carefully read and follow the label's directions
-Use the product in the manner directed by the manufacturer of the product. For example, misapplication of oven and drain cleaners may cause irreparable eye damage.
-Do not mix chemical substances
-Use the product at the recommended strength
-Utilize every ounce of each product: buy only what you need; purchase small quantities if possible; give leftover products in the original container to others who may use them
-Use natural, less toxic products or alternatives when possible -Prevent the splashing of chemicals
-Keep areas well ventilated
-Secure lids tightly

Household Hazardous Materials Investigation

Student Worksheet Name______________________

***** Safety *****

1. Parent or guardian supervision is recommended for this project.
2. Make sure all containers are tightly closed.
3. Do not open containers as fumes may cause burns or might be poisonous.
4. Immediately return all containers to a child-proof storage area.
5. Wash your hands when you are finished handling the containers.

Procedure:

1. Using the Household Hazardous Waste Wheel (HHWW) and the "Household Hazardous Materials Inventory" sheet, locate hazardous products in your home and record the brand name (for example, Drano) on the inventory sheet. You may find types of hazardous materials not listed on the HHWW. If so, record as much information as you can about these.

2. Write down the type of product--for what it is used (for example, drain cleaner).

3. List hazards as found in the caution labels, directions for use, or HHWW.

4. List the label directions for disposal, if given.

5. If these are in agreement with the information on the HHWW, write yes in the appropriate column; if not, write no.

***Note:**

--Are all containers tightly closed and returned to a child proof storage area?

--Did you wash your hands?

Conclusion Questions: (Answer these on your own paper.)

1. List some of the signal words that you found on containers.

2. Were all of the ingredients in the product listed by name? How do you know this?

3. Were all of the hazardous materials being stored properly? If not, give one example. Make sure to describe how it should be stored.

4. Select three hazardous materials found in your home. Describe the hazards, the non-hazardous alternative, and the pros and cons of using the alternative.

5. List 3 common ways that people dispose of hazardous materials. Describe the risks to health and environment created by each.

6. Do you think that you contribute to contamination of our groundwater? If so, list some specific ways that you can cut down on such pollution. List ways that you might get others to help protect our groundwater from hazardous chemicals.

Look for Household Hazardous Materials in your:

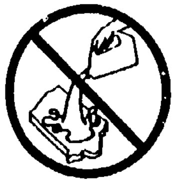
--Kitchen

--Bathroom

--Basement

--Garage

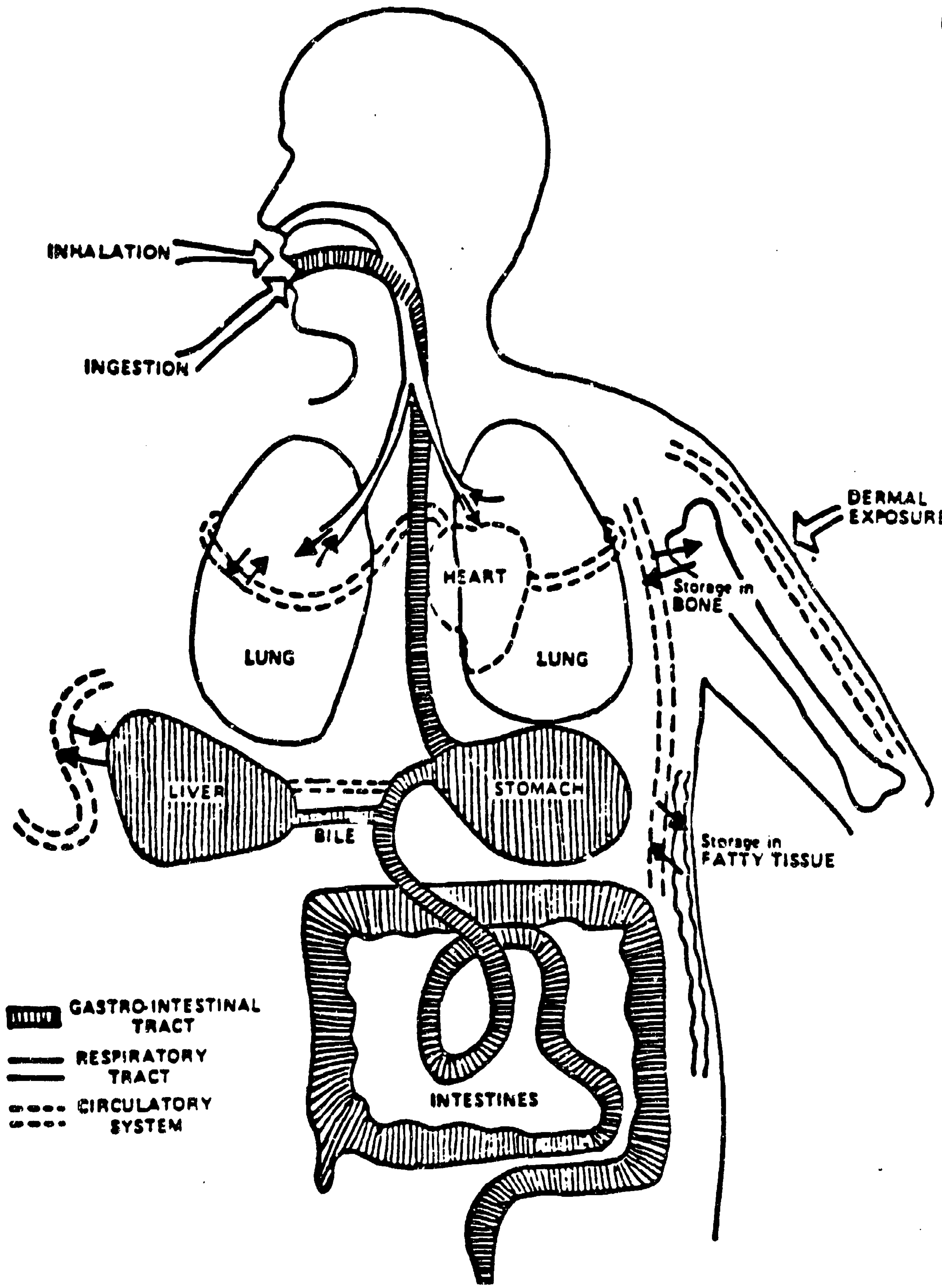
Household Hazardous Materials Inventory
Student Worksheet



Name____________________

Product Name	Type	Hazards	Label Disposal Directions	Agreement HHWW

How Toxicants Are Absorbed by the Body



from Toxics in My Home? You Bet!, Golden Empire Health Planning Center

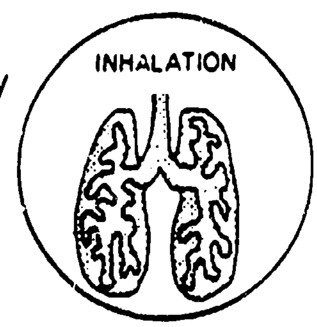
Fact Sheet: Toxicants in the Body

Toxic means poisonous. A poison is something that causes illness, injury, or death to any living thing. Some harmful effects appear immediately, but other health problems take a long time to develop. The amount of harm a person suffers from exposure to hazardous chemicals depends on: 1) the type of chemicals in the product, 2) how much of the chemical the person is exposed to, and 3) the physical makeup of the victim. Children, frail people, and the elderly suffer more harm from exposure than do healthy adults. Another concern is the potential adverse health effects resulting from the use of chemicals in combination with each other. The effect of a combination of chemicals is called the synergistic effect and little is known about the potential problems this causes.

There are three ways that toxic substances enter the body:

1. **Ingestion**--eating or drinking the toxin. The toxin enters the gastro-intestinal tract. Some substances will pass out the gastro-intestinal tract as feces, while others will pass from the stomach through the bloodstream to the liver. The liver can change many substances into a form that is more easily excreted. If toxic chemicals are not broken down, they may be stored in the liver or recirculated in the bloodstream. The liver can be severely damage by chemicals that destroy liver cells. The destroyed cells are replaced by scar tissue that impairs the liver function.

2. **Inhalation**--breathing in contaminated air. The toxin enters the respiratory system. A substance entering through the lungs passes directly into the circulatory system. Delicate tissues of the respiratory system can be damaged causing immediate respiratory problems or long term diseases.



3. **Dermal exposure**--skin contact. Substances absorbed through the skin may also pass into the circulatory system, and get carried around the body. Some will be removed by the kidneys and then passed out as urine. Others may be absorbed by the body's fatty tissues to reenter the blood stream whenever the fat is used.

Adapted from Toxics in My Home? You Bet.

Fact Sheet: HOUSEHOLD HAZARDOUS MATERIALS

General

According to federal law, a **hazardous substance** is:
"Any substance or mixture of substances which is toxic, corrosive, an irritant, flammable or combustible, a strong sensitizer, generates pressure, is radioactive, or can cause substantial injury or illness." (This applies only to immediate health effects, not long term.)

If a product fits the above definition, the **label** must contain the following:

- –Signal words such as "danger," "warning," or "caution" (front label)
- –Description of the hazard such as "flammable" (front label)
- –A statement warning users how to avoid the hazard such as "Use in a well ventilated room."
- –Common or chemical name for hazardous substance
- –If necessary, instructions for safe use
- –First aid instructions
- –Name and location of manufacturer or distributer
- –A warning that means "Keep out of the reach of children."

Toxic chemicals can be in the product that do not have to be labeled because they do not present an immediate hazard and/or make up less than four percent of the ingredients. Further adding to the confusion, the name of the hazardous substance does not have to be listed according to standard chemical nomenclature but by any number of chemical or common names. Also substances are often listed in vague terms.

Household Cleaners and Polishes

Cleaners and polishes are effective for the job they are designed to do because they contain strong chemicals. Some can destroy human tissue. Accidental drinking, breathing fumes, or skin and eye contact can result in injury and even death. Some harmful effects appear immediately and other health problems take a long time to develop. The effects of such products are not well studied. Air fresheners and deodorizers, for example, work by either desensitizing our sense of smell by coating nasal passages with an oily film or masking the unpleasant odor. Little is known about the health or environmental effects.

Solvents

A **solvent is** any substance that dissolves another substance. The most common solvent is water which is not hazardous. Other solvents such as turpentine are hazardous. Hazardous solvents are contained in such household products as dry cleaning fluids, furniture polish, nail polish and polish remover, paint, paint thinner, shoe care products, and aerosol sprays.

Solvents can be extremely **dangerous** to your health and safety, as well as harmful to the environment. Seven of the immediate health effects are: 1) itchy, burning, or tearing eyes; 2) itchy, burning, or dry skin; 3) nose, throat, or lung irritation; 4) coughing; 5) nausea; 6) headache; and, 7) dizziness, light headedness, or sleepiness. Long-term effects are liver and kidney problems, birth defects, and nervous disorders. Solvents are especially hazardous because they are so readily absorbed through skin and respiratory passages.

Pesticides

Pesticides are any substances used to kill or repel a pest. These pests include insects, weeds, and animals such as rats. Disinfectants are also considered pesticides since they destroy microorganisms.

Most pesticides are **poisons** and can also be harmful if swallowed by organisms other than pests. Authorities believe that between 60-90% of pesticides have not been tested for their ability to cause cancer, birth defects, or gene mutations. Chemicals are supposed to be tested for long-term effects but most pesticides are not, because they were on the market before the law was passed in 1972.

On labels, ingredients must be listed as active or inert. The term active applies to ingredients that do what the product is intended to do. The term inert refers to any other substances in the product. They usually are only there to make the active ingredient easy to apply. The term inert does not mean harmless. Some can be as dangerous as the active ingredients. Only the name of the active ingredient must be listed and the rest can simply be listed as inert and will probably make up the greatest percentage of ingredients. For example, organic solvents are often listed as inert, yet benzene, xylene, and toluene are known to cause cancer.

Some pesticides have been **banned** or **restricted**. These pesticides should be carefully stored and saved for a hazardous waste collection day. A partial list of these products follows:
Aldrin, Amitraz, Arsenic Trioxide, Benomyl, BHC, Bithionol, Chloranil, Chlordane, Chlorobenzilate, Copper Arsenate, DBCP, DDD (TDE), DDT, Diallate, Dieldrin, Dimethoate, EDB, Endrin, EPN, Fluorocetamide, Heptachlor, Kepone, Lindane, Mercury, Mirex, OMPA, Parathion, Polychlorinated Biphenyls, Phenarzine Chloride, Pronamide, Safrole, Silvex, Sodium Arsenite, Sodium Cyanide, Sodium Fluoroacetate, Strobane, Strychnine, Thallium Sulfate, TOK, Toxaphene, Trifluralin, Vinyl Chloride.

Information compiled from:

Household Hazardous Waste Curriculum, Environmental Hazards Institute.

Hazardous Household Products Handbook, Federation of Ontario Naturalists.

Groundwater Quality Protection in Oakland County: A Sourcebook for Teachers, East Michigan Environmental Action Council.

Toxics in My Home? You Bet!, Golden Empire Health Planning Center.

"Chemical Hazards in the Garage and Workshop," (poster), Illinois Hazardous Waste Research and Information Center.

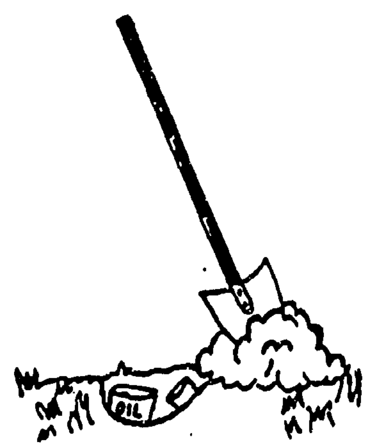
Fact Sheet: Unsafe Hazardous Disposal Practices

When hazardous chemicals are no longer needed or usable, too old, containers are corroding, inherited as part of a family estate, etc., people are faced with the problem of disposing of them. Often this is done by throwing them in a ditch or curbside, burying them on their own property, burning, throwing them in sewer systems/septic tanks, throwing them in the garbage, or continued storage. There are potential dangers in all of these unsafe practices.

Throwing in a Ditch or Curbside

Pets and children are most often threatened by this practice. Disposal of ethylene glycol (anti-freeze) in this manner is a common cause of fatal poisoning of pets since it is a sweet tasting but highly toxic substance. People may get these substances on their shoes and bring them into the home. Eventually rain will carry the residues into the gutters and down to our water supplies.

Burying



Burial of hazardous waste, especially in an uncontrolled site, almost certainly means the eventual contamination of water supplies as containers will corrode, leak, and leach into groundwater. Waste oil, which is most often buried or even worse, dumped directly into sewers and river, has devastating effects. One part oil to one million parts water (1 ppm) causes taste and odor problems in drinking water. Oil is contaminated with lead, a lethal metal, by gasoline transferred to the crankcase during combustion. Oil is also contaminated with many metals from engine wear.

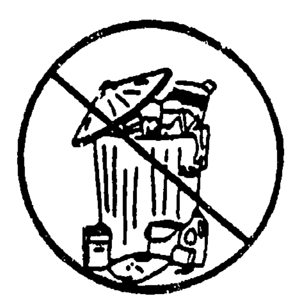
Burning

Toxic fumes can be created under high heat and the mixing of incompatible chemicals. Aerosol cans explode when exposed to high temperatures.

Pouring Into Sewer Systems/Septic Tanks

Sewer systems operate by having live organisms feed off the bacteria. If sufficient amounts of hazardous wastes are introduced, the organisms will be killed off, thus sending pollutants into waterways.

Throwing in the Trash



The trash is usually picked up by sanitation workers and compacted. Many cases of serious injury have resulted when chemicals splashed on them from the garbage truck or toxic fumes were created from mixing of various wastes by the compactor. Eventually this garbage ends up in a landfill which is not designed to contain hazardous wastes. Some of the hazardous wastes sites targeted for cleanup by the government were once community landfills.

Storing

Storing toxic chemicals indefinitely can also be a problem. It provides greater opportunity for children to be exposed to the product and an increased fire hazard. Containers often corrode and leak.

Adapted from Toxics in My Home? You Bet!

1?5

What's In a Label?

Earth/Life Science — 1 Class Period

Quick Summary: Students will use sample labels of hazardous household materials to answer questions about the proper use, disposal, safe alternatives, and harmful effects on health and groundwater.

Objectives: Upon completion, students will be able to:
1. Locate specific information from product labels.
2. Recognize "signal" words that give the hazards of the product.
3. Generalize from label information the dangers of the product to immediate health.
4. Discuss the possible danger of the product to the environment.
5. Decide if they would use a given product and formulate reasons for this decision.

Materials: None
Printed/AV Materials:
Worksheets: What's in a Label?
Student Information: (which can be reused by multiple classes)
Sample Product Labels A-B
Home Sweet Hazards brochure (2 pages)

Teacher Information:
Answer sheet
See fact sheets: Household Hazardous Materials
Toxicants in the Body
Unsafe Hazardous Waste Disposal Practices

Procedure:
1. Hand out the brochure, Home Sweet Hazards, A Guide to Household Hazardous Materials, and discuss. According to Iowa law, this brochure should be available wherever hazardous household materials are sold.

2. Hand out Sample Labels A-B. Present information about labeling. See the fact sheet, Household Hazardous Materials.

3. Hand out the worksheet, What's in a Label? Allow students to complete this.

4. Conduct a follow-up discussion using the fact sheets, Toxicants in the Body and Unsafe Hazardous Waste Disposal. (Refer to Hazardous Household Materials activity.)

5. Collect information sheets for the next class if necessary.

Reference:
Product labels from Toxics in My Home? You Bet!, Golden Empire Health Planning Center.

What's In A Label?
Answers

Product A
1. Toilet Bowl Cleaner
2. Signal word: danger
3. Yes. It is dangerous because it produces chemical burns, may be fatal if swallowed, and fumes are harmful to breathe.
4. 90.75% inert ingredients which are substances that make the active ingredients easier to apply but present no immediate hazard. They can be harmful, because they may cause long-term health or environmental problems.
5. Call the Poison Control Center or physician first.
6. Use all contents, discard in trash according to label directions.
7. Do not reuse empty container; wrap in plastic, & discard.
This is to prevent any remaining contents from leaking out. It will probably go to a landfill. Since it is nonbiodegradable, it will remain unchanged for centuries.

Product B
1. Garden Spray
2. Can poison by swallowing, inhalation, or skin contact.
3. From the label you need: what its dangers are, how it should be used safely, and on what kinds of plants it should be used.
4. First aid is under danger and antidote.
5. Perhaps it should not be put in the garbage or they are not sure of regulations in various states.
6. Ask your extension agent or garden center for organic alternatives.

What's In A Label?
Student Worksheet

Name____________________________

Product A

1. What is the product name?

2. What is the signal word on the front label?

3. Would you consider this a dangerous product? Explain

4. What is the percentage of inert ingredients?

What are inert ingredients?

Can they be harmful? Explain your answer.

5. First aid directions (internal) are given. If possible, what should you do before following these directions?

6. According to "Home Sweet Hazards," what are the disposal practices for this type of product?

7. According to the label, how are you supposed to dispose of the empty container?

What do you think is the reason for this kind of disposal?

What will happen to a container disposed in this way?

Product B

1. What is the product name?

2. What are the ways that this product can poison you?

3. What information do you think you would need from the label before using the product?

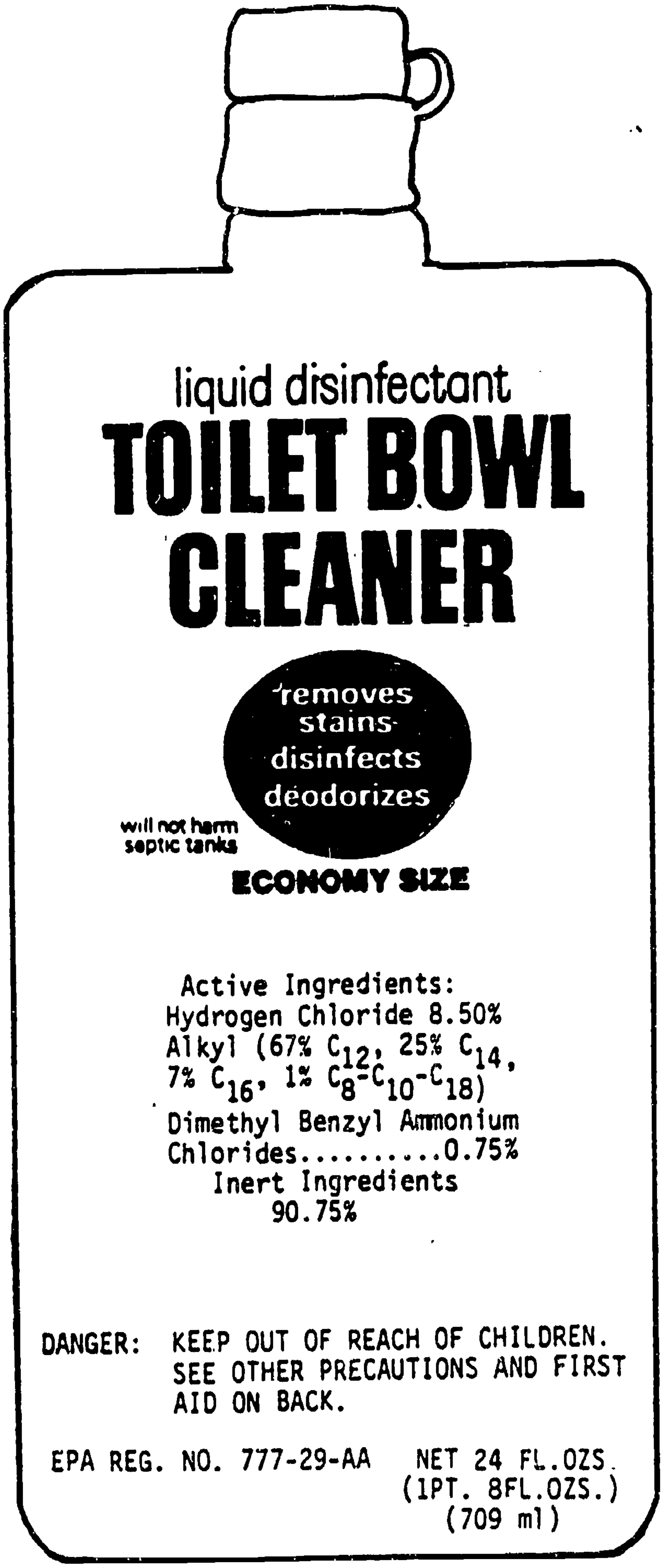
4. Where on the label do you find first aid treatment?

The treatment given, if this product is swallowed, is salt water to cause vomiting. This is proven to be a dangerous procedure, causing death in some children because of too much salt. If possible what should you do first before given such treatment?

5. There are no directions for disposal. What reasons would a company have for not giving such information?

6. According to "Home Sweet Hazards," what are ways to reduce or eliminate the use of this type of product?

Product A



Back Label

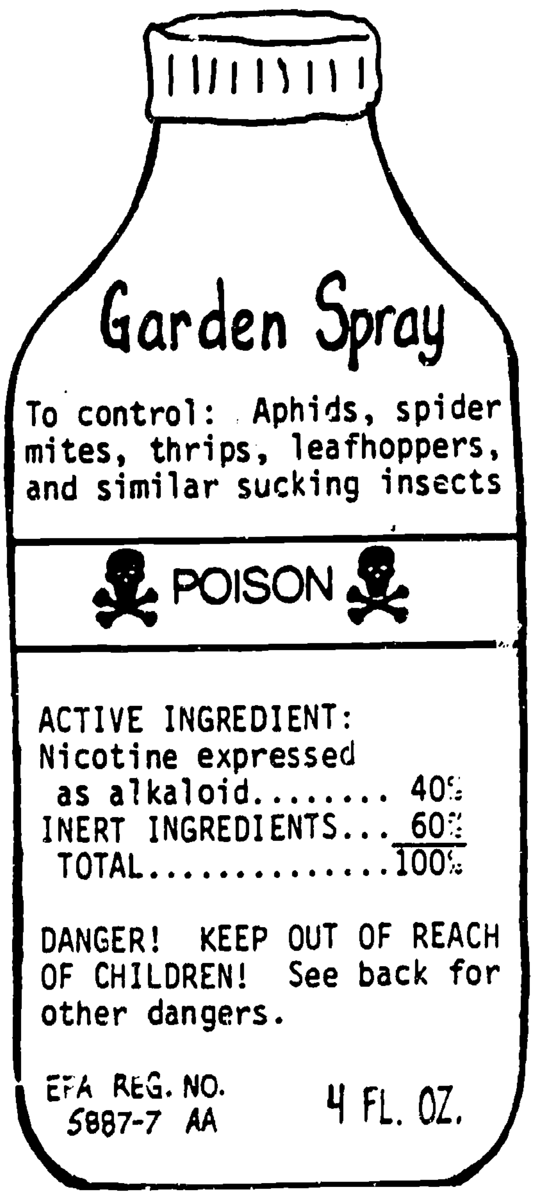
Directions: Point arrow away from you when opening or closing cap. Place finger under flip top and pull to open. After opening the cap point the top of bottle down into the bowl. . . . . .Close cap securely after each use. Rinse brush before putting away.

Disposal Direction: Do not re-use empty container. Wrap empty container in plastic bag and discard. Will not harm white or colored bowls. Will not harm plumbing. This product has been specially formulated for use only in toilet bowls; it should not be used or placed on toilet lids, vanities, sinks, bathtubs, etc.; it should not be used with chlorine (bleach) or other chemical products.

Danger: Corrosive--produces chemical burns. Contains Hydrochloric Acid. Do not get in eyes, on skin, or on clothing. May be fatal or harmful if swallowed. Do not breathe vapor or fumes. Keep out of reach of children.

First Aid: Internal--call a physician immediately. Drink a teaspoonful or more of magnesia, or small pieces of soap softened with water in milk or raw egg white.
External--Eyes--Wash with water for 15 minutes. Get prompt medical attention.
Skin--Wipe off the acid gently, immediately flood the surface with water, using soap freely, then cover with moist magnesia, or baking soda.

Product B



Back Label

Garden spray may be used to control: Aphids (plant lice), spider mites, thrips, leafhoppers, rose slugs, leaf miners, lacebugs, scale crawlers and other sucking insects on roses, gladioli, chrysanthemums and certain other ornamentals. Can also be used on grapes, apples, apricots, cherries, peaches, plums and citrus fruit to control certain specified sucking insects (see instruction sheet). Can be used on peas, tomatoes, onions and cabbage to control specified insects.

Use Garden Spray on the farm for poultry to control chicken lice and feather mites.

Danger: Garden spray is poisonous by swallowing, inhalation or skin contact. Do not breathe vapor or spray mist. Do no get in eyes, on skin, or on clothing. In case of contract, immediately flush skin or eyes with water and get medical attention for eyes. Launder clothing before re-use.

Antidote: Call a physician immediately. Give a tablespoonful of salt in a glass of warm water and repeat until vomit fluid is clear. Have victim lie down and keep warm. Give strong tea or coffee. Give artificial respiration if breathing has stopped.

Notice: Buyer assumes all risks of use, storage or handling of this material not in strict accordance with directions given herewith.

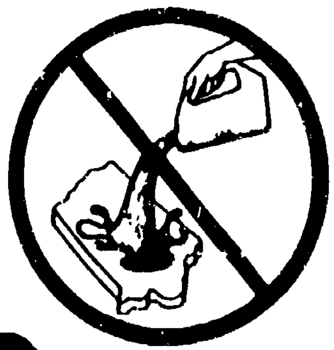
Directions: Mix Garden Spray with water at the rate of three teaspoonfuls in 1 gallon of water to which has been added one ounce of soap. Spray both upper and lower sides of foliage thoroughly with this solution. Repeat applications when necessary.

To control feather mite, apply Garden Spray to tops of the perches three times, three days apart at the rate of one ounce to 15 feet of roost. Repeat treatment when necessary

HOME SWEET HAZARDS

III-40

A GUIDE TO HOUSEHOLD HAZARDOUS MATERIALS



GENERAL TIPS ON HAZARDOUS PRODUCTS

USE:

- Read the label and follow directions.
- Keep unused products in their original containers. The correct label provides directions for use and proper poison treatment.
- Always store in a safe place.
- Buy only what you need.
- Be aware of the uses and dangers of products. If the directions are unclear, contact the manufacturer or dealer before using.
- Never mix different products; explosive or poisonous chemical reactions may occur.
- Use the exact amount specified; twice as much does not mean twice the results.
- Avoid skin contact and breathing fumes.

DISPOSAL:

- Never dispose of products containing harmful chemicals down the drain unless you know they can be treated. Many toxic substances disturb septic tanks or pass right through the treatment systems into rivers or lakes.
- Find a friend, neighbor or business who can use up excess products for their intended purpose.
- In an emergency, see phone numbers on the back.

PLEASE SAVE AND POST
FOR HANDY REFERENCE

NEED HELP? CONTACT:

EMERGENCY .... Check your local phone directory

UNIVERSITY OF IOWA POISON CONTROL CENTER 1-800-272-6477

To report hazardous substance spills in Iowa regardless of quantity .... 515-281-8694 (24 hr.)

Household hazardous materials information 1-800-532-1114

For information regarding risks associated with exposure to toxic substances, Natural Resources Defense Council 1-800-648-NRDC

Household products safety information can be obtained from your County Extension Service or write Consumer Product Safety, Washington, D.C. 20207

According to Iowa law, this logo should appear on the retailer's shelf wherever Household Hazardous Materials are sold. The shelf stickers, informational signs and this brochure are all made possible through funds retailers pay for a state license to sell Household Hazardous Materials and their cooperation in this environmental improvement program.

KINDS OF WASTES CONSIDERED TO BE HAZARDOUS

- EXPLOSIVE
- INFECTIOUS
- CORROSIVE
- RADIOACTIVE
- TOXIC

People have always produced hazardous wastes, but in the twentieth century the amount and variety have greatly increased. The kitchen drain and garbage truck are no longer viable options for disposal of many of these chemicals. Alternative disposal options must be sought such as:

- recycling
- incineration
- community collection programs

IN THE GARDEN

PRODUCTS IN THIS CATEGORY INCLUDE:

Pesticides Insect Sprays Weed Killers

TOXIC EFFECTS: All pesticides and herbicides are designed to kill specific pests. They are also poisonous to people, pets and wildlife.

SPECIAL WARNING: The following pesticides are now banned from sale or severely restricted in use:

DDT	Aldrin	Dieldrin	Chlordane
DBCP	Heptachlor	Lindane	Kepone
Mirex	Silvex	2,4,5-T	Toxaphene

Do not over-water; pesticides and fertilizers can run off with the excess water into nearby storm sewers or waterways.

ALTERNATIVES: Ask your garden center for organic alternatives to garden chemicals. When alternatives are not available, buy only small quantities and share the leftovers with neighbors and friends.

DISPOSAL: Never dump into any sewers, storm drains or septic tanks. Use all of the product before discarding empty container into trash destined to go to a landfill.

III-41

IN THE HOUSE

EXAMPLES OF HOUSEHOLD PRODUCTS CONTAINING TOXICANTS INCLUDE:

Oven Cleaners	Floor Wax
Spot Removers	Deodorizers
Furniture Polish	Drain Cleaners

TOXICANTS FOUND IN THESE PRODUCTS ARE:

Lye	Trichloroethane
Phenols	Napthas
Petroleum Distillates	Dichlorobenzene

TOXIC EFFECTS: Many of these are immediately poisonous or accumulate to toxic levels in people, fish and wildlife.

ALTERNATIVES: For clogged drains consider boiling water, snaking with a metal line and/or using a plunger. Use biodegradable and low phosphate products when possible.

Baking soda can be used for general cleaning.

All-purpose cleaner — 4T baking soda, 2 t. pure soap, 1 qt. warm water.

Lemon oil combined with mineral oil can be used to polish furniture. Other formulas also work well.

Furniture polish — 1 T vinegar, 1 T olive oil, 1 pt. warm water. This can be put into a spray bottle & warmed in the microwave oven before use.

DISPOSAL: Use all of the product, according to label instructions, before discarding empty container in trash. Look for disposal instructions on the container. Do not put into any drain unless label instructions say to, or primary product use is drain cleaner.

> Wastes which are *not* considered to be hazardous include:
> laundry detergents or soaps, dishwashing compounds, chlorine bleach and personal care products

IN THE GARAGE

TOXICANTS ARE FOUND IN THE FOLLOWING AUTOMOTIVE PRODUCTS:

Motor Oil	Engine Cleaners
Degreasers	Engine-radiator flushes
Batteries	Antifreeze
Car Wax and Polish	Rust Preventatives
Gasoline	

TOXIC EFFECTS: Waste oil and antifreeze are toxic to people, fish and wildlife. Waste oil contains heavy metals like lead and zinc, and petroleum hydrocarbons. Pets may die after drinking from sweet tasting puddles of antifreeze on driveways.

SPECIAL WARNING: Dumping waste oil into sewers, storm drains or any body of water is illegal.

DISPOSAL: Many local service stations will accept waste oil for recycling.

IN THE WORKSHOP & HOBBY AREA

PRODUCTS IN THIS CATEGORY INCLUDE:

Old Paint	Paint Strippers
Preservatives	Art Supplies
Solvents	Photographic Chemicals
Brush Cleaners	

TOXICANTS IN THESE PRODUCTS INCLUDE:

Lead	Ferrocyanide
Cadmium	Silver
Arsenic Oxide	Hexavalent Chromium
Asbestos	Potassium Dichromate

TOXIC EFFECTS: Many of these substances are suspected carcinogens, poisonous to people and animals, or capable of accumulating to toxic levels in the environment.

DISPOSAL: Solvents, paint thinners and wood preservatives, in particular, should not be dumped in any sewer system.

Let used turpentine or brush cleaner sit in a closed jar until paint particles settle out. Then strain and reuse; wrap the waste material and discard in the trash.

Septic tank systems can handle some photographic wastes, as long as the ratio of human to photographic wastes is no less than 10-1. However, solutions with sodium or potassium dichromate must be neutralized or filtered before dumping in the septic system.

Shopping for the Environment

Earth/Life Science 1 class period

Quick Summary:
Students will make purchasing decisions about products displayed by the teacher based on which products are least damaging to the environment.

Objectives: Upon completion, students will be able to:
1. Classify waste as biodegradable or nonbiodegradable.
2. Compare the relative energy use for producing and/or using some household products.
3. Identify the relative pollution potential of some household products.
4. Classify some household products as hazardous or nonhazardous.
5. Classify waste as recyclable, reusable, renewable or none of these.

Materials:
Products (See attached list)

Printed/AV Materials:
Student Shopping List
Teacher's Product List
Teacher's Discussion Sheet

Procedure:
1. Lay out products on tables before students arrive.

2. Hand students their "shopping list" and direct them to write their product choice in the second column. They are not to write in the third column yet.

3. The students are to make their choice based upon which product they believe is best for the environment. They are encouraged to read labels to look for clues but are warned that the label information may not be enough to make an informed choice. They will need to rely on their own knowledge and common sense.

4. Students are encouraged to talk with others about their choices as they do their shopping.

5. Shopping will take 20-30 minutes for most students, then the remainder of the class period (and/or a portion of the next) can be used for discussion. Refer to the discussion sheet.

6. Students may rate their own ability to make good choices by writing the Eco-rating for the products they chose in the third column during the discussion.

Shopping for the Environment
Student Shopping List

Name ____________

Item	Your Choice	Eco-rating
Apples		
Light Bulbs		
Bread		
Candy		
Bug Killer		
Soda Pop		
Carrots		
Toilet Paper		
Fish		
Window Cleaner		
Hair Spray		
Paint		
Detergent		
Milk		
Picnic Plates		

Shopping for the Environment
Teacher's Product List

Item	Product Choices
Apples	Canned applesauce--Fresh apple
Light Bulbs	75 watt--40 watt
Bread (French)	Wax paper wrap--Foil wrap
Candy	Large bar, paper wrap--Bag of small bars, foil wrap
Bug Killer	Roach motel--Fly swatter--Aerosol spray insecticide
Soda Pop	Can--Glass bottle
Carrots	Canned carrots--Fresh carrot
Toilet Paper	Printed and colored--White
Fish	Frozen raw fillets--Pre-cooked, shaped, breaded, frozen
Window Cleaner	Pump spray--Aerosol
Hair Spray	Pump spray--Aerosol
Paint	Oil base can--Oil base aerosol spray--Latex base can
Detergent	High phosphate--Low phosphate, biodegradable
Milk	Plastic jug--Paper carton
Picnic Plates	Paper--Foam plastic

Note: Student interest in this activity is greatly enhanced by full packages of real products.

Shopping for the Environment
Teacher's Discussion Sheet

Introduction
When choosing what to buy at the store, people rely on many different criteria. Some always choose the least expensive item, while others (for whatever reason) always choose the most expensive. Some look for the best value, some a certain brand, and still others will consistently choose the blue one. In this exercise the students are asked to disregard their normal choices and to choose the product which is best for the environment. No coaching is provided for what "best for the environment" means. The students are encouraged to pick up the products and to read the labels but they will also have to rely on their own knowledge and experience to make good choices. Factors of recycling, energy, pollution and others will enter into their decisions.

The students write their choices on their shopping lists and then rate their own decisions as the follow-up discussion goes on.

Product Discussion:

Item	Choice
Apples	Choose the fresh apple which requires much less energy and resources to bring to you. Score Canned = +2 Fresh = +1
Light Bulbs	Choose the 40 watt bulbs which use less energy Score 75 watt = +2 40 watt = +1
Bread	Choose the paper wrap which is biodegradable Score Foil = +2 Paper = +1
Candy	Choose the large bar which has less (biodegradable) wrap than the small bars Score small bars = +2 Large bar = +1
Bug Killer	Choose the fly swatter which may be reused many times or the roach motel which is all biodegradable and non-toxic Score Spray = +3 Fly swatter or Roach motel = +1
Soda pop	Choose the bottle which may be reused many times then recycled. The can is only used once and is from a more scarce and energy expensive resource. Score Can = +2 Bottle = +1
Carrots	Choose the fresh carrot (See the apple discussion) Score Fresh = +1 Canned = +2
Toilet Paper	Choose the plain white because the dyes are chemical pollutants for ground and water Score Colored = +2 White = +1
Fish	Choose the fresh frozen fillets which require much less energy to process and prepare Score Fresh frozen fillets = +1 Pre-cooked = +2
Window Cleaner	Choose the pump spray which does not contain polluting propellants and wastes much less chemical into the air Score Aerosol = +3 Pump = +2 (Both contain toxins)

Hair Spray	Choose the pump spray which does not contain polluting propellants and wastes much less chemical into the air Score Aerosol = +3 Pump = +2 (Both contain toxins)
Paint	Choose the cans over the aerosols (See above) Score Aerosol = +3 Cans = +2
Detergent	Choose the low phosphate biodegradable for less water and soil (ground water) pollution. Score High P = +2 Low P = +1
Milk	Choose the paper carton because it is biodegradable Score Plastic jug = +2 Paper = +1
Picnic Plates	Choose the biodegradable paper Score Plastic foam = +2 Paper = +1

Score: The best (lowest) score possible is 17.

Questions for discussion:

1. None of the products were given an Eco Rating of zero even though they were fresh or non-polluting. How do you explain this fact?
Answer: All products require resources and energy to deliver them to you, therefore all have some environmental cost.

2. What is the meaning of the following terms?
Biodegradable
Toxic-
Recycle-
Reuse-
Pollution-
Resources-
Conservation (Conserve)-

3. In what way is reusing products better for the environment than recycling?
Answer: Requires less energy and resources.

4. In what way is recycling materials better for the environment than throwing away the old and making new?
Answer: Uses less energy and resources, creates less solid waste and pollution.

5. When choosing what to buy, what criteria do you rely on the most? Would you ever use the "what is best for the environment" criteria alone without regard to other factors?

6. How do dyes and other chemical toxins get into the ground and surface water supplies?
Answer: They percolate through the soil or enter through untreated waste and poor management practices.

There Must Be a Better Way!

Earth/Life Science — 1/2 class period

Quick Summary: Students will list alternatives for discarding items.

Objectives: Upon completion, students will be able to:
1. List alternate uses for items discarded in the trash.

Materials: None

Printed/AV Materials:
Worksheet
Overheads: Let's Do Away With Trash
Ten Ways to Reduce

Procedure:
1. Have students complete the worksheet. Challenge them to not repeat any answers--otherwise many may just use recycling for almost everything. Remind them to be practical. If students have trouble generating ideas, let them read Ten Ways to Reduce.

Item	Ways to Reduce Amount or Eliminate From the Landfill
a. Notebook paper	Use both sides or recycle
b. Paper napkin	Cloth Napkin
c. Disposable diaper	Cloth diaper or diaper service (someone else washes the cloth diapers)
d. Worksheets	Use both sides or a blackboard or slates or recycle
e. Newspaper	Share with a friend or recycle
f. Kleenex	Handkerchief
g. Plastic sandwich bag	Reuse it or use waxed paper
h. Plastic garbage bag	Use grocery sacks or shopping bags instead
i. Lawn clippings	Compost, or cut grass higher and leave on the lawn
j. Moldy bread	Compost
k. Pop can	Recycle
l. Mayonnaise jar	Reuse or recycle
m. Old shirt	Give it to Good Will or other second-hand clothing outlet
n. Broken toy	Fix it

2. Use overheads to discuss waste alternatives. In 1989, a law was passed on Waste Volume Reduction and Recycling with the goal to reduce the amount of materials in the waste stream 25% by 1994 and 50% by the year 2000. What will your students do to help reach that goal?

Alternative:
Brainstorm ideas for the worksheet as a class.

Extension:
Have students survey their garbage at home or school and list the materials thrown away in one day. List alternatives for the specific items found in the garbage.

There Must Be a Better Way!
Student Worksheet   Name________________________

For each item below, write at least one way that will either put less in the landfill or keep it out completely. Make sure your alternatives are practical. **Try not to use the same answer twice.**

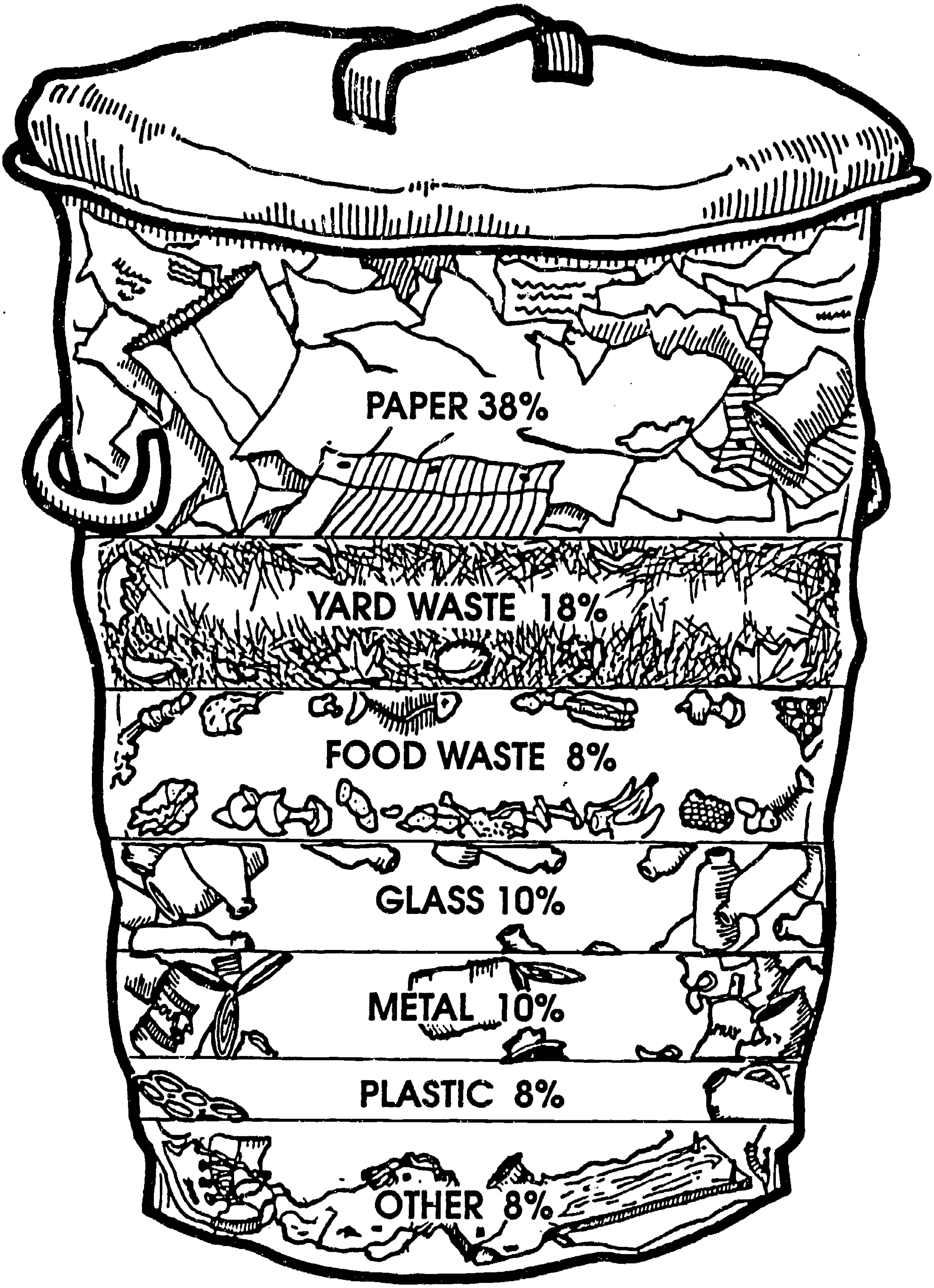
Item	Ways to Reduce Amount or Eliminate From the Landfill
a. Notebook paper	
b. Paper napkin	
c. Disposable diaper	
d. Worksheets	
e. Newspaper	
f. Kleenex	
g. Plastic sandwich bag	
h. Plastic garbage bag	
i. Lawn clippings	
j. Moldy bread	
k. Pop can	
l. Mayonnaise jar	
m. Old shirt	
n. Broken toy	

List three things you plan to do this week to put less in the garbage.

1 1

Let's Do Away With Trash

Overhead



Figures from EPA Municipal Waste Stream Analysis, by Franklin & Associates.

Ten Ways to Reduce (Solid Waste, that is) Overhead

1. Buy products that will last. Read and evaluate the warranty.

2. Buy products in recyclable, returnable, or refillable containers.

3. Don't buy items that are disposable such as pens, razors, diapers, etc.

4. Don't buy excessively packaged items.

5. Buy in larger quantities whenever possible as these use less packaging per ounce. Toothpaste is a good example. (Hazardous chemicals are an exception -- buy only what you need of these.)

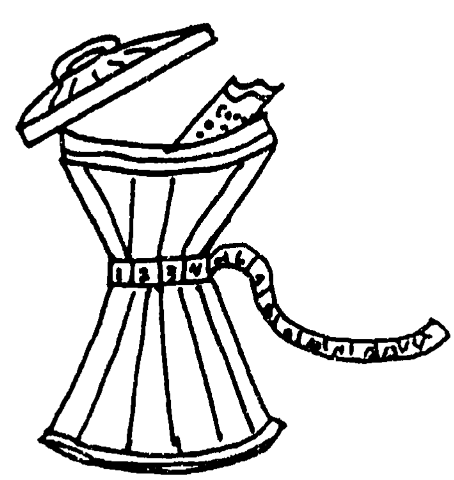
6. Cooperate in recycling projects by separating cans, bottles, newspapers, etc.

7. Buy products packaged in recycled materials.

8. Use less paper. Don't use paper plates, write on both sides of the paper, use scratch paper for notes.

9. Reuse products. Find another use for items. If you really don't need an item, take it to a garage sale, exchange it, or donate it to charity.

10. Pass on the good news. Influence others to reduce.



Let's Recycle (Paper)

Life Science — 1 1/2 class periods

Quick Summary: Students will recycle used paper and compare the environmental effects of manufacturing paper from trees to the recycling process.

Objectives: Upon completion, students will be able to:
1. Recycle paper from used paper.
2. Compare energy usage of manufacturing paper from trees to the recycling process.
3. Discuss the effects of the use of trees for paper production on the environment.
4. Formulate ways of reducing paper usage.

Materials: per group:
Used paper (torn into small pieces)
Newspapers (for blotters)
Flat dish (rectangular pyrex cake dish works well)
Bowl (capacity of at least 4 cups)
Egg Beater (A blender is faster and more effective)
Screen (fine mesh, cut to size of glass dish)
Starch (2 tsp or 5 ml) (optional-makes paper stronger)
Plastic sheets (pieces of plastic large enough to put recycled paper on to dry)
Hot water (2 cups)
Jar or rolling pin
Cup or beaker (for measuring)
Teaspoon or graduated cylinder (for starch if used)

Printed/AV Materials
Worksheet: Let's Recycle

Teacher Information:
The process for recycling paper is fairly simple. There are many different variations in the methods used. As long as the paper is in pieces, mixed until it is just woody fiber, the water is taken out, it is spread out evenly, flattened, and allowed to dry; the methods of doing this can vary. Many roll the pulp between blotter paper and iron it dry with a clothes iron. Any kind of paper works as long as it does not have a finish on it. Students can be creative by adding food coloring, grass, leaves, flowers, etc. either before the paper/water mixture is blended or into the pulp after it is mixed.

Paper is recycled by shredding it, mixing it with water, and beating the mixture to a mush-like pulp which flows onto a moving screen through which most of the water passes. The fibers are pressed by heavy rollers that remove more water and then it is sent through heated dryers. This is used in newspaper, cereal boxes, tissue, writing paper, etc.

Newspaper is most easily recycled. The commercial sector took the lead in recycling years ago in recycling corrugated cardboard to reduce disposal costs. Government offices and industrial offices collect and recycle office paper to save cost. This is a high grade paper that can be used in making writing and computer paper and paper towels. Mixed paper (food packaging, magazines, etc.) is low grade and does not have much of a demand. The 5000 tons of junk mail that Americans receive each day fits in this category.

DID YOU KNOW?

1. Recycling a stack of papers three feet tall saves one tree.
2. Recycling a ton of newspaper conserves three cubic yards of landfill space.
3. Recycled paper required 61% less water, produces 70% fewer pollutants, and saves 65% more energy than paper made directly from trees.
4. We Americans still only recycle 27% of our paper.

Procedure:

1. Hand out Let's Recycle worksheet. Describe the basic steps involved, using the necessary equipment.

2. Break the students into groups of 3-5 to do the paper-making activity. The paper-making process and cleanup will probably take a class period. (If using a blender, you might want to blend the paper mixture for each group.)

3. Have students answer the questions either as homework or in the next class period.

4. When students have completed the worksheet, discuss the answers to the question:

   Answers:

   1. Energy is used to transport the paper to and from the plant, to shred and mix paper, and to dry the recycled paper.

   2. Yes. More energy is used to make paper from trees. Energy is used to cut down trees, transport them to the processing plant, process, and transport to the manufacturer.

   3. Recycling paper conserves a renewable resource (trees), reduces solid waste, conserves energy, and reduces air pollution.

   4. Careful logging has little or no harmful effect on the environment. Forests may be replanted as they are harvested providing continual renewal of the resource. However, careless logging, overharvesting without replanting, tropical deforestation, and similar practices may lead to extensive erosion, habitat destruction and disruption of weather patterns.

   5. Examples of reducing paper waste: using less paper, using both sides of paper, reusing boxes and paper sacks, using cloth napkins and handkerchiefs, etc.

5. When the paper is dry, allow students to decorate their paper if desired, and display these.

Alternative:
Make paper as a demonstration. Use larger amounts and bigger equipment. A blender can still be used to change the mixture to pulp. Blend several batches and put them together.

Extensions:
1. Keep track of how much paper is thrown away in the classroom for a week.
2. Have a box for reusable scrap paper.
3. Have a newspaper drive to collect and take paper to a group or place that gathers it for recycling.
4. Have each student design and carry out a creative use for a brown paper grocery sack. Display the appropriate designs.

References:
Paper making adapted from Let's Recycle. Other facts obtained from: Oscar's Options, Waste Reduction and Recycling Methods, Trash Monster, and A-Way With Waste.

Let's Recycle
Student Worksheet

Name______________________

Purpose: To recycle used paper into new usable paper.

Materials:

Used paper	Starch (optional)
Newspaper	Plastic sheets
Flat dish	Hot water
Bowl	Jar or rolling pin
Egg Beater	Cup or beaker
Screen	Teaspoon or graduated cylinder

Procedure:
1. Have several layers of newspaper ready to use as a blotter.
2. Tear sheets of paper into small pieces.
3. Put about 1 cup (250 ml) of shredded paper into 2 cups (500 ml) of hot water.
4. Beat the mixture until it has a creamy-watery consistency. (Mix in 2 tsp (5 ml) of starch if you want stronger paper.)
5. Place the screens in the bottom of the dish and pour the pulp over it.
6. Move the screen around to spread out the pulp evenly.
7. Lift the screen up, let it drip, and place it on layers of newspaper.
8. Put more layers of newspaper on top.
9. Roll a rolling pin or jar over this to squeeze out the water.
10. Take off the top layer of newspapers. Put your hands under the bottom newspaper and flip everything over onto a piece of plastic. The paper pulp should now be on the bottom with the screen and newspaper on top.
11. Carefully remove the newspaper and screen.
12. Place the pulp, still on the plastic, in a place to dry for a couple of days.
13. Clean up your equipment and answer the discussion questions.

Discussion:
1. The process that you just used is basically the same when paper is recycled in large quantities. When paper is recycled, for what purposes would energy be used?

2. Do you think more energy is used to make paper from trees? Explain.

3. What are the benefits of recycling paper?

4. Americans use a total of 50 million tons of paper per year and because paper is made from trees, that means we use 85 million trees per year for paper alone. How does cutting trees for paper affect the environment? (Include the effects on wildlife, water, soil, and air).

5. Paper is 50% of the nation's waste. Recycling would cut down the amount of paper waste. What are some other ways of reducing paper waste?

Not Everything Made From Scratch Is the Best (Aluminum)

Earth Science 1/2 class period

Quick summary: Students will compare the environmental impacts of producing aluminum from an ore versus recycling.

Objectives: Upon completion, students will be able to:
1. Suggest reasons for the success of aluminum recycling.
2. Generalize from information given, ways that energy is used in the aluminum-making process.
3. Formulate a list of the benefits of recycling aluminum.

Materials: None

Printed/AV Materials:
Worksheet

Teacher Information:
Americans throw away 65 billion cans yearly. Not all cans are aluminum. Aluminum cans are seamless and usually have label information printed directly on the metal. There are also bimetal cans (aluminum top with a steel body) and tin cans (99% steel).

The aluminum recycling process is fairly simple. First a magnet removes any steel cans, then the aluminum cans are flattened and shredded and made into pellets or balled. These are sent to a smelting plant where they are melted, the impurities are skimmed off, and the metal is poured into molds and cooled. These go to a manufacturer who hot rolls them into sheets for use in cans, etc.

Other metals besides aluminum are recycled. Metals are divided into ferrous (containing iron and magnetic) and nonferrous (without iron). Recycling ferrous metals is a huge industry and world trade in this type of scrap metal is well over $11 billion dollars in comparison to $600 million for aluminum. Cars (3 million junked yearly in the U.S.) are a big source, but iron is also recovered from food and beverage containers. Recycling steel reduces energy consumption by 74%, air pollutants by 86%, water use by 76%, and mining wastes by 97%.

A BTU is a measure of energy and is defined as the amount of energy needed to raise 1 lb of water 1 degree Fahrenheit.

Procedure:
1. Hand out the worksheet.

2. If students are not familiar with BTU's as a term for energy, briefly explain. Students need to also know what is meant by a nonrenewable resource, recycling, and biodegradable.

3. Allow the students to work individually or in learning teams on the worksheet.

4. When students have completed this worksheet, discuss the answers.

   Answers:
   1. 94,614 lbs.; 47.3 tons

   2. Bauxite

   3. Carbon dioxide--is necessary for plant growth, but can be harmful if too much collects in the atmosphere and traps the heat, producing the greenhouse effect.

   4. Aluminum recycling's relative success is due to: its higher economic value; the aluminum industry's support for recycling because of concern for domestic amounts of bauxite; aluminum cans easily collected; and "bottle return" laws.

5. Petroleum coke and pitch.

6. Energy is also used in mining bauxite and other materials, transportation of raw materials to the processing plant, transportation of processed aluminum to the manufacturing plant, and transportation of the product to the consumer (sometimes through various distributors).

7. Recycling benefits include: conservation of land from mining practices; reduction in solid waste; reduction in litter; conservation of nonrenewable resources; reduction in air pollution; reduction in water pollution from mining practices and from less use of landfills.

5. Extend the discussion into recycling of other materials.

Extensions:

1. Conduct a debate on the advantages and disadvantages of the "bottle deposit" law.
2. Have students interview a person who operates a beverage container collection point such as a grocery store. Possible interview questions: What are the handling procedures of the containers while at this location? Are there any problems associated with this? Do they get compensated for serving as a dropoff center? If so, how much? Where do the containers go from there? (If they are transferred to another facility in your community, conduct an interview there.)
3. Have a person who operates a collection center for beverage containers come and talk to the class.
4. Discuss ways that we can conserve on the use of metals.

References:

Oscar's Options, Let's Recycle, Waste Reduction and Recycling Methods, Trash Monster.

Not Everything Made From Scratch Is the Best

Student Worksheet

Name________________________

Recipe for one ton of aluminum
81,766 pounds bauxite
11,020 pounds petroleum coke
966 pounds soda ash
327 pounds pitch
238 pounds lime
process with 197 million BTU's of energy

Pollutants generated
3,290 pounds red mud
2,900 pounds carbon dioxide
81 pounds air pollutants
789 pounds solid waste

1. How many pounds of material are required to make one ton of aluminum? ________lbs
How many tons is this? ______________tons (round to the nearest tenth)

2. What is the ingredient that is used in the greatest quantity? __________

3. What is the pollutant that goes into the air in the greatest quantities?____________________.
Is this pollutant harmful to our environment? If so, how?

Aluminum is made from bauxite, a nonrenewable natural resource. The United States is one of the largest manufacturers of aluminum but does not have large supplies of bauxite. Some bauxite is mined in Arkansas, Alabama, and Georgia, but most of the ore comes from foreign places such as Guyana and Jamaica.

Bauxite lies near the surface, and most of it is mined by open pit method. Explosives are put in holes drilled in the bauxite and the ore is blasted loose, loaded on trucks, taken to ships or railcars, and hauled to plants.

4. More than 50% of all aluminum cans are recycled, but all aluminum products such as lawn furniture and pie pans can be recycled. Aluminum recycling has been more successful than any other program. What do you think are the reasons for this success?

5. Does the recipe include any other nonrenewable resources? If so what are they?

6. Besides the 197 million BTU's of energy needed to actually make the aluminum, in what other ways do you think energy was used in the whole process of getting aluminum from the earth to the consumer?

7. Aluminum can be recycled for 96% less energy than it takes to produce it from "scratch". Besides this saving in energy, what do you think might be five other benefits of recycling aluminum rather than manufacturing it from bauxite?
a) ____
b) ____
c) ____
d) ____
e) ____

DID YOU KNOW?
- Each American uses 56 pounds of aluminum per year.
- If you drink two aluminum cans of pop per day and fail to recycle the cans, you are wasting more energy than a person in a developing country uses in one day.
- Twenty recycled cans can be made for the same energy as one new one.
- It would take an estimated 500 years to break down an aluminum can in a landfill.

Plastic Is A Problem

Earth/Life Science 1/2 class period

Quick Summary: Students will read an essay about recycling plastic and producing biodegradable garbage bags (new technologies in Iowa) and answer discussion questions.

Objectives: Upon completion, students will be able to:
1. Define biodegradable and nonbiodegradable and give examples of each.
2. Evaluate the benefits and concerns about biodegradable garbage bags.
3. List the benefits of recycling plastic.
4. Devise a plan to promote and carry out plastic recycling in your community.

Materials: None

Printed/AV Materials:
Worksheet
Teacher Information: Plastic Recycling Suggestions for Schools
Overhead: Enduring Litter

Teacher Information:
About 80% of all plastic (thermoplastics) can be remelted and reformed but 20% cannot be reformed. In most processes, plastics must be recycled with like plastics because different polymers do not stick to each other. Recycling plants receive the baled color-sorted bottles. They are then ground up, fed through an air cyclone separation to remove paper, gravity separated to remove the aluminum and the high density plastic of the bases, washed with caustic acid to remove adhesives, and sent through a water flotation system to separate usable and unusable plastics. The usable plastic (polyethylene terephallate--PET) is shredded, chopped, and made into pellets which are used to manufacture polystyrene fiberfill for jackets and sleeping bags.

Procedure:
1. Make sure students have a working definition of nonrenewable resource.

2. Hand out the worksheet. Have students read the essay and answer the questions either individually or in learning groups.

3. Discuss student responses:

   1. Tape and milk jug.

   2. Materials that can be broken down by microorganisms. Wrapper, sock, math paper.

   3. The microorganisms can't get in the bag, and there is not enough air and water for them to survive in the bag.

   4. Market for corn, create jobs, have bags that degrade in our landfills.

   5. Some environmentalists are concerned that the dust-like plastic particles will get into our water and air, creating another problem. Others think that promoting the use of corn encourages destruction of habitat and soil erosion. Other questions include: Will they start to decompose while sitting on the lawn? Will they be as strong? Also, biodegradable plastic bags are estimated to cost 5-10% more than nonbiodegradable bags.

   6. Keep it out of landfills, cut down on litter, provide more employment, save energy.

7. The long-term cost will be greater because of handling of nonbiodegradable materials in landfills, cleaning up litter, expended nonrenewable resources, pollution of groundwater because of continued need for landfills.

8. Collect and sell our plastic containers to a plastic recycling company, so we can save money for waste disposal.

9. Recycling plastic jugs have much more potential for reducing the volume of waste in landfills.

4. Use the overhead, enduring litter, to show how long various items remain unchanged in landfills.

Extensions:
Have a plastic milk jug drive to collect jugs to be recycled at Iowa Falls.

References: "Milk Jugs Become Park Benches," Iowa Energy Bulletin; "The Plastic Trash Bag That Ate Des Moines," Des Moines Register, March 3, 1988; Oscar's Options; Let's Recycle; A-Way With Waste.

Plastic Is A Problem
Worksheet

Name______________________

Iowa Companies Take The Lead In Finding A Solution

Stop! What's going to happen to that plastic bag full of trash that you just stuffed into the garbage can?...a garbage collector. OK, but what then?...a landfill. Right! But what then?...buried. Yes, but what then? You're not sure?

You think you've heard something about plastic being nonbiodegradable? Do you know what that means? Did you know that if you could come back in a couple of hundred years and dig up that landfill, that plastic bag will still be there? You'd be able to recognize that sock with the hole where your big toe went, the wrapper from the bubble gum with the watermelon flavor, the bone from that chicken leg you had for dinner, the Michael Jackson cassette tape that your little brother ruined, the math paper that you spilled pop all over, and the jug that didn't quite have enough milk left for your cereal.

The plastic bag would still be there because it is nonbiodegradable. It cannot decay because it cannot be broken down by microorganisms. Archer Daniels Midland, a company with plants in Cedar Rapids and Clinton, is trying to solve this problem. This company is using a technology brought from England that blends about 6 % cornstarch with plastic for garbage bags. This substance is sent to a company in Missouri that produces bags that are at least partially biodegradable, leaving dust-like particles of plastic.

However, some research suggests that garbage in landfills--no matter what it is bagged in--will not decompose very well. Conditions in a landfill are not as good for decomposition as they are in a compost pile. Research is presently being conducted to check unanswered questions concerning the effect of the remaining dust-like particles on the environment.

Remember that milk jug in your garbage? It is also nonbiodegradable. A company located in Iowa Falls is taking another approach to the plastic problem. The president of Plastic Recycling Inc. started the company because he could not get plastic particle board for hog confinements in the United States. He researched the technology that was used in England to make this product and developed the process that he now uses at his recycling plant. Plastic products such as your milk jug, are recycled and made into car stops, park benches, fence posts, and other molded products.

Both of these companies are pioneers in their field and are using technologies that are at least the beginning of a solution to the plastic problem.

Discussion Questions:

1. Plastic is nonbiodegradable. What other items in the garbage bag mentioned in this essay are nonbiodegradable?

2. Define biodegradable.

What items in the garbage bag are biodegradable?

3. If these items are biodegradable explain what would cause them to be unchanged after 200 years?

4. The Archer Daniels Midland Company could benefit Iowans in many ways. List three.

5. In 1989, the Iowa Legislature passed a bill that by 1992 will prohibit land disposal of nondegradable plastic grocery bags or trash bags, unless the Department of Natural Resources determines that degradable plastic bags pose an environmental hazard. What could be some environmental concerns about biodegradable plastic bags?

6. Plastics are part of the petrochemical industry which means they are made from natural gas and crude oil. The use of plastic beverage containers alone increased from 15 million in 1967 to 12.5 billion in 1985. Research shows that consumers prefer plastic containers of all kinds. Even such things as ketchup, salad dressing, and jelly come in plastic. List three benefits of recycling plastic in Iowa.

7. Plastic Recycling Inc. gets much of the waste plastic it uses from Chicago. It was costing Illinois $1000 a week to landfill this plastic. The cost of recycled plastic products at this time may be higher but the long-term cost is much lower. Explain what is meant by this statement.

8. Iowa is not taking full advantage of the opportunity that plastic recycling companies offer. How could Iowans benefit more fully? Be specific.

9. Which would reduce the volume of waste in a landfill more: recycling plastic jugs or using biodegradable plastic bags?

Plastic Recycling Suggestions for Schools

(based on the POPULAR project in Hamilton, Webster and Wright Counties)
by Jean Eells, Hamilton County Conservation Board

1. Find a way of baling, or grinding, shredding, and densifying the plastic bottles to reduce the volume of space needed for transporting the plastic. Businesses owning balers can be large grocery stores, scrap metal buyers, or any store which ends up with a sufficient quantity of cardboard waste that
they bale and sell. Offer to learn to run the baler and do the work at a convenient time for them. Perhaps they will be interested in a short-term project but not a long-term one.

2. Arrange a location to store the baled plastic in sufficient quantity to make a profitable load to sell. Think about the size of a semi trailer and look for that amount of space. It isn't cost efficient to haul smaller quantities unless two or three small amounts can be picked up in nearby towns. The Iowa Falls company, Polymer Products, will pick up a truck load from you.

3. You will need storage for bottles before they are baled other than inside the school. A good sized horse trailer works well for this as you can hold a lot of bottles--it will take a lot of bottles to make a bale depending on the size baler you can use. A couple of 4 cu. yd. dumpsters might hold enough for a bale if the bottles are crushed (stomped on!) ahead of time.

4. Odor is not a problem inside the school if you enforce a basic rule...the jugs must be clean and dry and be able to pass a "sniff" test before credit is given. Eventually students can be the "sniffers" and monitor the incoming jugs each day. Teach them to rinse the jugs at home in cold water as the cold water seems to dissolve the enzymes better and prevent odor problems later.

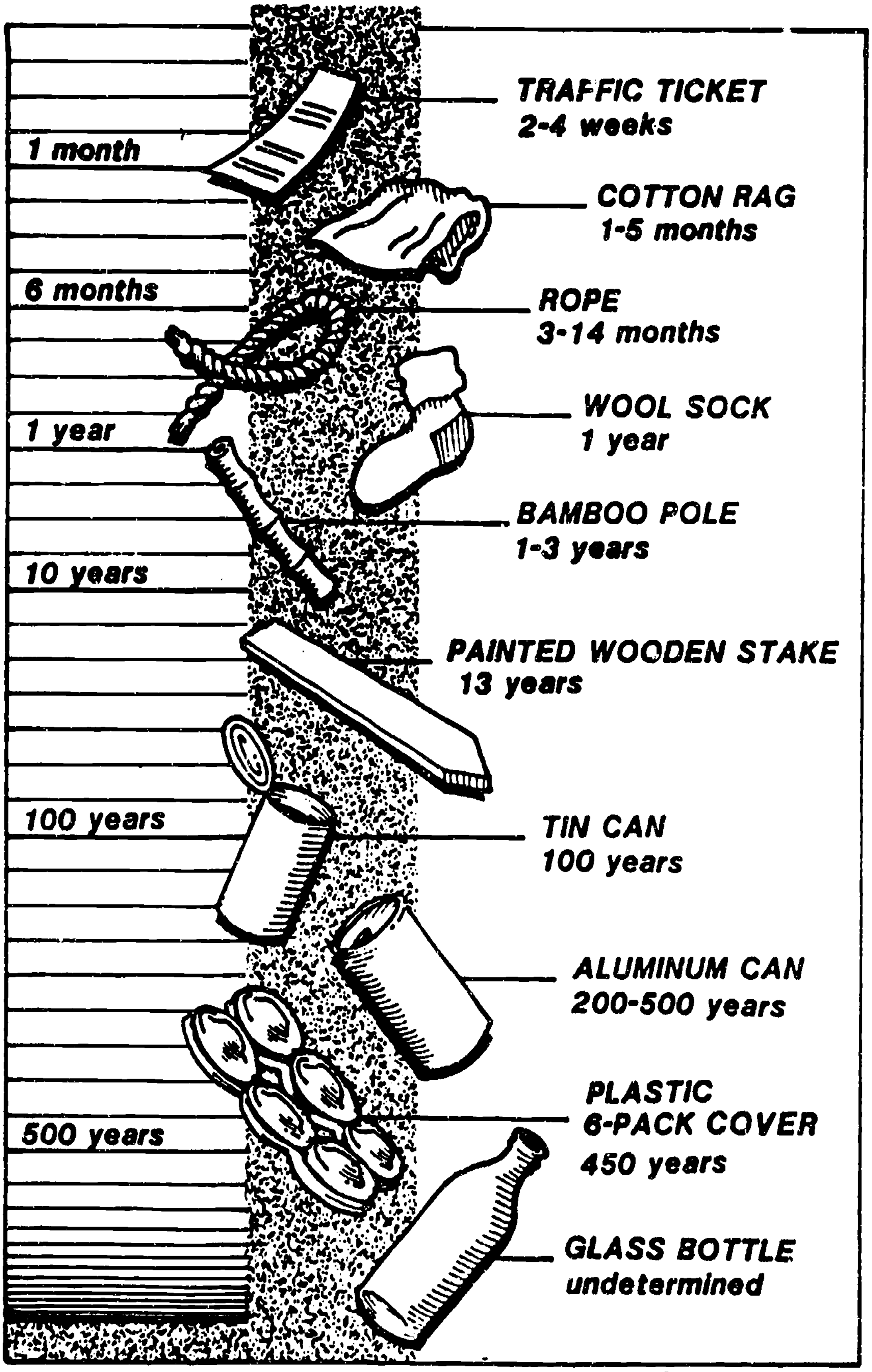
5. An inexpensive way of handling the jugs rather than using garbage bags all the time, is to tie a string to the handle of one and thread the rest on the string. The whole string of jugs can be tossed into the baler and baled.

6. The schools which ran in-school competitions gathered in the most jugs. The most effective visible means of encouraging the collection is to use bar charts on the wall and update the charts daily or weekly. Even the kindergarteners will learn to read the charts to "see who is ahead". The chart can be a basis for story problems unique to each grade level math. For example, how many jugs does the 4th grade class need to catch the 3rd graders? If the 4th grade students bring an average of 6 jugs per day, how many days will it take them to catch the 5th graders. How many cubic yards have we kept out of the landfill if each bale weigh 50 pounds and is 32"x36"x22"? etc.

7. The student's excitement (encouraged by you letting them know that they are doing something very valuable, indeed!) can be used for lessons all across the curriculum. News reports can be written and sent home, other studies about recycling can be done in science, etc.

Enduring Litter

Litter at the roadside is ugly. How long it will stay before decaying may be an ugly surprise.



Source Book of Lists 2

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Composting

Life/Science

First day: 1/2 class period
Second day: 1 class period

Quick Summary: Students will visit a compost pile to discover its composition, how it is managed, and its function. They will sample the organisms in the pile and will identify and sort them using a microscope or magnifier.

Objectives: Upon completion, students will be able to:
1. Describe the construction, components, products, and purposes of a composting operation.
2. Smell and feel the composted organic material.
3. Classify the living organisms from the compost obtained by using a Berlese funnel.
4. Relate composting to maintaining clean groundwater supplies.

Materials:
Small bags of organic waste (grass clippings, food waste, leaves, saw dust, coffee grounds, etc.)
Plastic bags for returning compost samples to the lab.
Berlese funnel apparatus or substitute (see attached diagram).
Magnifiers or binocular stereomicroscopes.
Tweezers, dissecting needles.
Isopropyl alcohol 70% (commercial rubbing alcohol)
Vials or baby food jars for specimens

Printed/AV Materials:
Student Information: Compost Critters
Other: Identification material for soil organisms (optional)

Procedure:
1. Identify a compost pile that your class may visit in the neighborhood of the school; obtain permission.

2. Take bags of organic waste with you to the compost pile. Throw the waste on top of the pile.

3. Dig into the base of the pile to reveal the composted material. Have the students feel and smell the compost. Compare it to the waste you threw on top.

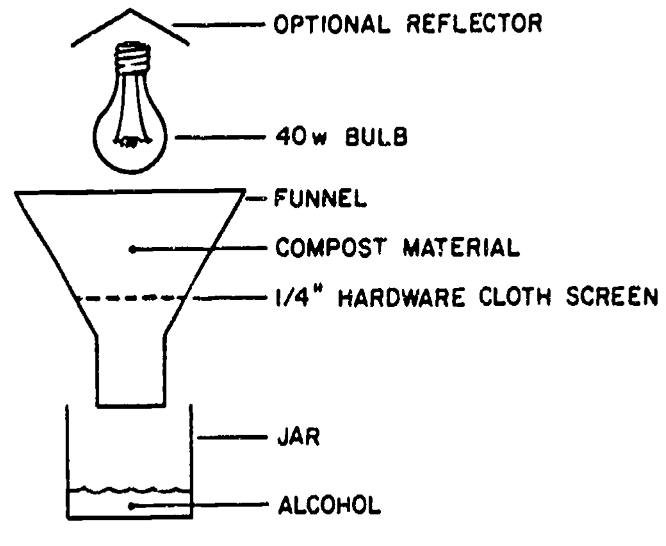
4. Have the students collect a double handful of compost material to take back to the lab for examination.

5. Put the compost material in the Berlese funnel apparatus and allow it to process overnight while the soil organisms fall into the alcohol below.

*****Safety*****
Caution: alcohol is poisonous and flammable. Follow the cautions on the container. Always pour from the original container or a safety container. Compost piles sometimes harbor harmful pathogens. Students must wash their hand with soap and water after handling compost especially if the pile contains animal waste.

Berlese funnel apparatus for sorting organisms from compost

The funnel may be metal or plastic (or a one-gallon jug or two-liter soft drink container with the bottom cut out). The light bulb should be close but should not touch the ringstand. Ordinary window screen is too small for the funnel. Use hardware cloth



6. The following day return the compost material to the pile and then use the magnifiers or microscopes to identify the organisms found.

7. Sort the organisms into vials of alcohol by the types shown on the Compost Critters page.

8. Students draw and name the organisms they found.

9. Questions for discussion:

   a. In a compost pile, how is the waste converted to compost?
   Answer: It is broken down by scavengers and decomposers living in the pile.

   b. How long does it take for waste to be composted?
   Answer: Depends a lot on the type of waste and the weather conditions. Gardeners turn, inoculate, and water their piles to speed the process. The best answer is from a few weeks to several months.

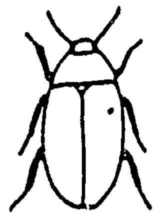
   c. In what ways is composting superior to throwing organic wastes into a landfill?
   Answer: You reduce the volume of material going into the landfill and produce a useful product.

   d. What factors may upset the healthy status of a compost pile?
   Answer: Dry conditions, toxic chemicals (pesticides, etc.), cold temperatures, matted material.

Alternative:
Instead of visiting a neighborhood compost pile or using one established on the school grounds, the students may bring in compost from the top, middle, and bottom of their pile at home.

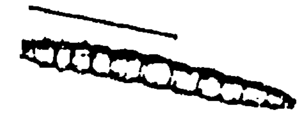
Extensions:
1. Make permanent mount microscope slides of organisms found.
2. Construct an identification key for organisms found.
3. Culture bacteria and molds from the compost.
4. Set up a preserved zoo of organisms found in the compost.
5. Discuss what factors make for a "healthy" compost pile.
6. Compare the organisms from different compost piles.
7. Invite a gardening expert to speak about the the value and many uses of compost in a gardening operation.
8. Use the compost in experiments relating to plant growth.
9. Study the use of composting as it relates to landfill management.

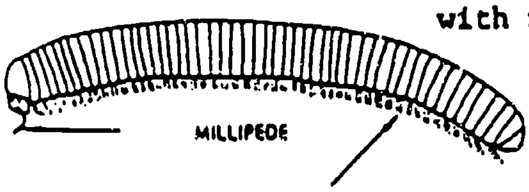
Compost Critters



Insect (adult)--
6 legs. 3 body regions. often 1 or 2 pairs of wings. 1 pr. antennae.

Insect (larva)--
These young insects vary much. Usually a segmented, worm-like body. May or may not have legs.

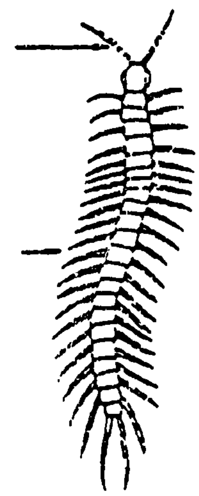




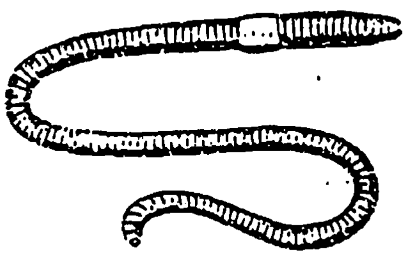
MILLIPEDE

Millipede--wormlike with many legs. 2 pr. of short legs on most body segments.

Centipede--
wormlike, flatter body with many legs. 1 pr. of legs per body segment.



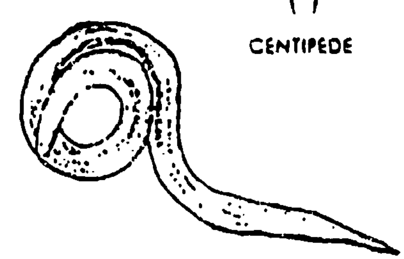
CENTIPEDE

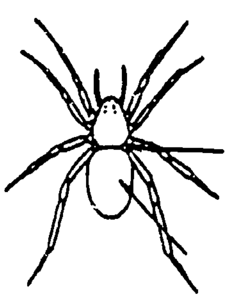


Earthworm

Earthworm--long, segmented brown worm.

Nematode worm--
long, worm without segments or flattened body.

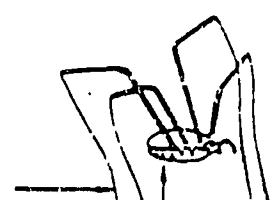




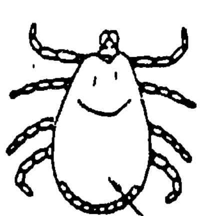
GROUND SPIDER

Spider--8 legs with definite narrow "waistline"

Daddy-long-legs--
8 very long, slender legs with small, oval body. Abdomen segmented.

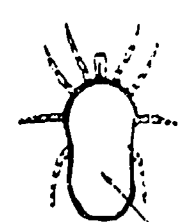


DADDY-LONG-LEG'

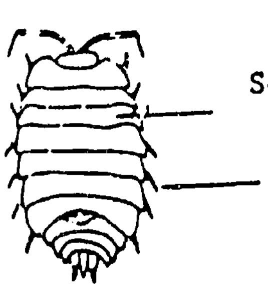


TICK

Ticks and mites--8 legs. Very small, more or less oval body. Abdomen unsegmented & broadly joined to front of body.



MITE



SOWBUG (isopod)

Sowbug--flattened body with 7 pr. of legs.

Salamander--
larger animal with smooth, moist skin, 4 legs, & a tail.

Tiger Salamander

Figure IV-1. Underground tanks and pipelines

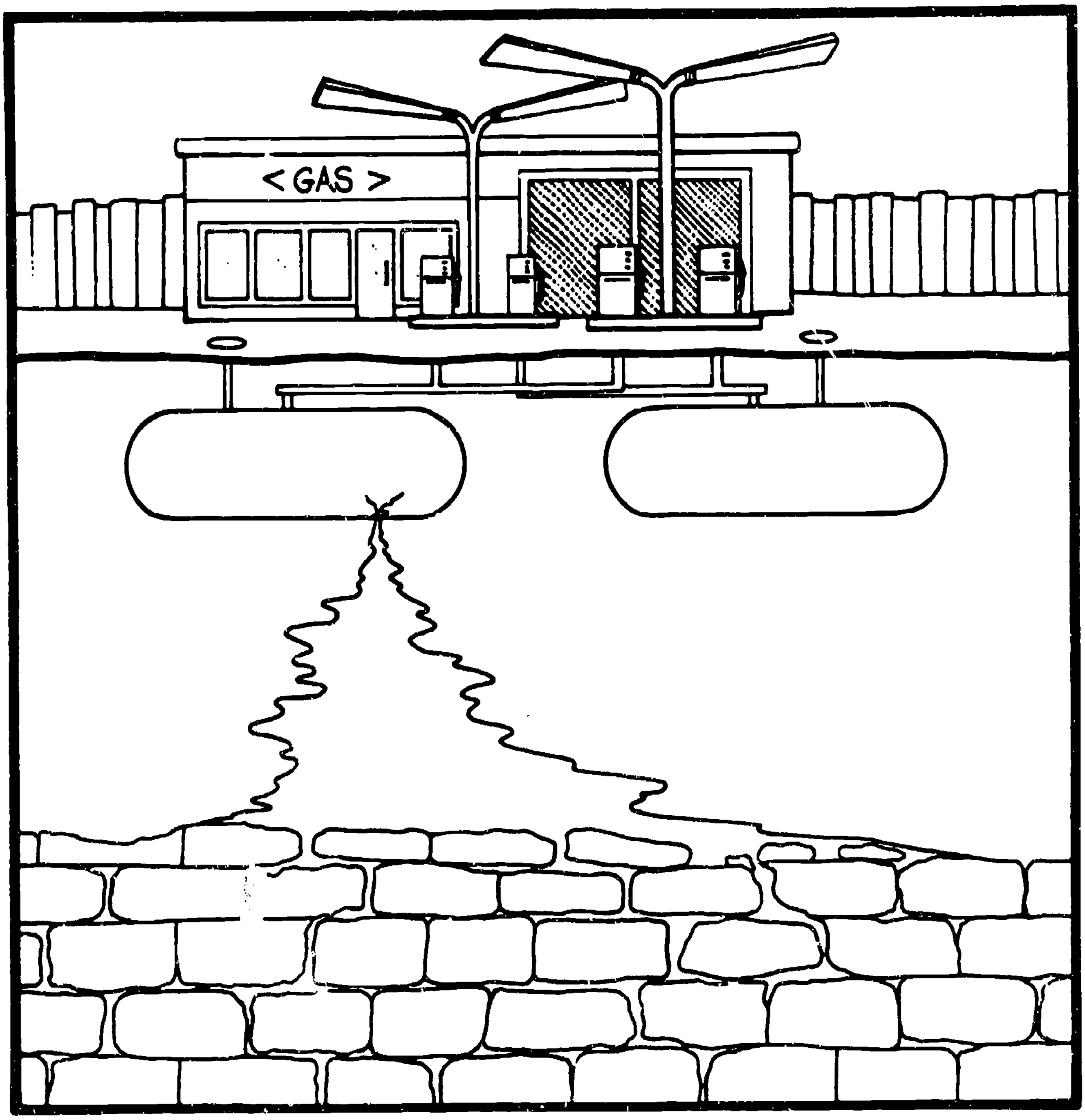


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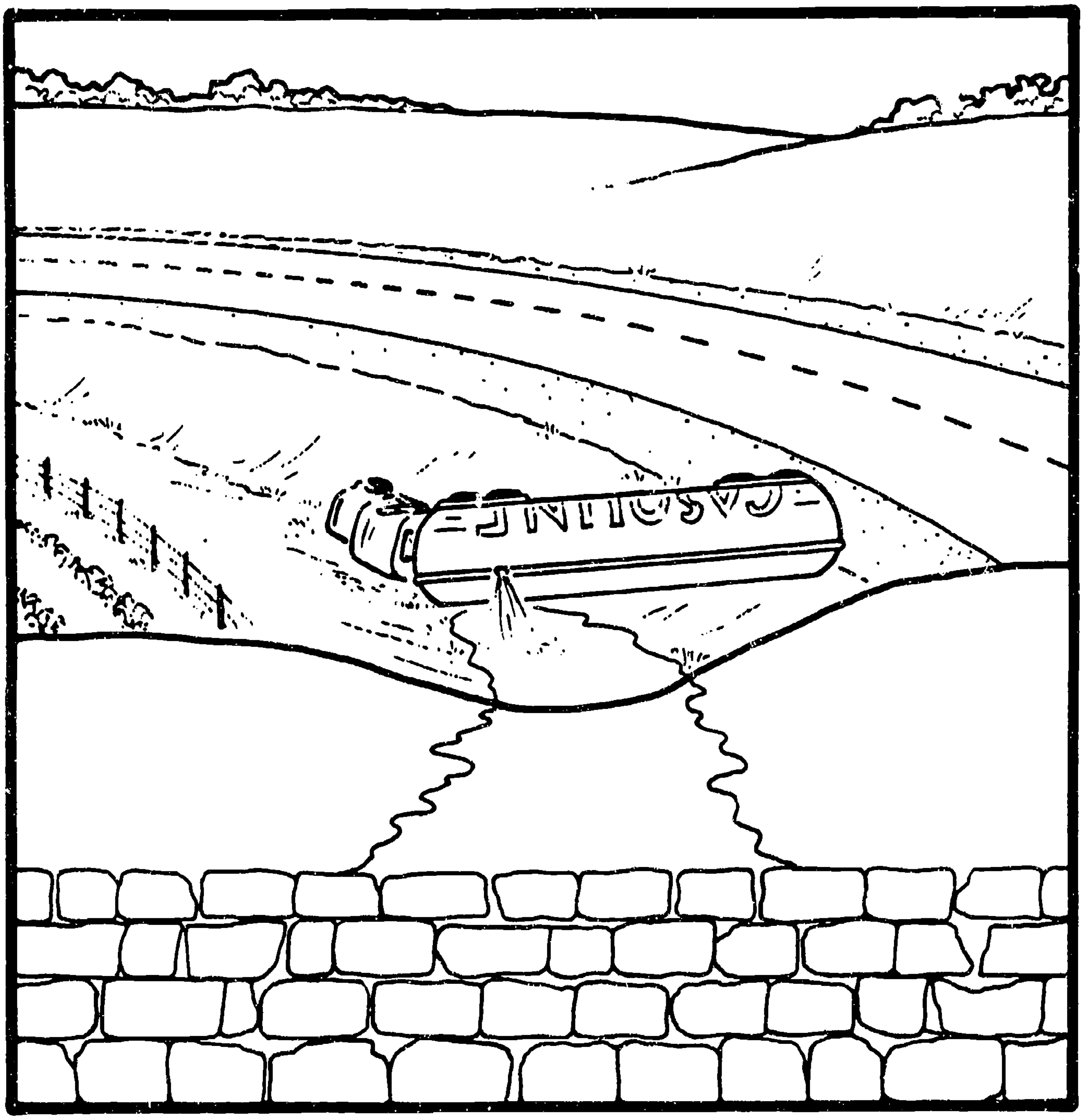
Figure IV-2. Hazardous materials storage, handling & transportation



IV. LUST: Leaking Underground Storage Tanks and Hazardous Materials Handling and Transportation

OBJECTIVES

1. Identify local waste management practices by surveying local businesses or industries.
2. Examine and compare how hazardous materials are transported and stored within the community.
3. State the risks and benefits of hazardous materials transportation and storage.
4. Evaluate economic and energy savings gained by utilizing best management practices for hazardous materials.

BACKGROUND INFORMATION

Hazardous Substances Storage, Handling and Transportation

Hazardous materials that could contaminate groundwater are a fact of our modern way of life. Safe and responsible storage, handling and transportation are crucial. Even with careful handling, some accidents will happen which may contaminate groundwater.

While many believe that most spills of hazardous materials occur in transportation accidents, this is not actually the case. About 65 percent of the spills in Iowa occur at the storage and handling sites. These may be due to poor facilities (such as corroding tanks, leaking valves, or poor maintenance) or careless handling (such as the daily practice of letting a hose drain on the ground which may add up to major contamination). Truck and train transportation accounts for about 25 percent of the spills, with highway accidents occurring more frequently. With the quick response of modern emergency response teams, fewer transportation spills are contaminating Iowa's groundwater. The remaining releases are caused by pipelines, fires and other sources. (Refer to Figure IV-3)

Petroleum products (usually gasoline or diesel fuel) are the most frequently spilled type of chemical. The next most common spill is mineral oil used in electrical transformers which is sometimes contaminated with PCBs (polychlorinated byphenyls). Chemical fertilizers constitute the third largest group, and pesticides the fourth. Acids, bases, solvents, and other chemicals are spilled the least.

Potential groundwater contamination from the storage, handling and transportation of hazardous chemicals is local in nature and depends on the vulnerability of the surrounding geology. The impact of this contamination can be reduced if best management practices (BMPs) for material handling are followed.

Underground Tanks and Pipelines

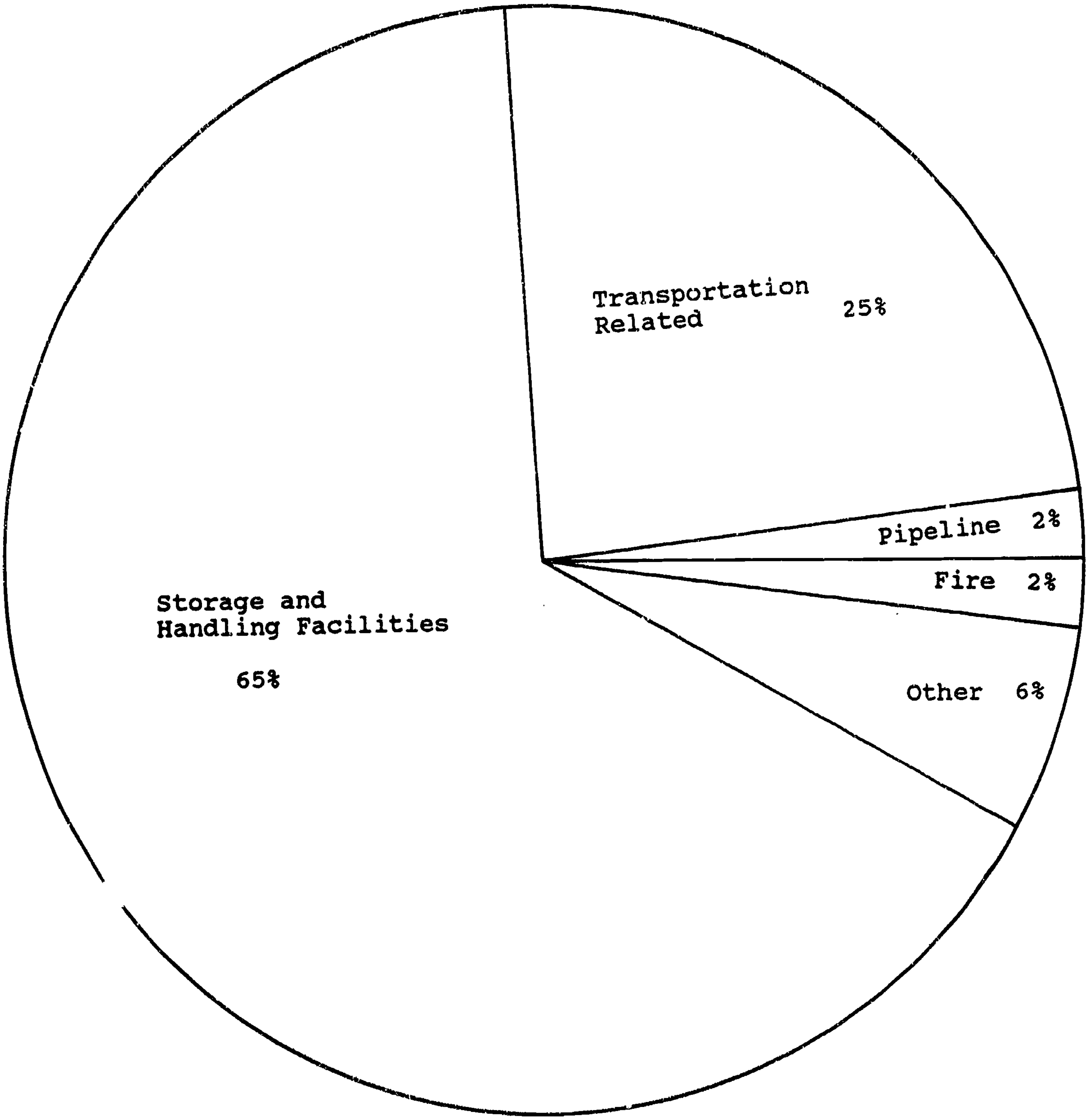
Leaking underground storage tanks (LUST) account for over half of the hazardous substances incidents in Iowa.

> The Roman Empire lives...
> and leaches on..........

Most **underground tanks** store gasoline or diesel fuel for vehicles. Examples of places with underground tanks include gas stations, school bus barns, and storage for government or business fleets. Tanks were originally required to be underground to reduce fire and explosion risks. However, the risk to groundwater has increased because contaminants are closer to the water table and leaks are harder to detect.

The impact of even a very small leak may be significant over the 20- to 50-year life span of an underground tank. An EPA study showed that about 25 percent of the existing underground tanks were leaking nation-wide. In Iowa, 85 percent of the reported underground storage tank leaks have resulted in contamination of shallow groundwater. Not only is water quality at risk when leaks occur, but the owner loses valuable fuel as well.

Figure IV-3: Number of reported spills of hazardous substance by source. Source: Iowa Department of Natural Resources, 1987



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Laws for underground tanks that store petroleum or hazardous substances are designed for:
-leak detection
-corrosion protection
-spill/overfill protection

For example, corrosion protection for corrosion protection new tanks have three choices:
1. Coated and cathodically-protected steel (cathodic protection is a system to prevent corrosion of steel tanks using a continuous electrical current)
2. Fiberglass (a noncorrosive material)
3. Steel tank coated with fiberglass

Existing tanks could use one of those options or add a cathodic protection system or an interior lining or both.

These standards lead to better-constructed tanks being installed. Previously, it was common to install either a bare steel tank or a tank covered with an asphalt coating. Such tanks can corrode very quickly, sometimes within two years of installation.

New tanks are also required to install external leak detection devices, such as groundwater monitoring wells or a monitoring device between the walls of a double-wall tank. Existing tanks also need external monitoring which will be required over the next few years depending on their age.

By October 1, 1989, all underground storage tanks, regardless of size, must be reported to the DNR **for registration**. All tanks with a capacity of 1,100 gallons or more must have a registration tag, and it is unlawful to fill any tank over 1,100 gallons that is not tagged.

Buried tanks which store heating oil used for heating a building on-site (such a farm homes or schools) are exempt from the monitoring laws. However, owners are responsible if these tanks leak, and many people are following guidelines required for other tanks.

There are 11,670 miles of **pipeline** in Iowa carrying natural gas, crude oil, anhydrous ammonia, and other petroleum products. Pipelines are found in every county in Iowa. Although less than two percent of the reported spills in Iowa involve pipeline breaks, the volumes involved are significant. Nearly all of the products stored in underground tanks and transported through pipelines are hazardous and pose some threat to human health, as well as other animals and plants in the ecosystem.

Above-ground Storage

Potential sources of spills, leaks and runoff from above-ground storage include: 146 regulated hazardous waste facilities; over 1,400 auto repair and service garages; about 1,300 ag-chemical dealerships; as well as numerous barge terminals, rail terminals and petroleum tank farms. In addition to handling and storage facilities, in 1983 over 11 million tons of chemicals were transported to or from Iowa by rail, barge or truck.

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Waste Product Survey for Business and Industry

Life/Earth Science 2 Class Periods

Quick Summary:
In this activity, the students will survey a local business or industry to determine its waste production and disposal practices.

Objectives: Upon completion, the students will be able to:
1. Describe what type of wastes and in what amounts a local business or industry produces.
2. Classify the business' waste as hazardous or nonhazardous.
3. Describe how the business disposes of its waste.
4. Identify waste disposal alternatives to landfill burial.
5. Describe how wastes from the business are transported to the disposal site.

Materials: None

Printed/AV Materials:
Work Sheet:

Teacher Information:
This activity can also be used in studying landfills; or emphasize the transportation and storage parts for this unit.

Procedures:
1. Divide students into groups of two or three.
2. Have each group draw up a short list of local businesses or industries from which they will choose one to survey. (See note in procedure No.4.)
3. Pass out the survey forms and explain the assignment.
4. Help students develop the best strategies for approaching the business. Emphasize to the students that they should make clear to the businesses contacted that this is a research project and the information gathered will not go any further than the classroom. Suggest that the group's best choice may be a business or industry at which one of their parents is employed. The business may be of any type – large or small. Each group must find a different business to survey.
5. Establish the time line for completing the survey (perhaps three days).
6. Each day check on group progress and offer encouragement and suggestions.
7. Have each group give a brief (two- to three-minute) oral summary of what they have found.
8. Questions for discussion:
   a. What are some major waste-producing businesses and industries in our community?
   b. What types of hazardous waste is produced in our community?
   c. How are hazardous wastes transported and disposed of in our community?
   d. What dangers (health, surface or groundwater pollution, air pollution, etc.) do these wastes present for our community?
   e. What alternatives to landfill disposal of wastes are used by the business and industrial community? In what ways are these better than burial in the landfill?

Alternative:
Have a representative of a local business or industry come to the class as a guest speaker. Ask the guest to talk about the waste disposal practices of his/her business. Have the students ask questions (as in the survey) and then write their report within their group.

Business and Industry Survey Form
Student Worksheet

Names____________

Name of Business:

Address:

Number of Employees:

Contact Person:

Position:

Type of Business Carried On:

Waste Produced By This Business:
Type: Amount: Hazards: How Transported and Disposed Of:
Type: Amount: Hazards: How Transported and Disposed Of:
Type: Amount: Hazards: How Transported and Disposed Of:
Type: Amount: Hazards: How Transported and Disposed Of:

Has this business had waste emergencies or problems in the past? What are the estimated costs of waste management for this company? Does this company have plans to change its waste management practices? Is there anything else relating to the waste management practices of this business?

1 f i

Community Hazardous Materials Storage

Earth/Life Science | 1 Class Period

Quick Summary:
Students will compile the information they have about where in their community hazardous materials are stored. They may also consult "experts" in the community about hazardous materials during the activity. They will also use the groundwater model to demonstrate how leaking tanks can contaminate groundwater.

Objectives: Upon completion, students will be able to:
1. List places in their community where hazardous materials are stored.
2. Identify the persons in their community who have knowledge or some official capacity with regard to hazardous materials storage or transportation.
3. Interpret the symbols on a map to identify the routes of transport for hazardous materials in or near their community.

Materials:
State Transportation Maps (printed by Department of Transportation)
For each small group of students: groundwater model and supplies (see Appendix A).

Printed/AV Materials: None

Teacher Information:
Use this activity as a wrap-up after the students have surveyed businesses in their community. This allows you to take the information which they have gathered and add some additional material. The main activity is simply listing places where hazardous materials are stored, their routes of transportation, and those persons who are most knowledgeable about them within your community.

Procedure:
1. Have students set up the groundwater model as shown in Figure 4 of appendix A, Great Ways to Use the Groundwater Model.
2. On a large piece of paper, on the overhead, or on the blackboard list the places where the students already have found hazardous materials stored within their community.
3. Make a second list of persons who they know have some knowledge or official function with regard to these materials. This list might include: high school chemistry teacher, sheriff, police chief, fire chief, county (or city) civil defense director, mayor or city manager, county supervisors, county engineer, private business persons, or state officials.
4. Using state transportation maps in small groups or individually have the students identify transportation routes through or near their community where hazardous materials might be carried. Make a third list for the class. This list might include: roads, rivers, pipelines, airports and/or rail lines.

Alternatives/Extensions:
1. Have the students contact the persons on their second list to find out what their knowledge and/or official function is with regard to hazardous materials. Report back to the class.
2. Invite one of the persons from the second list in to speak to the class on the subject of transportation and storage of hazardous waste in our community.

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Risks and Benefits

Earth/Life Science 1 class period

Quick Summary:
Students will discuss the risks and benefits of various methods of transportation and storage of hazardous materials.

Objectives: Upon completion, the students will be able to:
1. List some of the hazardous materials that are transported or stored in their community.
2. Discuss and list the risks and benefits associated with the transportation and storage of various hazardous materials within their community.
3. Describe the routes by which spilled hazardous materials in their community may contaminate the groundwater supplies.
4. Describe some of the health risks associated with potential spills of hazardous materials within their community.

Materials: None

Printed/AV Materials:
Student worksheet: Risks and Benefits

Teacher Information:
Hazardous materials which are transported or stored in your community all have various associated risks and benefits. The benefits are usually the same -- stockpiling near area of use, bulk handling to save energy and cost, on-hand inventory at point of manufacture or production, etc. The risk of spill depends upon the method and timing of transportation and storage. The health risk depends upon the local drainage patterns, geology, water supply practices, etc. Help the students see that all of these hazardous substances carry attendant risks and benefits. If there were no benefits, we would not be transporting or storing them. Working first in small groups and then discussing as a whole class should enable the students to come up with suitable answers for the worksheet.

Procedure:
1. Divide the class into groups of four to six students.

2. Hand each student a worksheet and instruct them to fill it out as they discuss the items within their group. Tell them that they will be sharing what their group comes up with in a whole-class discussion.

3. Allow adequate time for the small groups to complete their discussion (perhaps 20 minutes).

4. Circulate from group to group during the work time to listen, offer suggestions, or give encouragement.

5. After the small group work is completed, lead a whole-class discussion allowing the small groups to share what they have written with everyone. Ideas may be put on a blackboard or flipchart for everyone to see. Groups should be encouraged to compare and even debate ideas.

Extension:
Discuss pros and cons: If not there, then where should these materials be stored and/or transported?

Risks and Benefits
Student Worksheet

Name________

Directions:
For each example tell at least two risks and two benefits. Also, describe how a spill of the material might contaminate the groundwarer and explain what possible health risks the material may present for us.

Example:
Transportation of low level nuclear waste across Iowa on trucks traveling Interstate Highway 80 from Nebraska to Illinois.

Risks - Traffic accident may spill radioactive waste.Wastes may spill during loading or unloading.

Benefits - Radioactive materials are useful in treating cancer and other medical procedures.The site in Nebraska must have an economical way to transport nuclear wates to theapproved site in Illinois.

Possible ground water contamination - soil may become contaminated in the event of a spill. Water seeping down to water table may carry radioactive material down.

Possible health risks - a spill of radioactive material may expose people to radiation causing illness or even death. If the water supply is contaminated it may not be drinkable for a long time.

Storage of gasoline in large underground tanks at the local service station.

Risks -

Benefits -

Possible ground water contamination -

Possible health risks -

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Storage of liquid nitrogen fertilizer in large above ground tanks at the local farm service store at the edge of town.

Risks -

Benefits -

Possible ground water contamination -

Possible health risks -

• •

Transportation of natural gas through our community through a pipeline.

Risks -

Benefits -

Possible ground water contamination -

Possible health risks -

• •

Storage of a large inventory of insecticides, herbicides, and other pesticides at a large garden center near the center of town.

Risks -

Benefits -

Possible ground water contamination -

Possible health risks -

Best Management Practices

Earth/Life Sciences 1 class period

Quick Summary:
The students will analyze two hazardous materials leakage situations and will then answer questions about each.

Objectives: Upon completion, the students will be able to:
1. Describe two common problems with leaking hazardous materials.
2. Identify some of the variables associated with these problems.
3. Suggest some possible solutions to these problems.
4. Evaluate the money and energy costs of these problems.

Materials: None

Printed/AV Materials:
Worksheet: Storing Hazardous Materials Case Study

Teacher Information:
Hazardous materials may be handled in many different ways. Common sense, trial and error, and time have taught us the current best management practices which allow the transportation and storage of these materials while reducing the risks involved. In this activity, encourage the students to think about the best ways to do what needs to be done which will protect the groundwater, the pocketbook, people's health, and energy supplies.

Procedure:
1. Have the students work in groups of two or three. Each group should read the case then discuss and answer the questions. One set of written answers per group.
2. After the group work is done, lead a class discussion centered on each case. Relate the cases to the real situation in the student's community.

Answers:

CASE 1: Shelly's Standard Station

1. $1,600 per year.

2. $.40 per gallon profit.

3. $800 per year in lost profit.

4. $2400 per year total loss.

5. The leaking fuel goes into the ground and perhaps into the surface or groundwater supplies. It may contaminate the water supply, poison the soil, leak into basements, kill animals or plants, cause an explosion or fire, etc. Benzene, a component of gasoline and fuel oil, is a cancer causing agent. Many times benzene is found in shallow drinking water wells near service stations. In low levels, benzene does not have a taste or odor. It can be present for years before it is discovered, but by that time, the exposure from daily ingestion may have already caused harm to those drinking the water. This type of lawsuit could bankrupt most station operators since their insurance coverage in most cases would have a ceiling limit on the amount of coverage or even an exclusion clause if involved in a lawsuit.

6. The lost fuel must be replaced by pumping more crude oil, transporting it, refining it, and then transporting it to the service station. All of these steps require energy expenditure.

7. If Shelly has detected a leak in the 15 year old tanks, it may be a wise idea to pull the old tanks, test the soil and water as required, install new tanks with appropriate early detection devices and conduct any clean-up of the soils and groundwater as required by the state.

CASE 2: Fred's Fertilizer and Farm Supply

1. He probably won't be able to sell the damaged sacks.

2. Fred must pay for the sacks his employees damaged.

3. Fred passes his costs along to his customers with higher prices.

4. The spilled herbicide may get into the bodies of his employees through the lungs or skin and may cause illness like poisoning or cancer or may cause long term effects like birth defects.

5. Both Fred and his customers benefit from having a large stock of the product on hand where it is ready when needed. Fred can also probably buy a volume discount when purchasing large quantities allowing him to lower the price to his customers.

6. Both the surface and groundwater supplies may be threatened by the spill. Rain might carry the herbicide down through the soil to the groundwater or it might wash off the lot into the stream and be carried to other surface water supplies or later into the groundwater at some other place.

7. The spilled herbicide may threaten beneficial insects, fish in the stream or downstream, birds, worms in the soil, or any other members of the food chain along the way (including us).

8. Fred might...
   Store the sacks indoors
   Handle the sacks more carefully, clean up any spilled material right away, provide a dam or other barrier around the stored material to keep it from flowing away if spilled, or find a storage place away from the stream.

9. The packaging and manufacture of the product takes energy as does the transportation to Fred's place.

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Storing Hazardous Materials Case Study
Student Worksheet

Name______________

CASE 1: Shelly's Service Stations
The underground storage tanks at Shelly's Service Station are made of steel and are more than 15 years old. The tank that holds the super unleaded gas has developed a tiny leak through which five and one half gallons of gas leaks out into the ground each day. Although this leak did not show up on daily inventory checks due to the contraction and expansion characteristics of gasoline, a routine tank test did reveal this leak. Shelly buys her gas for eighty cents per gallon and sells it for $1.20 per gallon.

1. Shelly's leak of only 5-1/2 gallons/day results in a loss of about 2,000 gallons/year. About how much does Shelly have to pay for the leaked gas per year?

2. What is Shelly's profit (ignore all of her other expenses for now) on each gallon of gas she sells?

3. How much profit does Shelly lose from that little leak in a year?

4. Shelly's total losses from this leak include what she must pay for the leaked gas and what she doesn't get in profit. How much is her total loss per year?

5. Where does this leaked fuel go? What are some problems associated with leaking petroleum products?

6. How is this leaked fuel replaced? What are the energy implications?

7. Suggest ways in which Shelly might correct her problem.

CASE 2: Fred's Fertilizer and Farm Supply
At Fred's Fertilizer and Farm Supply they just received a large supply of herbicide. The herbicide is in paper sacks but is covered with a plastic tarp and is stored at the edge of the parking lot next to a small creek. As the sacks are being placed there by a fork lift a few of them tear open and some of the herbicide powder spills out onto the parking lot.

1. Is Fred going to be able to sell the torn sacks of herbicide?

2. Who must pay for the damaged materials?

3. Who does Fred pass his costs along to?

4. How might the health of Fred's employees be affected by the spill?

5. Who benefits and what are the benefits from having a large stock of herbicide at Fred's F & FS?

6. What water resources might be contaminated by the spilled herbicide and how might the contamination come about?

7. What living things might be threatened by the spilled herbicide?

8. List some things Fred might do to reduce the risk of environmental contamination from this pesticide.

9. List some ways that energy is used to manufacture and deliver the chemical to Fred's lot where it is wasted on the ground.

Figure V-1. Agricultural drainage wells

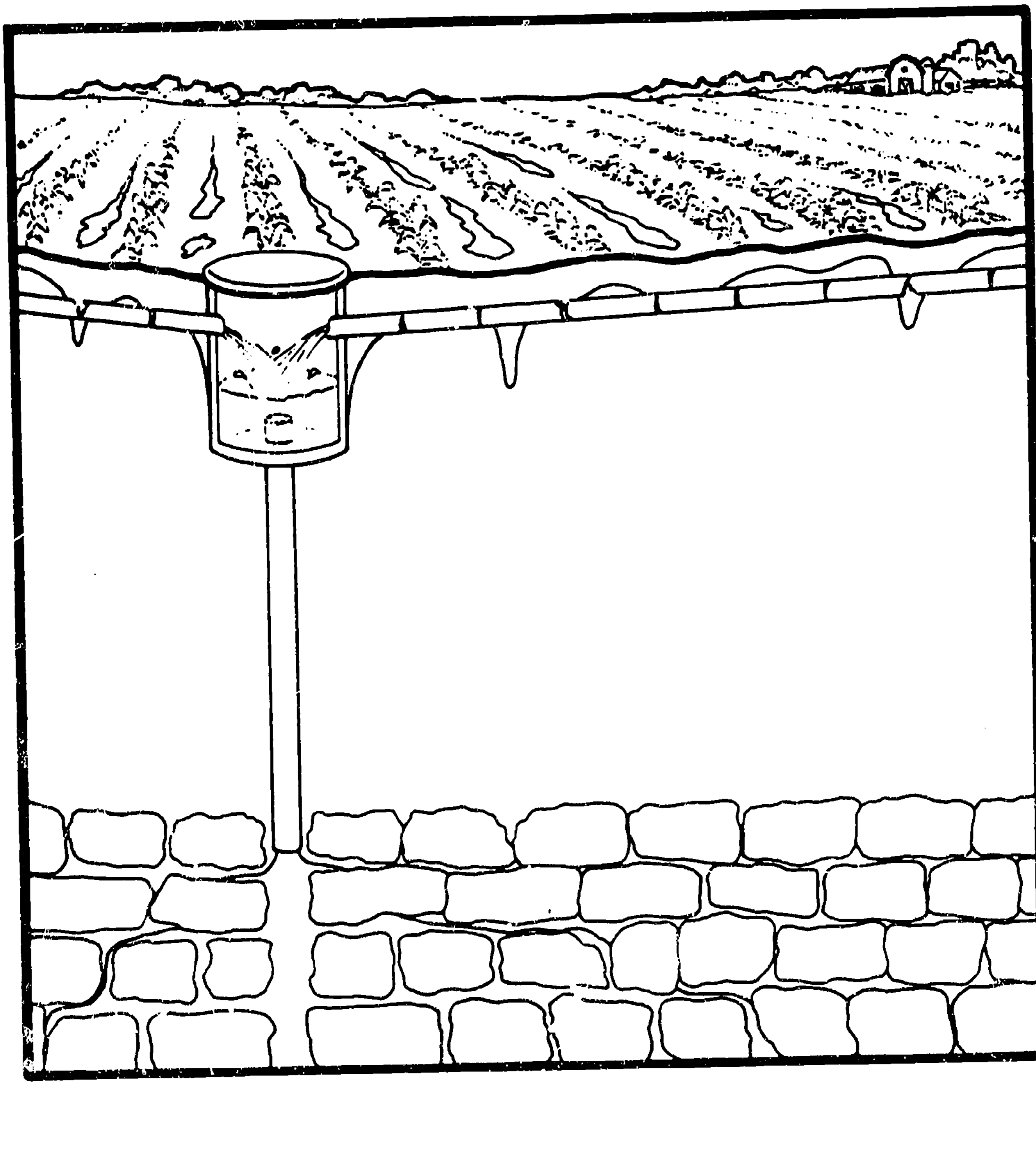

Figure V-2. Abandoned wells

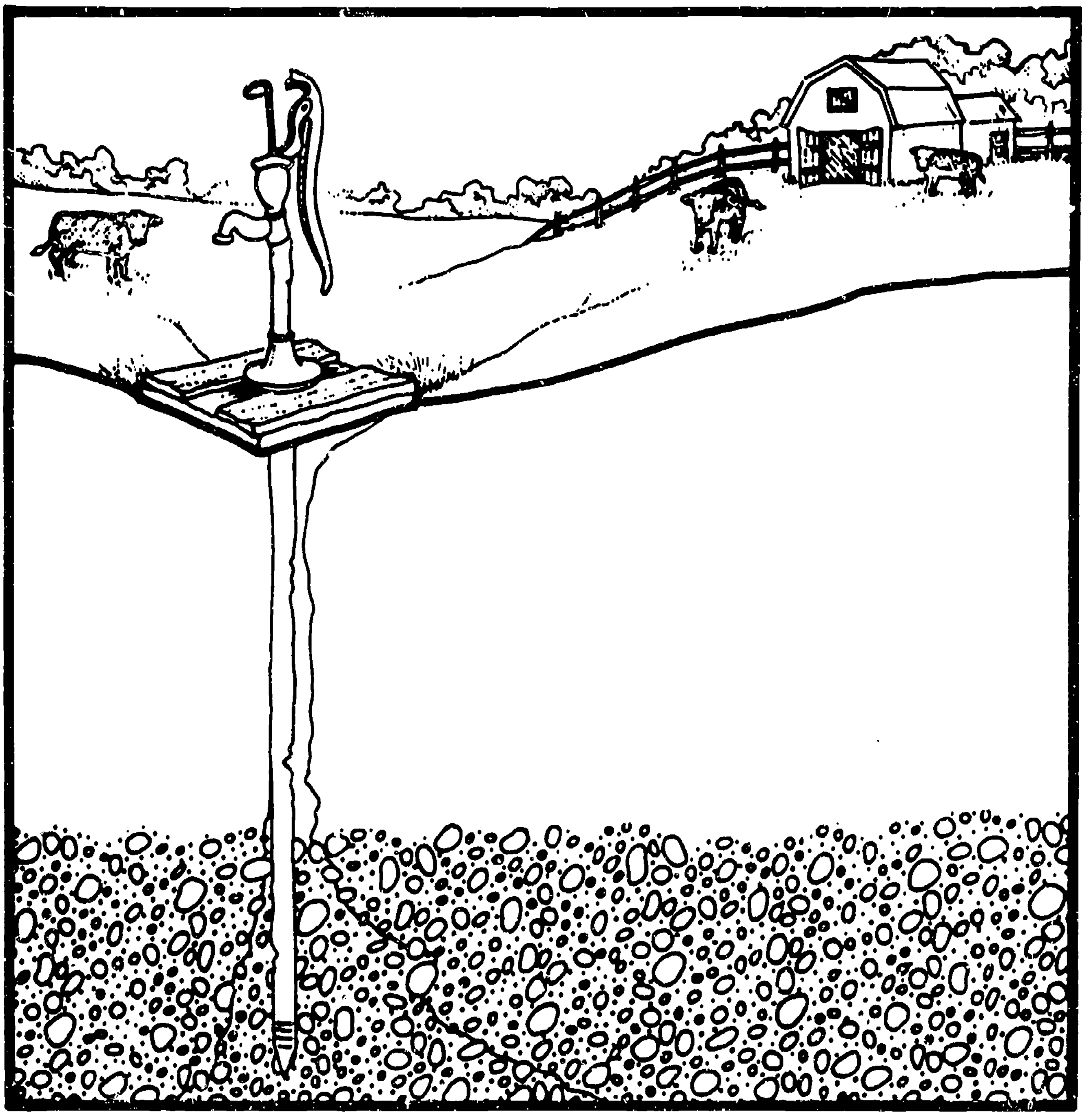

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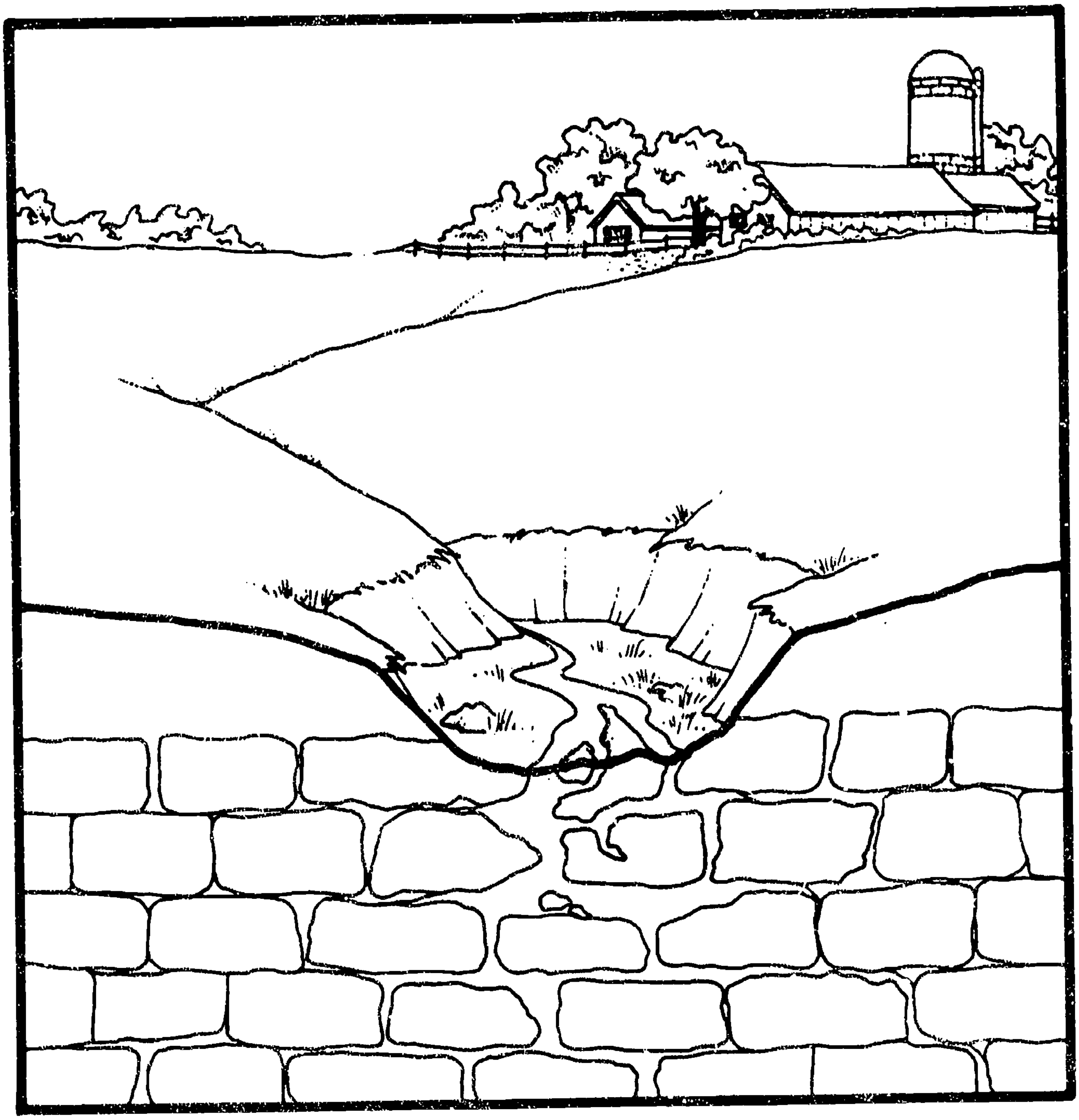
Figure V-3. Sinkholes



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V. Direct Paths of Contamination: Agricultural Drainage Wells, Abandoned Wells and Sinkholes

OBJECTIVES

Agricultural Drainage Wells

Upon completion, students will be able to:
1. Identify the region of Iowa that has been most affected by the use of agricultural drainage wells.
2. Construct a groundwater model that will illustrate how an agricultural drainage well may pollute groundwater.
3. Discuss critically the reasons for/against using agricultural drainage wells.
4. Devise methods to prevent groundwater contamination by agricultural drainage wells.

Abandoned Wells

Upon completion, students will be able to:
1. Identify the regions of Iowa that may be affected by groundwater pollution from abandoned wells.
2. Construct a groundwater model that will illustrate how an abandoned well may pollute groundwater.
3. Discuss critically a law requiring the plugging of abandoned wells.
4. Devise methods to prevent groundwater contamination through abandoned wells.

Sinkholes

Upon completion, students will be able to:
1. Identify the region of Iowa that may be affected by groundwater pollution from sinkholes.
2. Construct a groundwater/sinkhole model that will illustrate how sinkholes may pollute groundwater.
3. Devise methods to prevent groundwater contamination through sinkholes.

BACKGROUND INFORMATION

What is a Direct Path?

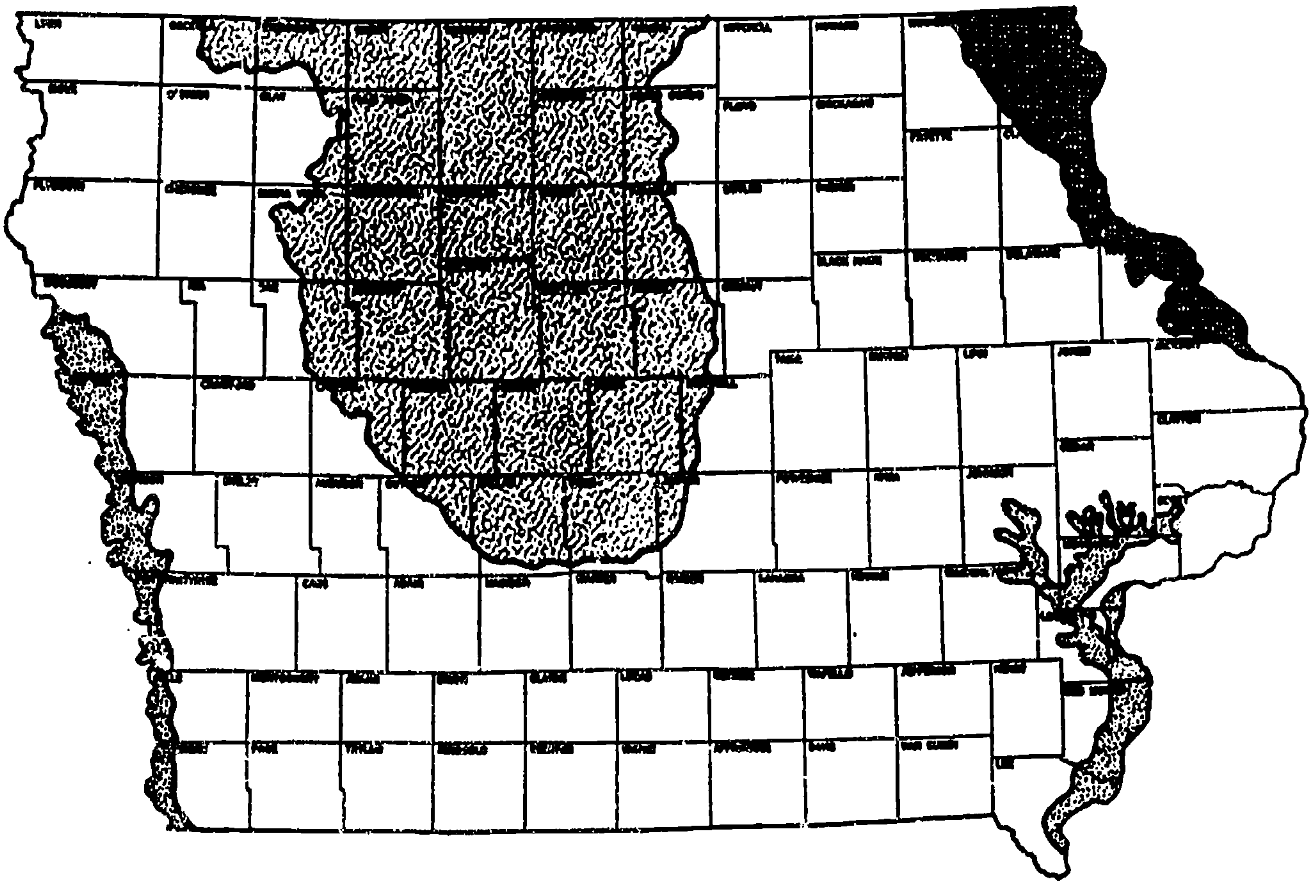
Any hole in the ground that reaches an aquifer provides a direct path by which the aquifer may become polluted. In Iowa, the three direct paths of contamination that are of special concern are: agricultural drainage wells, abandoned wells, and sinkholes.

Agricultural Drainage Wells

Agricultural drainage wells (ag-drainage wells) are used to drain water from marshes, ponds, and other wet areas into deep aquifers. The land covered by the most recent glacier (commonly referred to as the "Des Moines Lobe"—see Figure V-4), became flat, poorly-drained land when the glacier "bulldozed" it flat. Agricultural drainage wells are particularly significant in this area (see Figure V-5). Other parts of Iowa have had thousands of years for streams to erode and create valleys and drain the land.

Past to Present Practices

In 1903, forty percent of the land now farmed in the Upper Des Moines River Basin of north central Iowa was considered too wet to farm. As Iowa's subsurface was explored, bedrock layers were discovered that could hold water and offered a solution to the drainage problem. Bedrock formations could be used to drain water as long as they contained large fractures and lay at economically accessible depths.



ALLUVIUM

DRIFT FROM DES MOINES LOBE OF WISCONSINAN GLACIER

DRIFT FROM OLDER GLACIERS

"DRIFTLESS AREA" ISOLATED EXPOSURES OF DRIFT

FIGURE V. 4. MATERIALS FROM MOST RECENT GEOLOGIC AGE IN IOWA

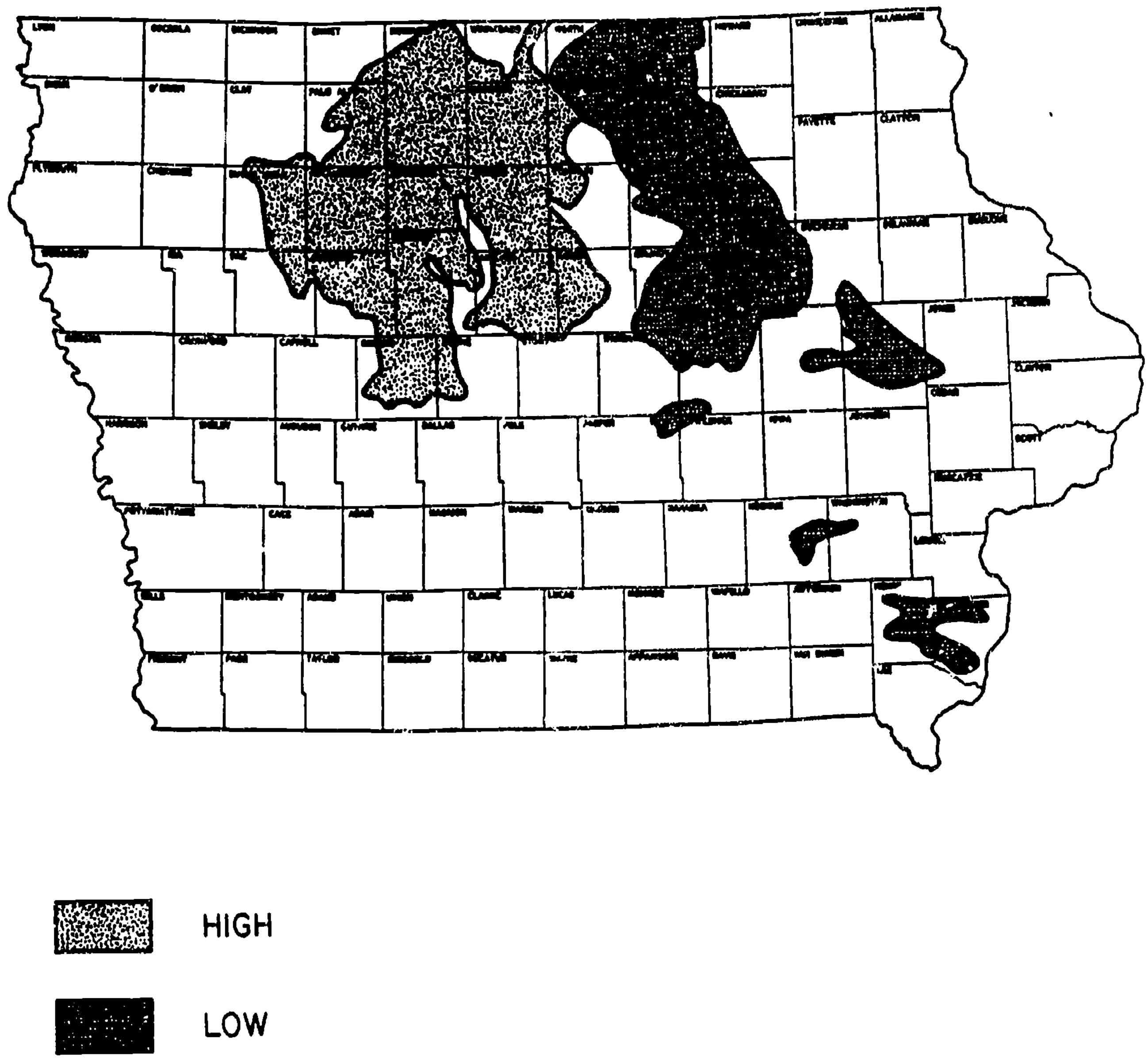


FIGURE V. 5. POTENTIAL FOR DRAINAGE WELL USE IN IOWA

Ducks Limited

Enactment of the Iowa Drainage Law in 1906 resulted in millions of acres of wetland being drained into natural streams. Today ditches and mains (pipes) channel most of Iowa's Ag-drainage into streams. However, nearly 700 drainage wells are estimated to be in use. Areas of north central Iowa may have as many as eight ag-drainage wells per square mile. Enactment of state legislation in 1957 curtailed construction of new drainage wells by requiring a state permit to either construct a new drainage well or to expand the drainage area of existing wells. Since 1957, only two permits have been issued.

The 1987 Groundwater Protection Act included the following:

All ag-drainage wells must be registered with the DNR by January 1, 1988.

The Department of Agriculture and Land Stewardship (DALS) will set up a demonstration project to show what types of practices will eliminate groundwater contamination from ag-drainage wells and sinkholes and also suggest alternative drainage methods.

By 1991, all ag-drainage well owners must submit a plan to DALS showing how contamination will be eliminated from their ag-drainage wells.

Benefits and Risks

Ag-drainage wells have allowed more land to be farmed. In a typical year, nearly 5 million gallons of excess water must be artificially drained from a flat 40-acre field in north central Iowa. Excess water can enter a drainage well in two ways. (See Figure V-6.) About 75% of the water enters drainage wells after percolating a short distance through the soil. The rest of the excess water, about 25%, enters as run-off through surface inlets to tile lines.

The risk to the groundwater depends on the kinds of contaminants flushed into the drainage well. Studies have shown that:

1. High concentrations of silt and bacteria are common in surface run-off through tile inlets.

2. Low levels of pesticides have also been found, but much remains to be discovered about the effects of long-term exposures to low level of pesticides.

3. Water percolating slowly through the soil contains much less silt, bacteria, and pesticide than surface run-off but nitrate levels are quite high in percolation water.

Note: Health risks of nitrates are listed in the CHEM unit.

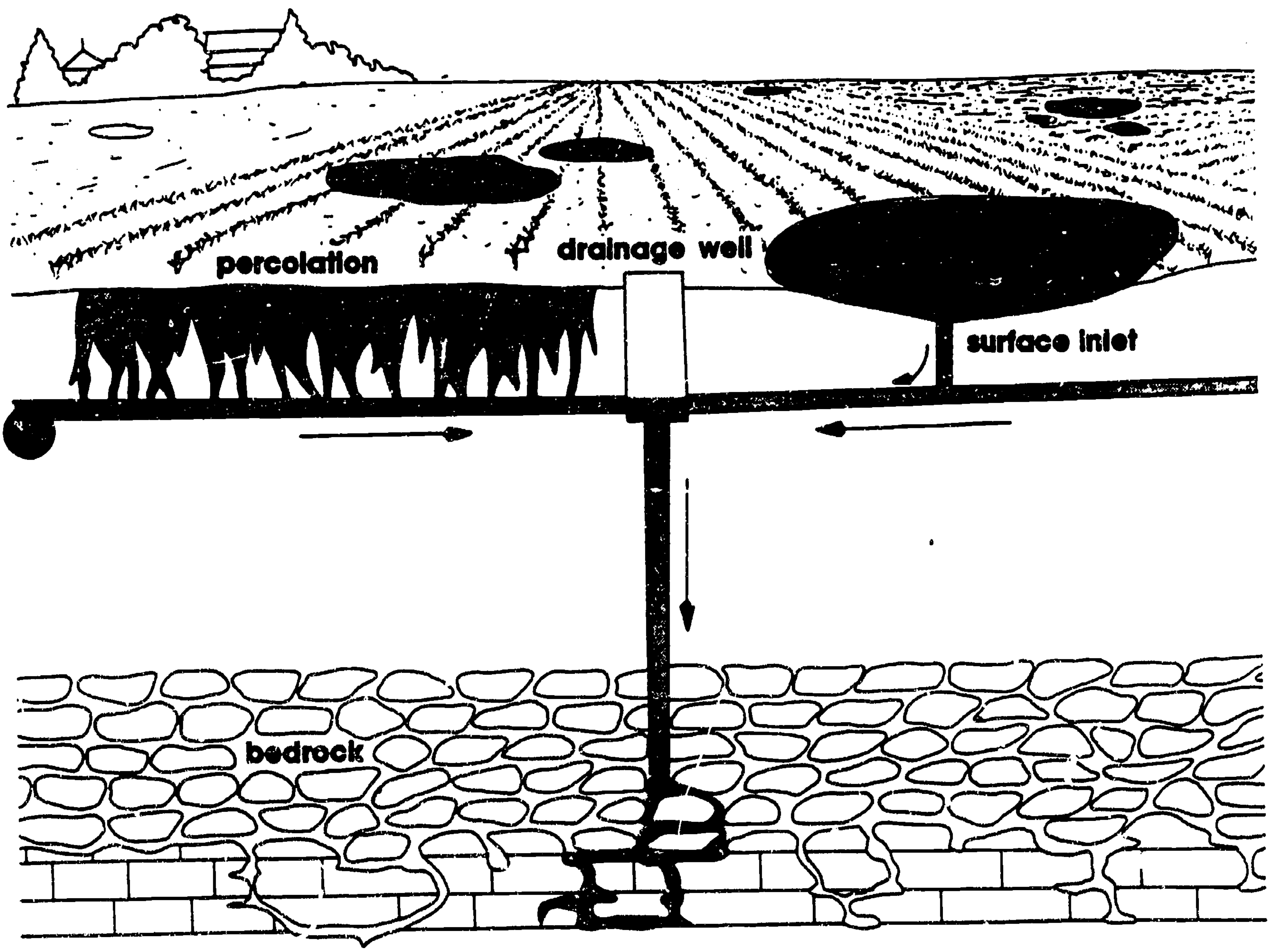
Alternatives, Best Management Practices

There are three major alternatives to the use of ag-drainage wells. The first is to **plug the wells**. This might cut corn yields by an average of 50 bushels per acre and soybeans by about 18 bushels per acre. In addition, delayed planting and harvesting, farm equipment stuck in wet fields, and fertilizer losses would add to the problem of reduced crop yields. Excess water could be removed from fields and discharged into surface drainage but cost estimates range from about $100 to about $300 per acre depending on the nearness of existing drainage. Benefits might be gained, however, in dry years and in the production of ducks, other wildlife and the marsh ecosystem.

Removing surface inlets would exclude high concentrations of silt, bacteria and pesticides. However, prolonged ponding of water in low spots would result in crop reduction or loss.

Reducing or eliminating agricultural chemicals can reduce chemical levels in drainage.

Figure V-6. Two ways that water enters drainage wells. Source: ISU Cooperative Extension Service, Pm-1201, Agricultural Drainage Wells in Iowa.



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Abandoned Wells

The Iowa Department of Natural Resources defines an abandoned well as: "a water well which is no longer in use or which is in such a state of disrepair that continued use for the purpose of accessing groundwater is unsafe or impracticable." Abandoned wells may carry surface runoff, including human and animal waste, farm fertilizers and pesticides directly into groundwater. Most abandoned wells are in south central Iowa and to a less extent in northwestern Iowa, but there are abandoned wells in all 99 Iowa counties.

Past to Present Practices

There are two general types of abandoned wells in Iowa: (1) large diameter, shallow wells bored or hand-dug in soils, and usually less than 100 feet deep and (2) small diameter, steel-cased, drilled wells that draw water from deeper glacial drift and bedrock aquifers at depths of 20 to more than 3,000 feet. Estimates of the number of abandoned wells in Iowa vary. Conservative estimates range from 36,000 to 57,000 abandoned wells. It is possible that there are hundreds of thousands of abandoned wells in Iowa. Until recently, there were no laws requiring the plugging of abandoned wells.

Risks

Large-diameter wells represent a major safety hazard because the large opening allows more pollutants to enter aquifers more quickly. Also, many of these wells are uncovered and receive surface run-off, and usually there is standing water several feet below the land surface. These wells are recharged by percolating surface water, which makes them very susceptible to contamination.

Drilled wells represent a problem because the steel casing may corrode. Pitted, cracked, or collapsed well casings allow surface water and contaminants to seep into wells. Figure V-7 illustrates pathways for contaminants into an unprotected well.

Alternatives, Best Management Practices

Well construction essentially involves drilling an open hole and installing a casing to prevent collapse of the bore holes. While this does provide access to the groundwater, it removes the filtering soil cover and provides a pipeline for contaminants to enter the groundwater source. Good well design and construction incorporate protective features that block pollution pathways. Figure V-8 illustrates some of these protective features and a brief summary follows:

1. Casing - to ensure that surface water filters through an adequate amount of soil, there should be at least 20 feet of permanently installed casing. In areas with a thin soil cover, the casing should extend down so that it is firmly seated in bedrock. The casing should be watertight.

2. Top of the well - Wells should extend at least one foot above ground or above the highest known water level in flood prone areas. Adaptations can be made to existing wells to eliminate contaminant entry at the top of the well.

3. Grout - Grout, a slurry of cement or clay, is used to seal the space between the casing and the bore hole.

4. Well seal - A tightly fitting seal should be installed at the top of the casing to prevent foreign materials from entering the well.

5. Disinfection and water testing - All new or reconstructed wells must be disinfected and a water sample analyzed before drinking.

Figure V-7. Pathways for contaminants into an unprotected well. Source: ISU Cooperative Extension Service, Pm-840, Good Wells for Safe Water.

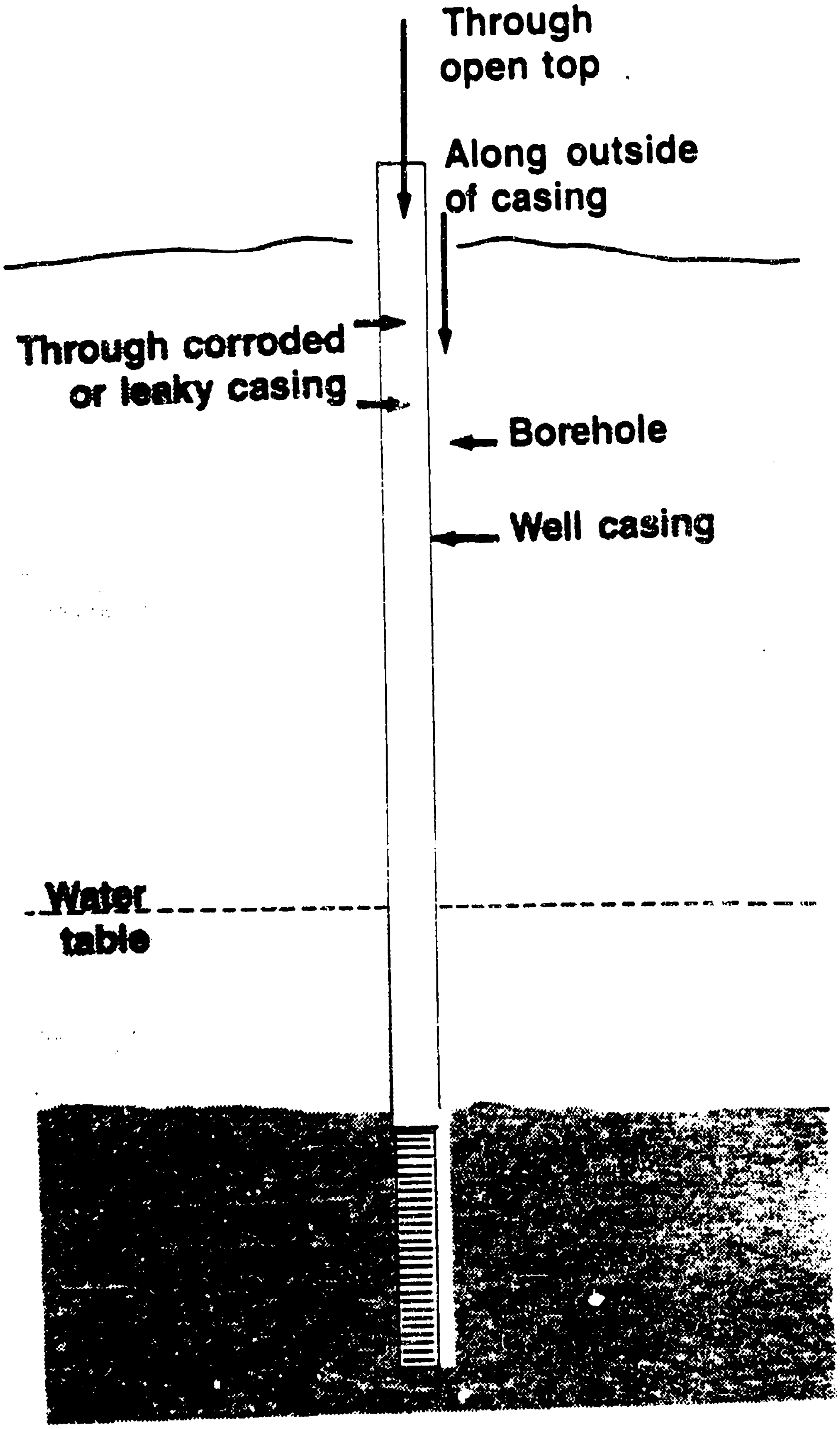
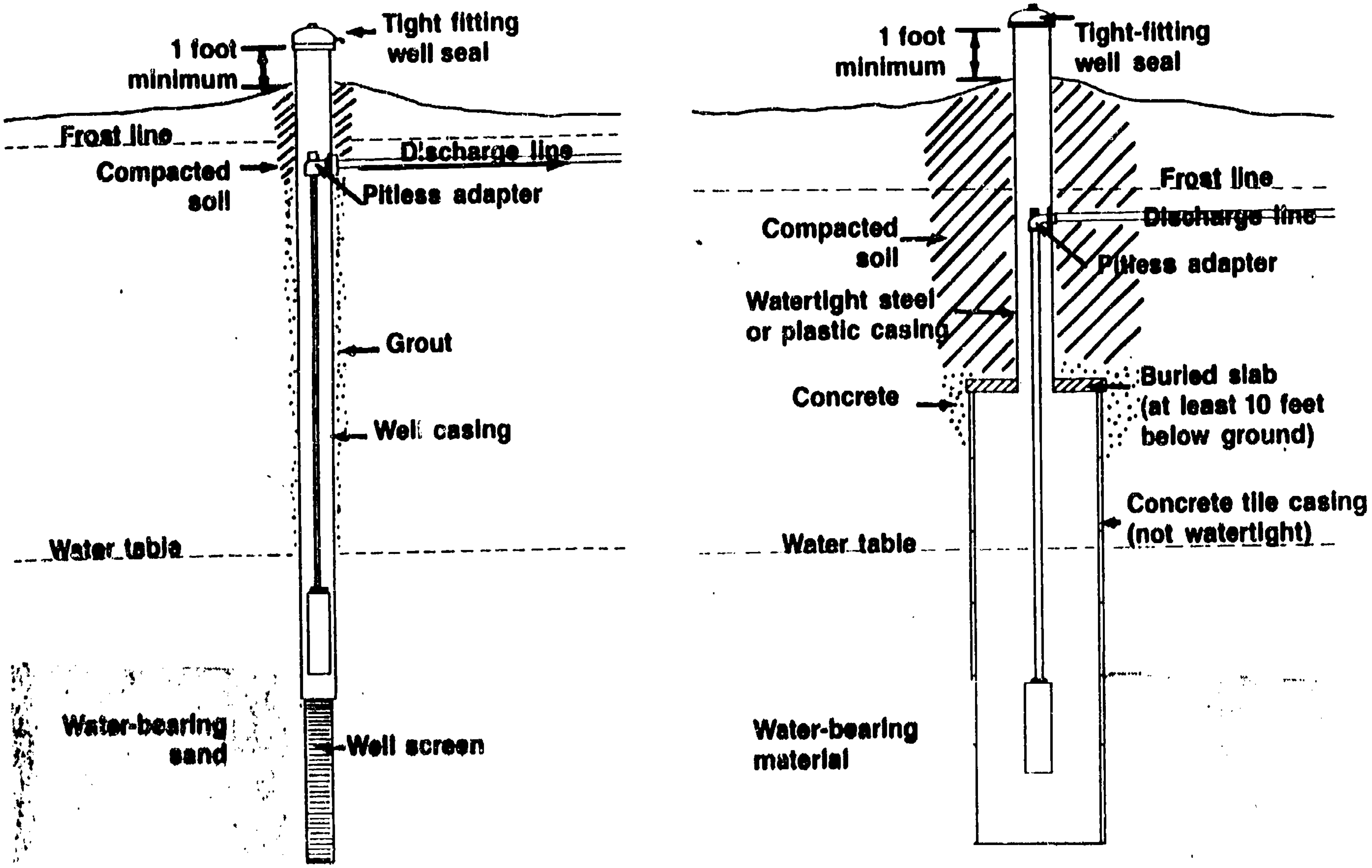


Figure V-8. Wells with protective features: a. Drilled well tapping water-bearing sand; b. Buried slab design for bored well. Source: ISU Cooperative Extension Service, Pm-840, Good Wells for Safe Water.



a.

b.

After a well is no longer in use or it is in need of repair, plugging it is preferred to simple abandonment. The objective of plugging is to fill the hole with impermeable material that will prevent movement within the wall. Sealing materials are either neat cement or clean clay (bentonite clay). concrete mixtures are not acceptable because they can break down.

Sinkholes

Sinkholes are natural holes in the ground caused when rainwater (which is slightly acidic) dissolves carbonate rocks, either limestone or dolomite. Over time small fractures in the rock become larger and allow more water to move through the system. Fractures may develop into caves, and unsupported surface materials may collapse into the void space forming sinkholes. Sinkholes allow sediment, bacteria, and other contaminants to run directly into the upper bedrock aquifer. In addition, sinkholes have been used as dumps in some areas, which further endangers groundwater quality. In Iowa, sinkholes are found in the northeastern and eastern parts of the state. The changing nature of sinkholes makes it more difficult to control problems associated with them.

Past to Present Practices

Sinkholes are down in the dumps.

Water quality problems in karst regions of Iowa appear to be the result of the interaction of natural recharge processes with modern agriculture. Nitrate levels approaching or exceeding health standards are becoming common. Herbicide levels are low in concentration but the levels are higher and more persistent than other areas. During times of run-off the water may turn "muddy" and likely will contain bacteria, higher than normal loads of herbicides, and perhaps insecticides.

Alternatives, Best Management Practices

Sinkhole flow and percolation through shallow soils must be considered if shallow groundwater sources are to be protected. To prevent or reduce groundwater contamination through sinkholes:

1. Abandon the use of sinkholes as disposal areas.
2. Adopt run-off and erosion control measures, such as grass filter strips around sinkholes.
3. Incorporate ag-chemicals into the soil to reduce their movement with run-off.
4. Avoid over-applications of nitrogen fertilizer and animal manure.
5. Cease fall application of nitrogen fertilizer.
6. Use more rapidly degradable pesticides.
7. Reduce unnecessary pesticide use.

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Agricultural Drainage Wells

Earth Science 1 Class Period

Quick Summary: Students use a map and the groundwater model to identify the region of Iowa most affected by ag-drainage wells and to view how ag-drainage wells may cause groundwater pollution.

Objectives: Upon completion, students will be able to:
1. Identify the region of Iowa that has been most affected by the use of agricultural drainage wells.
2. Demonstrate how an agricultural drainage well may pollute groundwater, using a groundwater model.
3. Discuss critically the reasons for and against using agricultural drainage wells.
4. Devise methods to prevent groundwater contamination by agricultural drainage wells.

Materials:
Iowa road map (which shows lakes) for each student.
Groundwater Model (as shown in Figure 5 of Appendix A. Great Ways to Use the Groundwater Model) for each team of 4-6 students.

Printed/AV Materials:
Overheads: Figures V-1, V-4, V-5, V-6 from Background Information.
Relief Map of Iowa.
Outline Map of Iowa - Answers
Worksheets: Outline Map of Iowa
Ag-drainage Wells.

Teacher Information:
The most recently glaciated area of Iowa, often called the "Des Moines Lobe," has its boundary roughly marked by the location of several natural lakes in Iowa and the City of Des Moines. This glaciation left much of north central Iowa poorly drained. Lots of standing water made this region unfit for agriculture. The relief map used in conjunction with the outline map with the lakes located on it should give students a mental picture of the topograph of the area.

Ag-drainage wells contributed to the draining of prairie wetlands in Iowa, although they were not solely responsible. In presettlement times Iowa had an estimated two to three million acres of wetlands. Currently it is estimated that there are only about 35,000 acres of wetlands available for duck nesting in Iowa. The current 60,000 ducks hatched per year has decreased from an estimated 12.5 million to 25 million presettlement times.

Procedure:
1. The teacher (after reading the ag-drainage wells background) should introduce the topic. A basic introduction should include what ag-drainage wells are, where they're used and what they're used for.

2. On the outline map of Iowa and using an Iowa road map, students should mark the locations of the lakes listed, number them and connect them with a line.

3. Have students compare their maps with the relief map of Iowa. (Overheads can be made of the relief map of Iowa and the outline map of Iowa--answers sheet, and overlain on top of each other.)

4. Have students construct the groundwater model as shown in Figure 5 of Appendix A. Great Ways to Use the Groundwater Model. A straw will represent the ag-drainage well and food coloring or powdered drink mix will represent the contaminant. This model will show a pathway by which surface contamination is transported to underground aquifers.

5. After completing the activity, students can answer the questions on the worksheet or in a teacher-led discussion.

Answers:

a. North central Iowa has been most affected by ag-drainage wells.

b. Ag-drainage wells transfer surface contaminants directly to groundwater.

c. For ag-drainage wells: creates more agriculturally productive land, and increases yields, and reduces problems with mired farm equipment and delays in planting and harvesting. Against: reduces wetland habitat, increased groundwater contamination if ag-chemicals are used, increased yields may decrease prices.

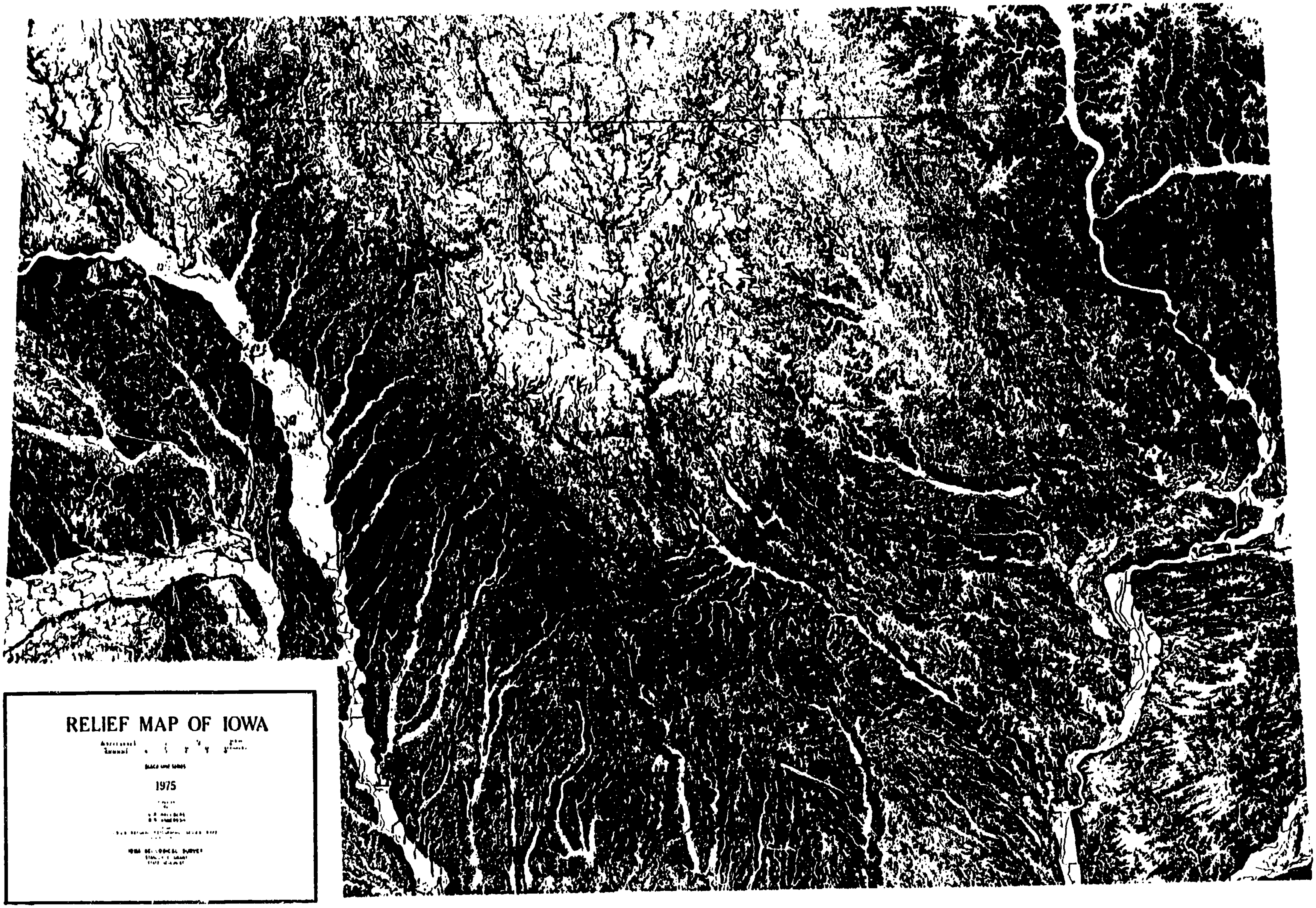
d. Possible methods to reduce groundwater contamination through ag-drainage wells include: plug the ag-drainage wells and/or surface inlets, and reduce applications of nitrate fertilizers and pesticides. (See CHEM unit.)

e. The use of ag-drainage wells has drastically cut duck populations (by the millions) as well as other wildlife that live in wetlands.

Alternative: Teacher lecture/demonstration.

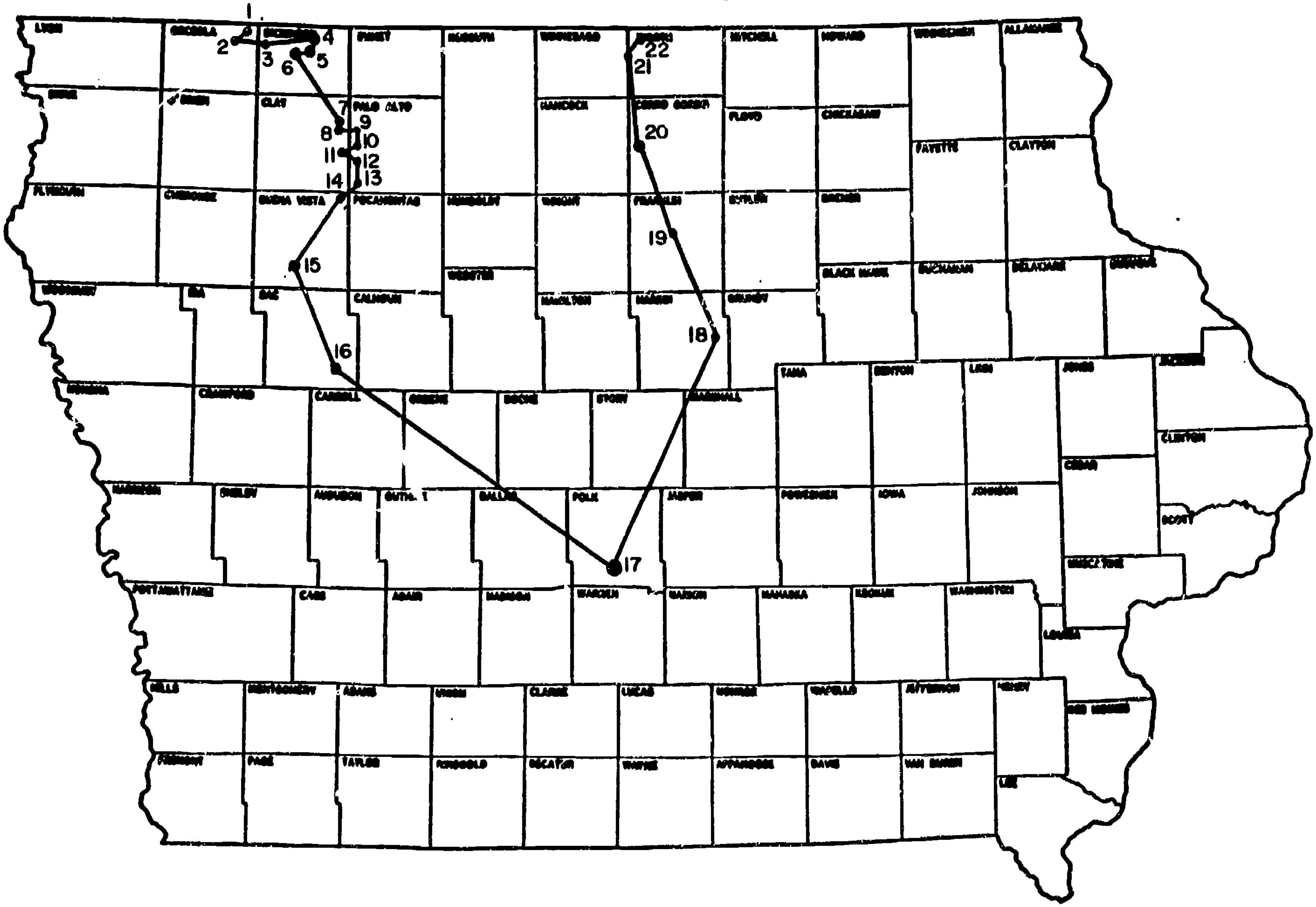
Extensions:
1. Set up a debate using teams of students representing both sides of the ag-drainage well issue.
2. Role playing - farmer vs. duck hunter.

V-17



Outline Map of Iowa

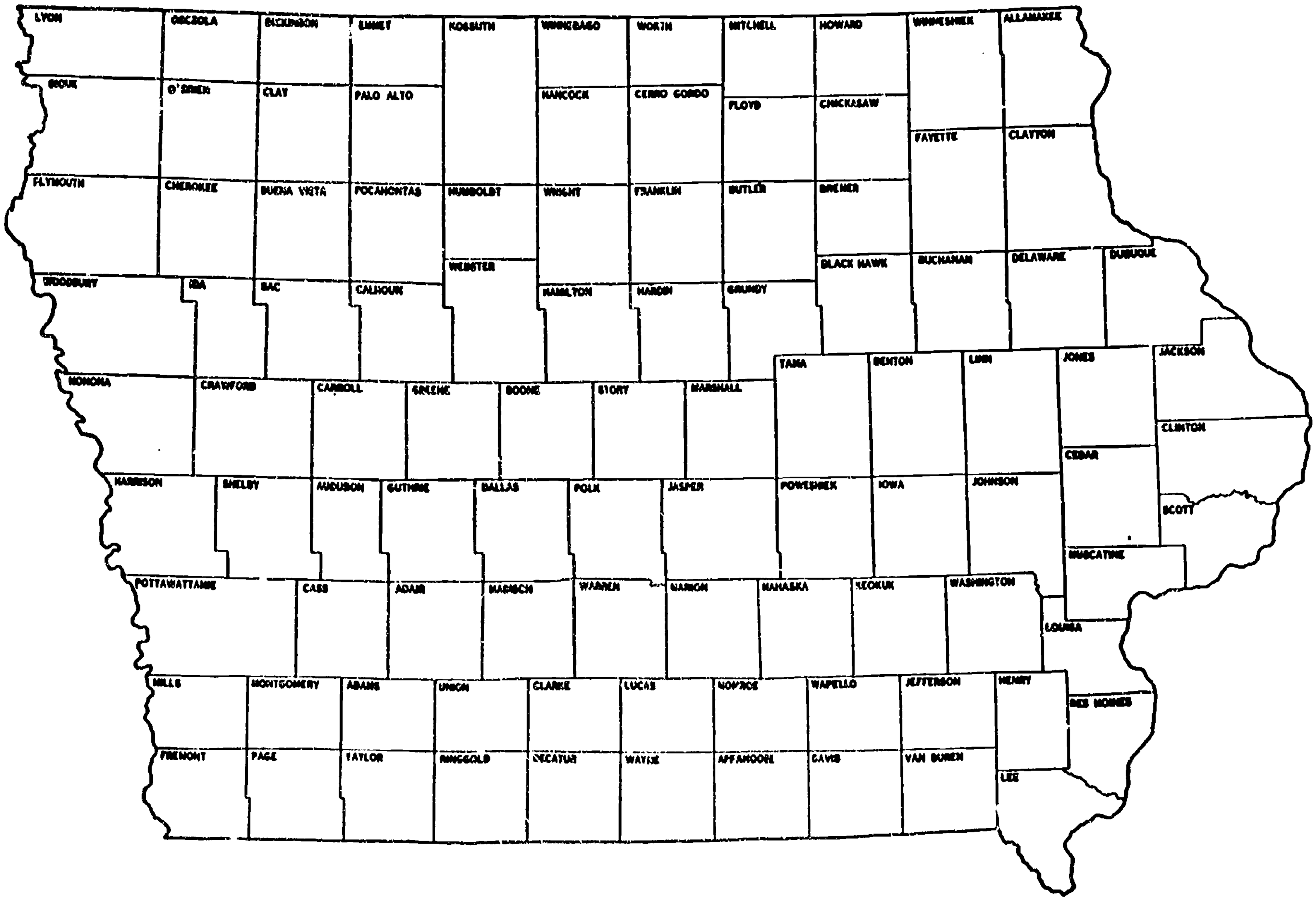
Answers



Lakes to be located:

1. Iowa Lake (Osceola County)
2. Rush Lake (Osceola County)
3. Silver Lake (Dickinson County)
4. Big Spirit Lake
5. East Okoboji Lake
6. West Okoboji Lake
7. Trumbull Lake
8. Round Lake
9. Lost Island Lake
10. Virgin Lake
11. Elk Lake
12. Silver Lake (Palo Alto County)
13. Rush Lake (Palo Alto County)
14. Pickeral Lake
15. Storm Lake
16. Black Hawk Lake
17. the city of Des Moines
18. Pine Lake (Hardin County)
19. Beeds Lake
20. Clear Lake
21. Rice Lake
22. Silver Lake (Worth County)

Outline Map of Iowa



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15. Storm Lake
16. Black Hawk Lake
17. the city of Des Moines
18. Pine Lake (Hardin County)
19. Beeds Lake
20. Clear Lake
21. Rice Lake
22. Silver Lake (Worth County)

Ag-Drainage Wells
Student Worksheet

Name______________

a. What region of Iowa has been most affected by the use of ag-drainage wells?

b. How does an ag-drainage well contribute to the groundwater pollution problem?

c. Discuss critically reasons for and against the use of ag-drainage wells.

d. Devise methods to prevent groundwater contamination by ag-drainage wells.

e. How has wildlife been affected by the use of ag-drainage wells?

Abandoned Wells

Earth Science 1-2 Class Periods

Quick Summary: Students use a groundwater model to view how an abandoned well may cause groundwater pollution.

Objectives: Upon completion, students will be able to:
1. Identify the regions of Iowa that may be affected by groundwater pollution from abandoned wells.
2. Demonstrate how an abandoned well may pollute groundwater, using a groundwater model.
3. Discuss critically a law requiring the plugging of abandoned wells.
4. Devise methods to prevent groundwater contamination through abandoned wells.

Materials:
Groundwater model (as shown in Figure 6 of Appendix A. Great Ways to Use the Groundwater Model) for each team of 4-6 students.

Printed/AV Materials:
Overheads: Figures V-2, V-7, and V-8 from the background information.
Worksheet

Teacher Information: Refer to background information at the beginning of this unit.

Procedure:
1. Construct the groundwater abandoned model as instructed in Appendix A. Great Ways to Use the Groundwater Model.

2. Using food coloring as a pollutant, have students demonstrate how an abandoned well may cause groundwater pollution.

3. After students have constructed the model and demonstrated how an abandoned well might lead to groundwater pollution, lead them in a discussion of what methods might be used to prevent groundwater contamination or have them write answers to the worksheet.

a. Abandoned wells are in all Iowa counties, with the greatest concentration in south central Iowa and to a lesser extent northwest Iowa.

b. Abandoned wells transfer surface contamination directly to groundwater.

c. See background information.

d. See background information.

Alternative:
Teacher lecture/demonstration.

Extensions:
Interview a well driller.

Abandoned Wells

Student Worksheet .

Name______________

a. Where are abandoned wells located in Iowa?

b. How do abandoned wells contribute to the groundwater pollution problem?

c. Discuss critically the need to plug abandoned wells.

d. Devise methods to prevent groundwater contamination through abandoned wells.

2 ·

Sinkholes

Earth Science 1 Class Period

Quick Summary: Using the groundwater model, students will view how sinkholes contribute to the groundwater pollution problem.

Objectives: Upon completion, students will be able to:
1. Identify the region of Iowa that may be affected by groundwater pollution from sinkholes.
2. Construct a groundwater/sinkhole model that will illustrate how sinkholes may pollute groundwater.
3. Devise methods to prevent groundwater contamination through sinkholes.

Materials:
Groundwater model for each team of 4-6 students.
Sugar cubes (20-30)
Hot water
Food coloring or powdered drink mix
2 rulers or 2 pencils

Printed/AV Materials:
Overhead: Iowa Sinkhole Density Map
Worksheet

Teacher Information:
Refer to Background Information at the beginning of the unit.

Procedure:
1. Introduce the topic of describing what a sinkhole is and showing an overhead (Figure V-3).

2. Use the overhead on Iowa Sinkhole Density and ask students why the pattern of sinkhole density exists.

3. Using the groundwater model previously constructed, use sugar cubes to represent a below surface carbonate deposit. Refer to Figure 7 in Appendix A. Great Ways to Use the Groundwater Model.

4. Have students suspend a pop can with 3 pin holes in the bottom. The can may set on two pencils or rulers.

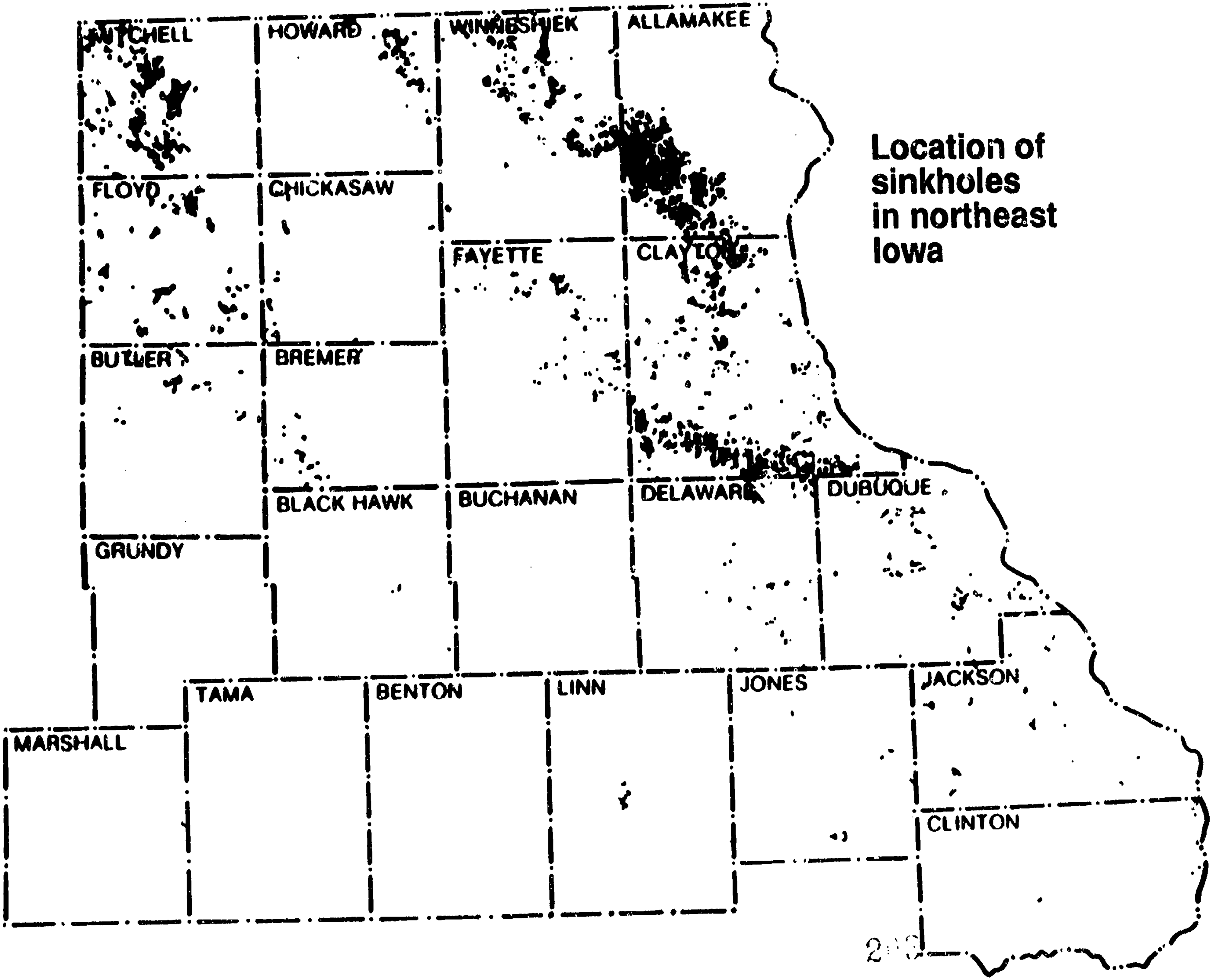
5. Hot water placed in the can should be allowed to run over the gravel on top of the sugar cubes.

6. Have students observe what happens.

7. Use food coloring or powdered drink mix to show how surface-applied contaminants may affect the groundwater source.

8. Lead the students in a discussion or have them complete the sinkhole worksheet.
   a. Sinkholes are concentrated in Northeast Iowa.
   b. Sinkholdes transfer surface wastes directly to groundwater.
   c. For methods to prevent groundwater contamination through sinkholes, refer to the background information at the beginning of the unit.

Alternative:
Teacher lecture/demonstration.



Location of sinkholes in northeast Iowa

Sinkhole

Student Worksheet

Name_______________

a. In what region of Iowa are sinkholes located?

b. How do sinkholes contribute to the groundwater pollution problem?

c. Devise methods to prevent groundwater contamination through sinkholes.

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Figure VI-1. Land-applied wastes

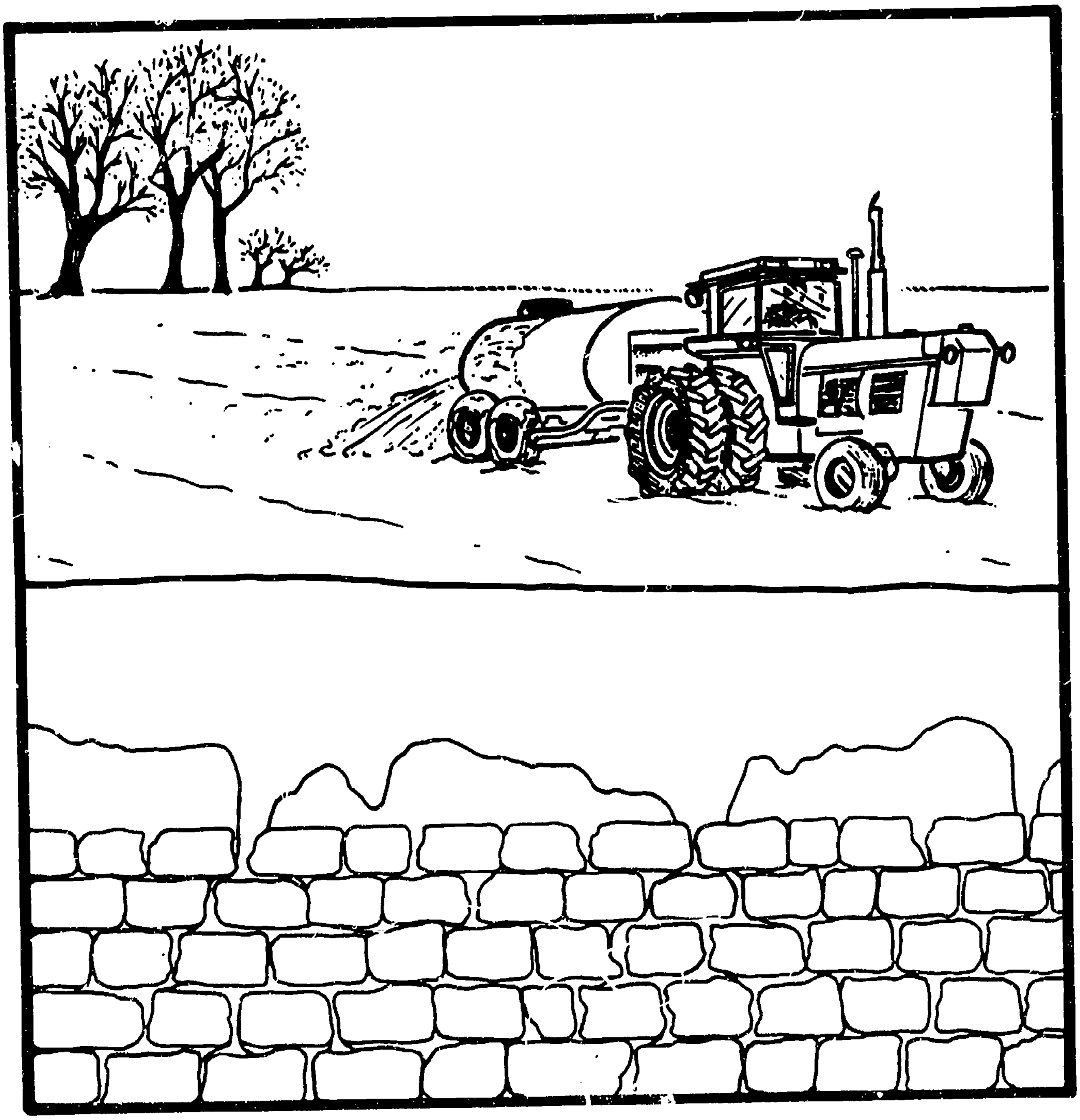

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Figure VI-2. Lagoons

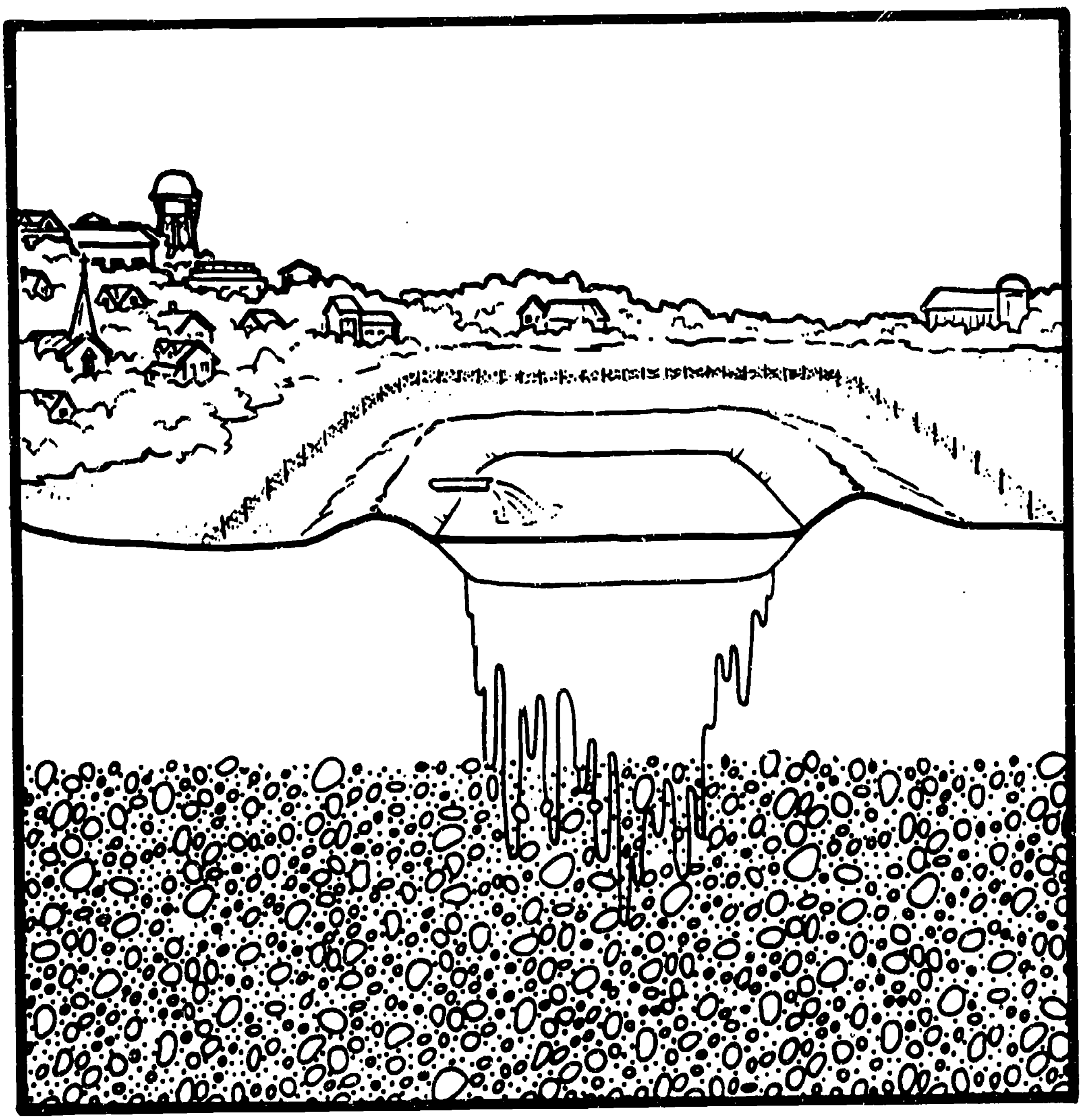

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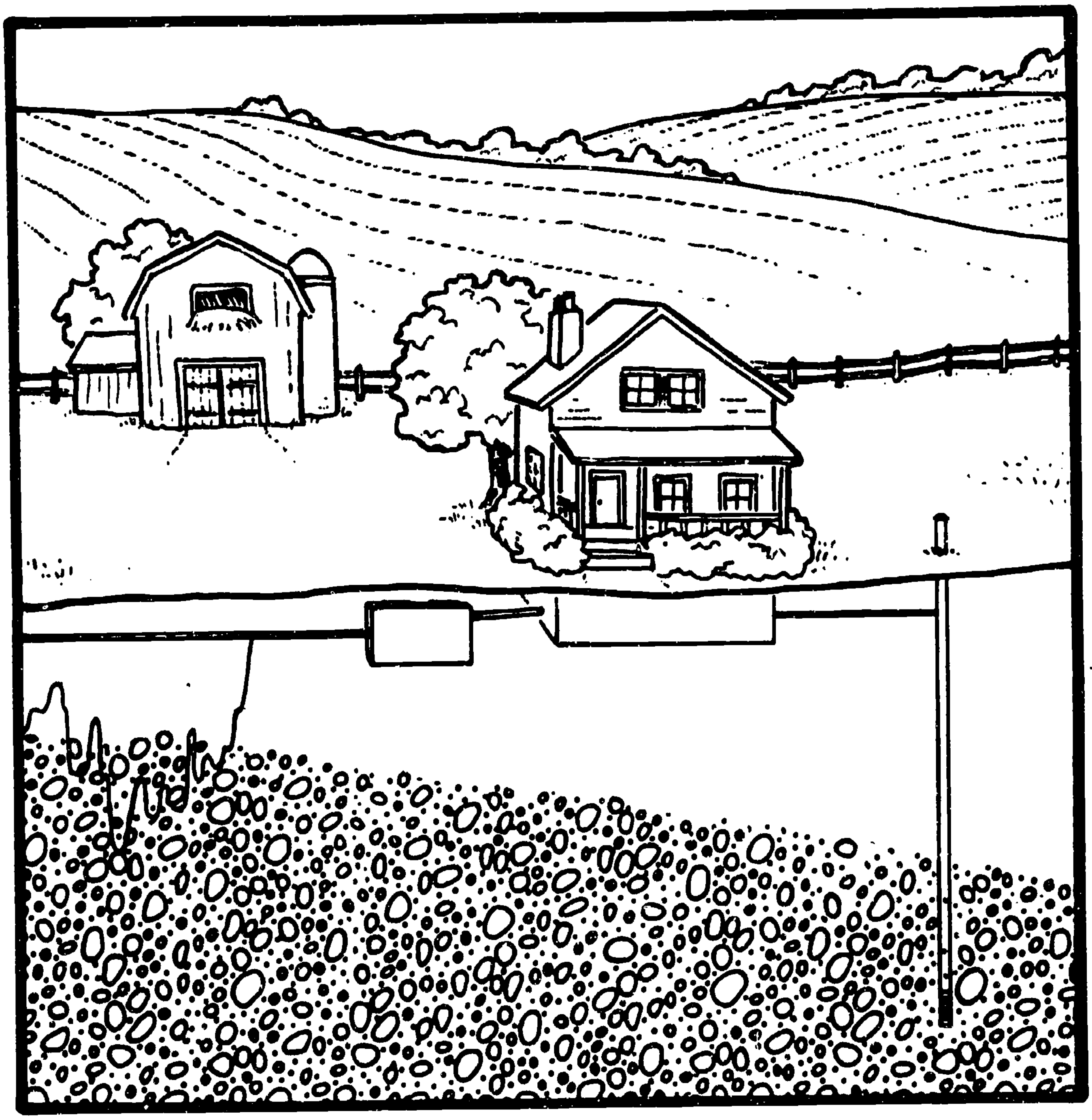
Figure VI-3. Septic systems



VI. DUNG: Land-Applied Wastes and Sewage Treatment

OBJECTIVES

Upon completion, students will be able to:
1. Critically discuss the application of animal wastes, municipal sewage, and industrial wastewater treatment sludge on the land.
2. Discuss the role that septic tank systems play in on-site wastewater treatment.
3. Discuss critically the safe use of sewage lagoons.

BACKGROUND INFORMATION

We depend on soil to filter animal and human wastes, whether these wastes are spread over fields or put in a septic tank. Most soils can filter physically (such as removing turbidity) and biologically (such as bacteria), but they are not as good at filtering many chemicals (particularly those invented in the last few decades). Also, not all soils are good filters, and even the soils that are good filters can be overloaded. That is why the natural filter system that worked so well for early inhabitants is not working as well for us today -- we have stretched the system past its limits in some places.

Water that goes down our drains generally gets treated in one of three ways : (refer to Figure VI.4)
1. Most farms: septic systems;
2. Most small towns : lagoons;
3. Most larger towns: sewage treatment plants that produce sludge.

There are three levels of sewage (wastewater) treatment. Primary treatment is a physical process which removes visible solids (like rats, grapefruit and sand) through filtering and settling. Secondary treatment is a biological process where bacteria decompose organic matter. To provide oxygen to help this process, either a trickling filter or activated sludge process is used. Tertiary treatment is a biological and chemical process which may use a variety of chemical techniques to remove inorganic or synthetic organic chemicals.

Secondary treatment is the minimum level required by federal law. An estimated 10 to 20 percent of Iowa sewage treatment plants provide tertiary treatment. For example, ammonia may need to be removed to protect aquatic life.

I. LAND APPLICATION OF SOLID AND LIQUID WASTES

Applying **animal wastes and sludges** (from both industrial wastewater treatment and municipal sewage) on the land has become a common practice. It is an alternative to burning or discharging our wastes to rivers and streams. To land apply sludges, they must be stabilized (not actively decomposing and thus having little odor) and incorporated (put under soil). The maximum amount allowed is generally 2 tons of dry sludge per acre, which is only a fraction of an inch deep.

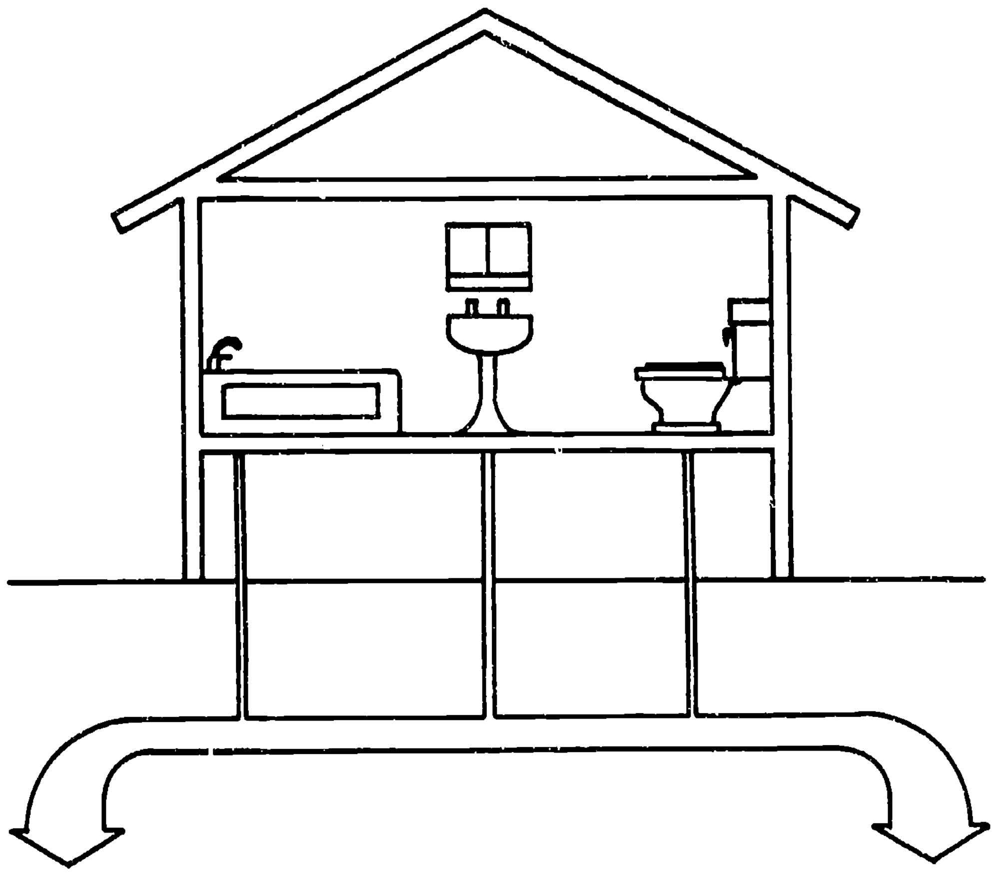
At these sites, water-soluble chemicals such as chlorides and nitrates can **move through the soil and into groundwater**. Other contaminants may become soluble under low pH conditions or simply exceed the absorptive properties of the soil and move into the groundwater or surface water

Energy savings can result from using manure or sludges instead of commercial fertilizer which uses natural gas and much energy for production , packaging, transportation and application.

Animal wastes and sludges can be valuable **fertilizer** for crops. However, commercial nitrogen fertilizer may also be applied on the same field. The nitrogen from the land-applied waste must be credited in order to avoid nitrate leaching from excessive application.

Much of Iowa's **manure** "goes to waste" (is not used for fertilizer), probably due to transportation and storage limitations. This natural recycling of nutrients could also be more effective if improved manure handling techniques were used to preserve more of the fertilization value of the manure.

Figure VI-4. Water Down the Drain -Where Does It Go?



<u>Private</u> OR <u>Municipal Sewage Treatment</u>

Most Farms: septic systems	Most Small Towns: lagoons	Most Larger Towns: sewage treatment plants that produce sludge

Of the 675 **municipal wastewater** sewage treatment plants in Iowa, most of them land apply their **sludge** which has been tested and found not to have hazardous levels of contaminants. There are also 20 permits for the disposal of municipal wastewater sludges which may contain hazardous substances such as lead or cadmium. The permits specify how toapply sludges at safe levels. To date, studies conducted in other states have shown no significant changes in groundwater quality due to the application of sewage sludge containing heavy metals.

Beware of heavy metals.

Industrial land applications of waste occur the least frequently and vary from paunch manure (from inside slaughtered or dead animals) to lime sludge which has a high pH (left over from water treatment). Industrial wastes are controlled under the Resource Conservation and Recovery Act (RCRA) and state rules for land disposal. At these sites, groundwater conditions and waste contents are considered prior to issuing a permit for disposal of most of these types of wastes.

Bacterial contamination is a concern where sludge has not been properly stabilized, where public access has not been controlled, and for shallow wells within 300 feet of the site (especially along alluvial aquifers).

Current land application practices do not appear to have had any significant impact on groundwater quality, although clearly there has been a lack of monitoring at these sites. The number of acres involved in land application may increase in the future as restrictions on landfills become more stringent.

Managing Natural Fertilizers for Minimal Risk
(from "A Guide for Safe, Profitable Fertilizer and Pesticide Use" by the Soil and Water Conservation Society)

Environmental risks presented by manures and sludges, or "natural" fertilizers, are much the same as those provided by commercial fertilizers. However, solutions for minimizing environmental risks may be different.

1. **Tie applications to crop use.** Timing of manure and sludge applications should be as close as possible to periods of use by the crop. Avoid spreading these materials on frozen soils or snow cover to minimize soluble nitrogen and phosphate losses resulting from runoff caused by rainfall or snowmelt. Applications during periods when evapotranspiration exceeds precipitation can also help minimize groundwater contamination.

2. **Incorporate.** Getting the manure down into the soil by injection or immediate tillage greatly reduces nutrient losses. However, plowing, disking or other tillage in the fall that buries most crop residue can increase soil erosion risks unless proper precautions are taken. Nitrification inhibitors may help reduce nitrogen losses also if manure or sludge is incorporated because nitrogen in manure or sludge typically is in the ammonium form.

3. **Consider erosion potential.** When necessary to apply these materials in the fall or winter, or when incorporation is impossible, select fields with low erosion and runoff potentials. Applications on well-established winter cover crops and on pasture or hay fields can reduce the potential for nutrient loss and surface water contamination.

4. **Document heavy metal content of sewage sludge.** Sewage sludge often contains cadmium, lead, zinc, copper and other heavy metals that may be toxic to crops, humans and other animals. Because tolerance levels for heavy metals depend upon a soil's physical and chemical characteristics, you should first work with a professional to establish tolerance levels for each soil type. Never apply sewage sludge until heavy metal content is known. Keep a ledger of annual applications for each field, and never apply sludge to a field where heavy metal tolerance levels may have been reached.

5. **Avoid excessive rates.** Apply manures and sludges on soils having a high seasonal water table or rapid permeability at rates based on an analysis of their nutrients and heavy metal concentrations as

well as yield goals. The risk of groundwater contamination is high on these soils. Use of nitrogens in manures and sludges may be low when applied to land intended for a legume crop.

6. Consider energy production from methane gas.

Methane Production

Sources for the production of methane gas include animal wastes, industrial processing wastes, municipal sewage, and solid waste in landfills. The production of methane from these feedstocks involves anaerobic (without air) digestion, a process in which bacteria consume plant or animal material in an airtight environment. The main product is biogas, which rises out of the slurry.

Biogas is a colorless, flammable gas composed of 60 to 70 percent methane, 30 to 40 percent carbon dioxide, and traces of other gases, including hydrogen sulfide. The heating value of methane is 600 to 700 Btu/cubic foot, and the gas can be used either directly as a heating fuel, for electricity generation, or in internal combustion engines.

Many types of plant and animal matter can be digested anaerobically, although the efficiency and the rate of production varies. Generally, the best feedstocks are wet biomass such as fresh animal manure or wastes such as those generated by industries that process cheese, vegetables, fruit, meat, grain and pharmaceuticals.

Animal manure is the most widely used feedstock because it requires little pretreatment before entering the digester. Pig, cow and poultry wastes are most commonly used because they have high non-fiber solubles.

Table VI-1. Methane Production Facilities in Iowa

Feedstock	Facility
Sewage Sludge	Algona, City of
Sewage Sludge	Ames Water Pollution Control Plant
Sewage Sludge	Anamosa, City of
Sewage Sludge	Atlantic Water Pollution Control
Sewage Sludge	Cedar Falls Water Reclamation Facility
Municipal Solid Waste	Cedar Rapids, City of
Sewage Sludge	Clarinda, City of
Sewage Sludge	Council Bluffs Pollution Control
Sewage Sludge	Decorah Wastewater Treatment Plant
Sewage Sludge	Denison Municipal Utilities
Municipal Solid Waste	Des Moines Metropolitan Area Solid Waste Agency
Food Processing Wastes	FDL Foods, Inc., Dubuque
Sewage Sludge	Forest City Wastewater Treatment Facility
Municipal Solid Waste	Glenwood Pacific Junction Wastewater Treatment Plant
Manure	Greig and Company, Estherville
Landfill	Iowa Electric Light and Power Company, Cedar Rapids
Sewage Sludge	Keokuk Water Pollution Control Plant
Sewage Sludge	Knoxville Wastewater Treatment Plant
Sewage Sludge	Maquoketa Water Pollution Control Plant
Sewage Sludge	Marshalltown Water Pollution Control Plant
Sewage Sludge	Mason City Wastewater Treatment Plant
Manure	McCabe Hog Farm, Mount Pleasant
Sewage Sludge	Metcalf & Eddy Services, Water Pollution Control Plant, Fort Dodge
Sewage Sludge	Muscatine Water Pollution Control Plant
Sewage Sludge	Nevada, City of
Sewage Sludge	Newton Water Pollution Control Plant
Sewage Sludge	Pella Public Works Department
Municipal Solid Waste	Professional Services Group, Sioux City
Sewage Sludge	Sioux Center Landfill
Sewage	Washington, City of

II. LAGOONS

> Groundwater ......
> the secret's leaking out.

Most lagoons are built to decompose human wastes (in municipal sewage) or animal wastes (in agricultural lagoons). **Leaking lagoons** are a known source of groundwater contamination. The impact is very similar to landfills except that the waste content differs and the contamination process does not depend on the recharge from rainfall. There is a constant hydraulic head present in a lagoon (pressure from the wight of the liquids) which forces the liquids down through the soil. Less than five percent of Iowa's lagoons are suspected of leaking.

The Iowa Department of Natural Resources requires an operating **permit** for all municipal and industrial lagoons that discharge to surface water. The Department has also issued operating permits for about half of the semi-public or private lagoons in the state. A seepage rate of 1/16 of an inch per day with six feet of head is allowed. For a one acre lagoon, 1/16 of an inch equals over 600,000 gallons per year.

Research has shown that **agricultural lagoons** have a natural bottom sealing mechanism which prevents excessive seepage after a short period of use. However, lateral seepage into nearby streams or discharge points is also expected. Groundwater monitoring near a hog waste storage pond in central Iowa found nitrate concentrations of eight to ten times the drinking water standard for nitrate.

Lagoons located near private or public wells in karst terrain and lagoons containing toxic wastes have the highest potential for causing significant groundwater contamination problems.

Lagoons are inexpensive to construct, maintain and operate. Thus, they will continue to be used in the treatment of wastewaters in the future.

III. SEPTIC TANK SYSTEMS

Septic tanks can **pollute groundwater** if there is too much waste for the soil to treat or if the soil is too permeable, allowing untreated wastes to reach the groundwater table.

An estimated 25 to 35 percent of the households in Iowa use septic tanks. Local contamination may occur near any single unit; however, regional problems caused by the density of tanks in a region have been the major concern of most regulatory agencies.

A **density of** 40 or more **septic tank systems** per square mile represents a potential threat to the shallow groundwater of the area. Based upon county-wide statistics, Polk County and Linn County are the only counties which approach or exceed this density in the state. Of course, local densities may exceed these estimates several times depending upon the distribution within the county.

The **pollutants** most commonly found relative to septic tank systems are nitrates, bacteria, a mixture of organic compounds, and several inorganic compounds (such as sodium, chlorides, potassium, calcium, magnesium and sulfates). Septic systems are not a major source of nitrate for groundwater although they are one of many sources.

Iowa Department of Natural Resources rules contain siting and construction **requirements** including: a minimum depth to groundwater of three feet, a minimum separation distance of 50 feet from a private water supply well and 200 feet from a public water supply well; and a maximum percolation rate of one inch in 60 minutes. No minimum percolation rate is given, though unstable ground is to be avoided.

While contamination from septic systems has a local impact on water quality in areas of high septic tank density, the number of septic tanks is expected to decrease near metropolitan areas as public treatment facilities are made available. Specifically, expansion of the Des Moines wastewater treatment plant is expected within the next five years and will service portions of the city previously unsewered. Unsewered rural communities are also encouraged to provide public treatment. Zoning or land management controls to restrict the density of septic tanks according to soil types may be helpful in some locations

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Soil Conservation Service. 1988. Water Quality Field Guide. p. 43-45.

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Land-applied Wastes

Life Science 1 period

Quick Summary: Students will filter "simulated liquid/solid waste" through layers of soil, record observations, and discuss implications for land-applied manure or sludge.

Objectives: Upon completion, the student will be able to:
1. Critically discuss the application of animal wastes, municipal sewage, and industrial wastewater treatment sludge on the land surface.

Materials:
For each group of 2-4 students: 2-liter pop bottles, food coloring, pencil shavings, fine sand, coarse sand, gravel, potting soil, clear plastic tumblers, paper towels.

Printed/AV Materials:
Student worksheet
Overhead: Managing Natural Fertilizers for Minimal Risk

Teacher Information:
Manures and organic materials can benefit soil in two ways. First, they contain important plant nutrients; second, they add organic matter to the soil, thus contributing to the maintenance of soil structure and tilth. But when improperly applied, nitrogen and other chemicals represent potential problems for water resources. Heavy metals often found in sewage sludge may present additional environmental risks. (See also the background information at the beginning of this unit.)

Procedure:

1. Advance preparation -- prepare a "simulated liquid/solid waste": add several drops of food coloring, a small quantity of pencil shavings and tiny paper scraps (paper punch) to 1/2 liter of water.

2. Divide the class into groups of two to four students, and distribute worksheets and materials, reviewing directions if necessary.

3. Have students perform the simulation of land-applied wastes.

4. Discuss results and questions using the overhead Managing Natural Fertilizers for Minimal Risk. Note: Sludge is often applied in a dry form and spread over the field, not dumped in one spot as the simulation might suggest.

5. Discuss why spreading manure on fields could be good for energy conservation. (It can replace commercial fertilizers which use natural gas and lots of energy for production, packaging and transportation.)

Alternative:
If more than one class is doing this, use the same bottle to show how land becomes unable to filter as well if overloaded. The time can be measured for the simulated waste to drain through the simulated soil. It will take longer each time and have less color change.

Extension:
1. What concerns does industrial sludge present? What possible hazards does municipal sewage sludge present?
2. If there is a methane production facility nearby, contact them for more local information . Refer to the list of facilities in the unit background information.

References:
1. Pye, V. and Ruth P. "Groundwater Contamination in the United States: Science Vol. 221, August 19, 1983.
2. Managing Manures and Other Materials - Soil and Water Conservation Society

Land-applied Wastes
Student Worksheet

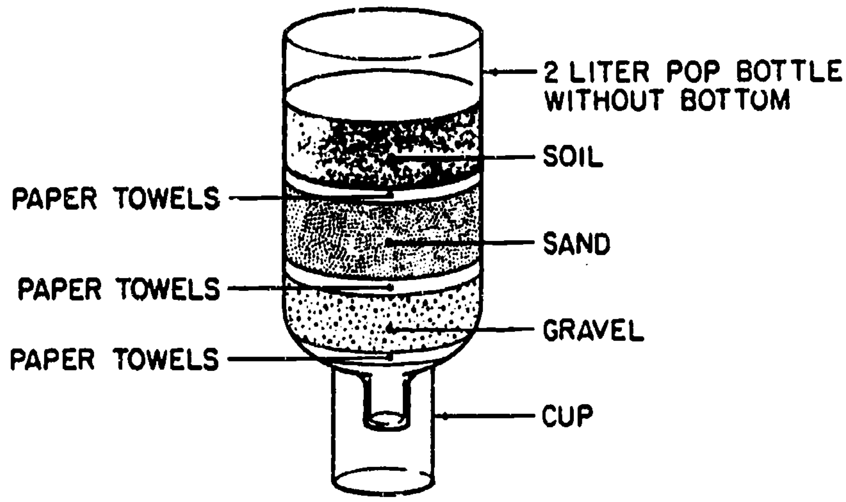
Name___________

1. Prepare c clear plastic pop bottle as follows:

   a. Remove bottoms to produce a large funnel (save caps).

   b. Add soil, sand, gravel in alternating layers to the funnel (about 1" layers). Separate each layer with a paper towel. Cap bottles.

   c. Pour clean tap water through the "simulated soil profile" to speed the simulation later.



"SIMULATED SOIL PROFILE"

2. To simulate the use of land-applied manure or sewage sludge, pour "simulated liquid/solid waste" slowly in the "simulated soil profile." Make careful observations of the simulation, and record them here.

3. Collect a small amount of leachate (10 ml) and compare the beginning solution with the sample of leachate. How are they alike? How are they different?

4. How does filtration reduce the potential pollution due to manure or sludge spread over a field?

5. What are the risks when liquid/sc ' wastes (like manure and sludge) are applied on the land?

21;

Managing Natural Fertilizers for Minimal Risk

Overhead

1. Tie Applications to Crop Use.
2. Incorporate
3. Consider Erosion Potential
4. Document Heavy Metal Content of Sewage Sludge
5. Avoid Excessive Rates
6. Consider Energy Production from Methane Gas

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Septic Tank Systems

Life Science 1-1/2 periods

Quick Summary: Students make and operate a simulated septic tank system and survey someone with a septic system to check for safe placement.

Objectives: Upon completion, the student will be able to:
1. Discuss the role that septic tank systems play in on-site wastewater treatment.

Materials: For each group of 2-4 students: 2 clear plastic tumblers (6-8 oz.), sand, paper towel, soil sample, flexible straws.

Printed/AV Materials:
Information sheet
Overheads:
Septic Tank System
Figures VI-1, VI-2, VI-3 on page 1-3 of this unit
Figure VI.4, Water Down the Drain, from unit background information

Worksheet: Septic Systems -- Simulation & Survey (2 pages)

Teacher Information:
Pollution of groundwater from septic tank systems occurs when the capacity of the surrounding soil to treat the wastewater is exceeded or when the underlying soils are highly permeable allowing contaminants to rapidly move to the groundwater table before treatment is complete. (Refer also to the Information sheet.)

Procedure:

1. Using the overheads, briefly discuss where wastewater goes.
2. Briefly discuss how a septic tank system works, using the Septic Tank System overhead.
3. Divide the class into groups of two to four students, and distribute the worksheets and materials, reviewing directions briefly.
4. Have the students do the simulation (part 1) in class, and take the Septic System Survey (part 2) to do at home.
5. Discuss results of the simulation and survey.

Extension:
Visit a septic tank system.
Survey the student population for use of on-site sewage treatment system.
Compare on-site sewage treatment system with municipal sewage system.
Call the county health department for county regulations on septic tanks.

Reference: PM-938 ISU Cooperative Extension Service, Home Sewage Treatment, November, 1982.

Septic Systems
Information Sheet

The Leaching Field
The soil absorption field or leaching field has two major functions. It safely disposes of wastewater below the surface of the ground, and it acts as a filter by removing harmful bacteria and viruses and many chemical contaminants from the wastewater before they reach the water table.

Watertight pipes transport wastewater from the septic tank to the absorption trenches. A distribution box or several drop boxes may be used to divide the wastewater among the trenches. Perforated rigid plastic pipe or agricultural drain tile is used to distribute the wastewater throughout the trenches. A gravel bed below the distribution pipes provides temporary storage for the septic tank effluent until it can be absorbed by the floor and sidewalls of the trench.

Trenches are purposely shallow (generally 36 inches or less) to take advantage of well-drained topsoils and the oxygen contained in them. Oxygen in the trench (aerobic conditions) speeds the decay of the nutrients in the wastewater and promotes the formation of end products which are less odorous than those formed under oxygen-deficient (anaerobic) conditions. At greater depths, soils are frequently less permeable and the probability of encountering the water table is greater.

The Septic Tank
The purpose of a septic tank is frequently misunderstood. While septic tanks play an important role in on-site wastewater treatment, they do not provide complete sewage treatment. Effluent from septic tanks contains bacteria, viruses and dissolved chemicals which can contaminate groundwater or lakes and streams. To achieve adequate treatment, septic tank effluent must pass through a soil absorption field or some alternative treatment device such as a mound or sand filter.

Protecting the soil absorption field is a primary function of the septic tank. An adequately sized tank allows settleable solids to form a sludge layer in the bottom and floating materials to accumulate in a scum layer at the water surface. A baffled or submerged outlet from the tank allows clarified wastewater to leave the septic tank while retaining the scum and sludge. This is extremely important because scum or sludge can easily clog soil pores causing premature failure of a leaching field.

Bacterial action within a septic tank helps to break down the scum and sludge that is retained. The rate of decomposition is normally quite slow; therefore, a gradual buildup of these components can be expected and periodic removal of scum and sludge is necessary. The use of kitchen garbage disposal equipment increases the solids content of the wastewater and generally accelerates the rate of sludge accumulation. Selecting a septic tank with adequate storage volume for scum and sludge is important since this reduces the frequency of removal of these materials.

Conventional System Failures
One of the most serious breakdowns that can occur in conventional systems is soil absorption field failure. This occurs when trenches cannot absorb the daily wastewater load. As a consequence, wastewater backs up into the building sewer or seeps to the ground surface. Proper design, construction and maintenance of the system are the best insurance against absorption field failures.

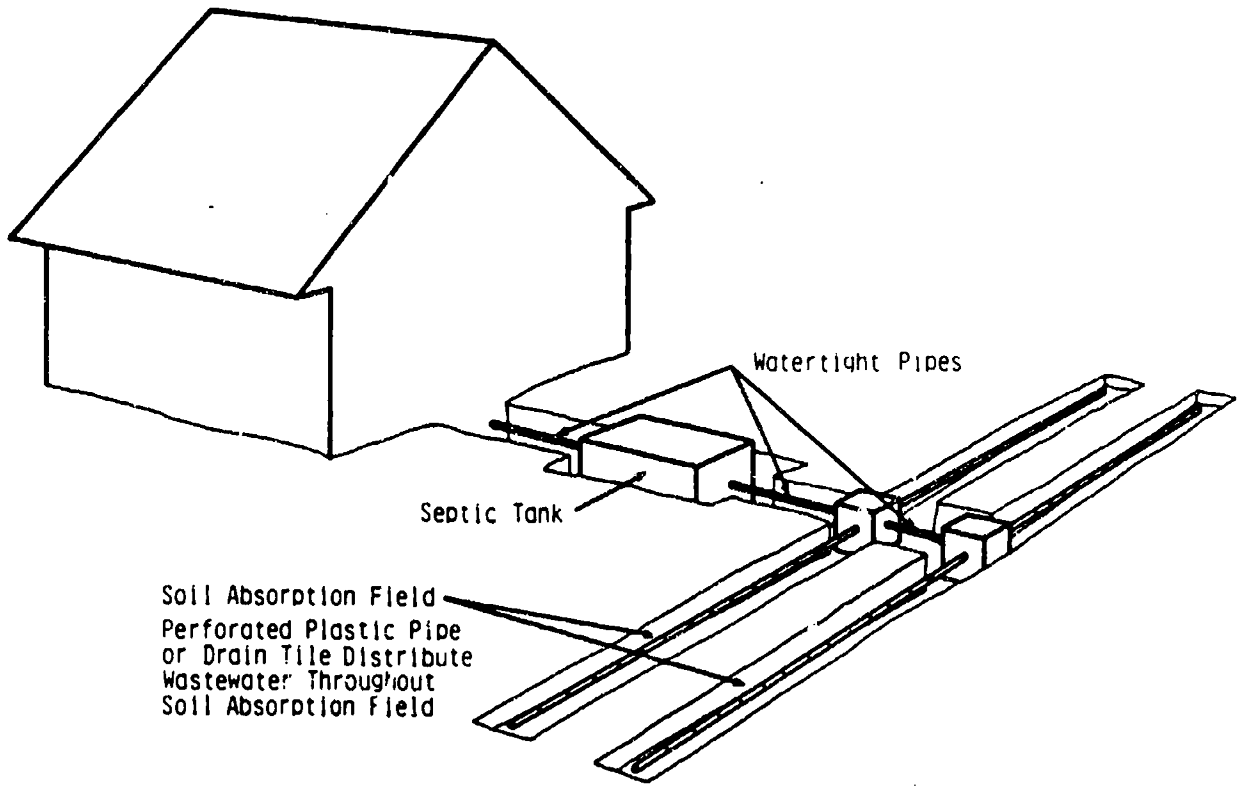
Planning A Conventional System
Good planning includes a site survey of buildings, water supplies, the soil and drainage characteristics. Proper sizing of the absorption field and septic tank are also important.

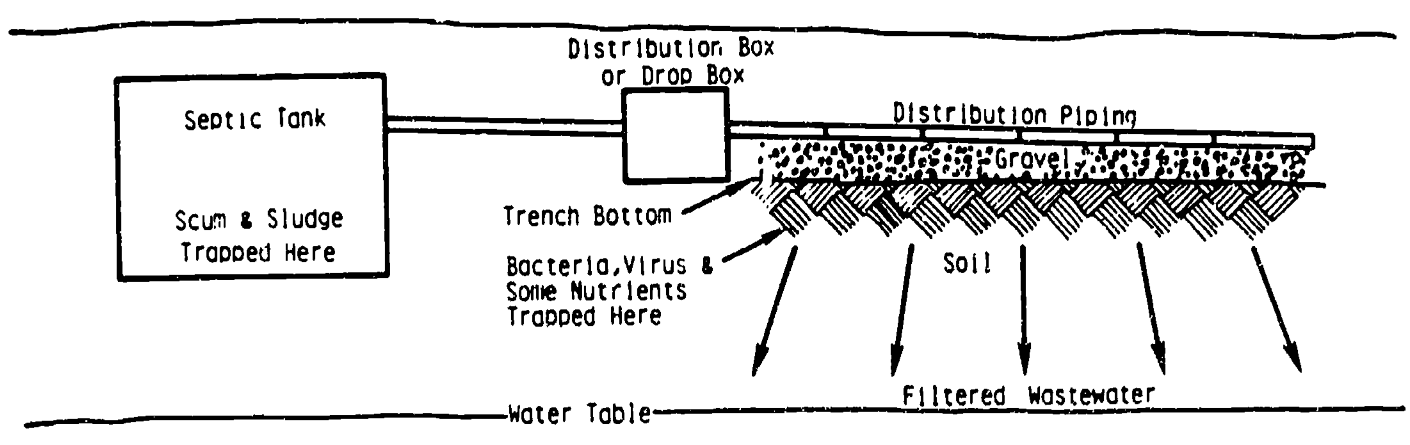
How often does a septic tank need to be cleaned out?
Depending on the size of the tank and the number of persons in the household, cleaning may be needed as often as every two years or as seldom as every 10 years.

Septic Tank System -- Top and Side Views

Source: ISU Cooperative Extension Service Pm-938

Overhead





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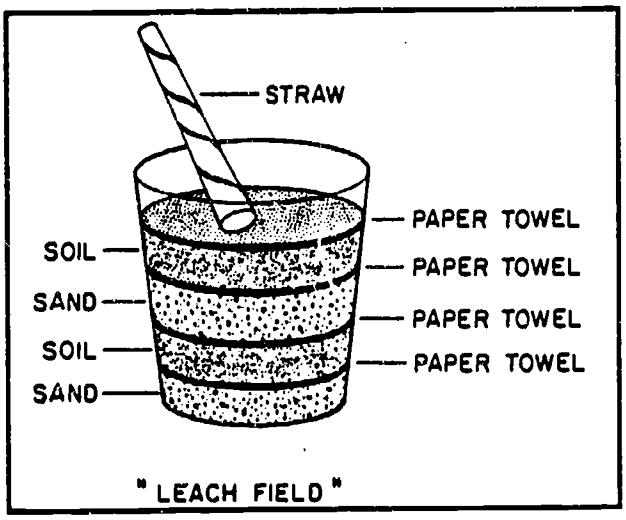
Septic Systems
Student Worksheet

Name ________________________

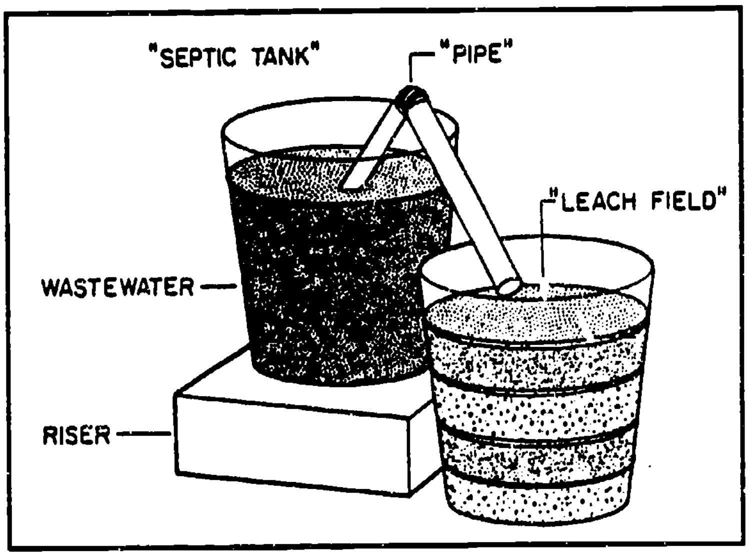
Part 1: Simulation

1. Prepare a "wastewater" sample -- sand and bits of paper (from paper punch)
2. Construct a model septic tank system:
   a. Label one clear plastic tumbler as the "septic tank."
   b. Pour into "septic tank," about 3/4 full, a well-stirred sample of "wastewater."
   c. Allow "wastewater" sample to sit for one or two minutes. -- Observe carefully and record.



   d. Prepare a second tumbler, "simulated leach field," as follows: Add alternating layers of sand and potting soil, separated by paper towels. Thoroughly wet with water to hasten the flow of liquid through the system and to "simulate" the leach field action.

   e. After the "wastewater" has settled, you will connect the "septic tank" with the "leach field" via a flexible straw. Set the "septic tank" on a book or other riser. Use a rubber bulb or other suction to get water into the straw and allow the "wastewater" to flow into the "leach field." (If the "leach field" gets too full, pull the straw out of the "wastewater".) Make and record careful observations of the action of wastewater in the "leach field."



Part II. Survey

Find a friend or relative who has a septic tank system (instead of being connected to a municipal sewage treatment system). Find out the following information.

1. a. From where do they get their drinking water?

   b. If their water is from a private well, how close is the septic tank to it?

   c. How close is the absorption field?

2. How close is their house to:
   a. the septic tank?

   b. the absorption field?

3. Refer to the table below. Is there anything closer to the septic tank or absorption field than the recommended minimum separation distance? Write "yes" or "no" for each item.
If so, record to one side how close it is.

4. Besides separation distance, what is one other factor to consider when planning a septic system?

Table 1. Recommended Minimum Separation Distances in Feet from Various Units to Septic Tank and Absorption Field.

Unit	Septic Tank	Absorption Field	Closer than Recommended Minimum? (Yes or No) If yes, record distance.
Private Water Supply Source	50	100	
Public Water Supply Source	200	400	
Lake or Reservoir	50	100	
Stream or Open Ditch	25	25	
Dwelling or Other Structure	10	10	
Side or Rear Lot Lines	5	5	
Front Lot Lines	10	5	
Other Subsurface Sewage Treatment Facilities	5	10	
Pressurized Water Lines	10	10	
Suction Water Lines	50	100	

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Sewage Lagoons

Life Science 1 period

Quick Summary: Students operate a groundwater model to demonstrate how lagoons can contaminate groundwater and discuss the safe use of lagoons.

Objectives: Upon completion, the student will be able to:
1. Discuss critically the safe use of sewage lagoons.

Teacher Information:
Refer to unit background information.

Materials: For each team of four students:
groundwater model and supplies (refer to Appendix A.)

Printed A/V Material:
Overhead : Figure VI-2. Lagoons, page VI-2

Procedure:
1. Have students set up the groundwater model as shown in Figure 8 of Appendix A. Great Ways to Use the Groundwater Model
2. Discuss reasons for using lagoons.
3. Discuss reasons why lagoons are potentially harmful.
4. Discuss regions of the state of Iowa which are of concern regarding lagoons.

Extension: Survey local area for sewage lagoons and use.

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Appendix A. GREAT Ways to Use the Groundwater Model
(GREAT - Groundwater Resources and Educational Activities for Teaching)

The following are instructions for using the groundwater model for student activities and/or teacher demonstrations. These are suggested methods. Teachers are encouraged to experiment. Further background information is given in each section.

Materials:

plastic box (12"x 6" x 2")	paper towel
aquarium gravel	film canister
foam (2 pieces, 13"x 2 1/4" and 9"x 2 1/2")	popcan
spray pump	rulers (2)
plastic straws (2)	sugar cubes (20-30)
powdered drink mix	cup (plastic or paper)
food coloring	water container

Basic Groundwater Model: Use aquarium gravel, pump, plastic straw, and foam to build the groundwater model as shown in Figure 1. Pour water in the model. Observe, record, and discuss the results. Use the spray pump to show how a well pumps water from an aquifer. Use the plastic straw to simulate an artesian system. (The confining layer of foam on top may need to be held in place.)

Fertilizer/Pesticide Model: Build the groundwater model as shown in Figure 2. Sprinkle powdered drink mix on the surface as shown to represent fertilizer or pesticides put on a field. Sprinkle water over the surface to simulate rain and observe, record, and discuss the results.

Landfill/Abandoned Waste Site Model: Build the groundwater model as shown in Figure 3. Roll a paper towel into a ball and saturate it with food coloring. Place it beneath the surface as shown to represent an improperly designed abandoned waste site or landfill. Pour water on the surface and observe, record, and discuss the results.

Leaking Underground Storage Tank Model: Build the groundwater model as shown in Figure 4. Puncture a film canister in several places with a pin and fill it with colored water. Place it beneath the surface (not along the side of the box) as shown. Pour water on the surface and observe, record, and discuss the results.

Ag-Drainage Well Model: Build the groundwater model as shown in Figure 5, except for the straw. Pour clear water on the impermeable foam to simulate a marsh. Then insert the straw (ag-drainage well) and pour clear water on it. Then pour colored water (to represent agricultural chemicals) on it. Observe, record, and discuss the results.

Abandoned Well Model: Build the groundwater model as shown in Figure 6. The straw with holes in it and with clay plugging the bottom simulates an abandoned well. Pour colored water into the abandoned well and observe, record, and discuss the results.

Sinkhole Model: Build the groundwater model as shown in Figure 7. Bury about 20-30 sugar cubes (at least 3 high, 4 wide and 2 deep) to represent a layer of limestone that will be dissolved to form a sinkhole. Use a nonpermanent marker to draw a line showing the surface. Set up a pop can with holes to slowly sprinkle hot water onto the surface over the sugar cubes. Pour colored water into the sinkhole to simulate contaminated water entering the aquifer through the sinkhole. Observe, record, and discuss the results.

Lagoon Model: Build the groundwater model as shown in Figure 8. Tape over the hole. Pour water into the gravel to create a water table as shown. Fill the lagoon (bottom part of a small plastic or paper cup with pin holes) with colored water. Pump, and observe, record and discuss the results.

GREAT WAYS TO USE THE GROUNDWATER MODEL

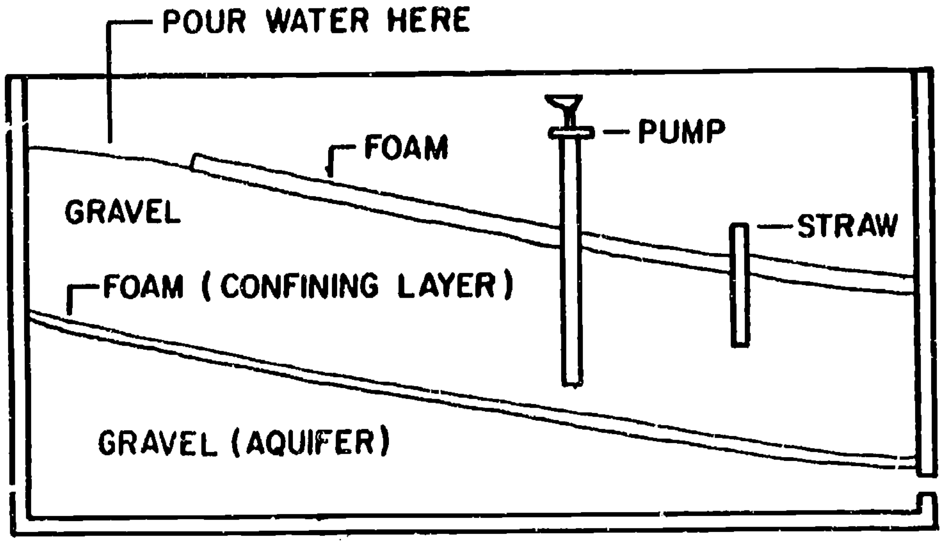

Fig. 1: BASIC GROUNDWATER MODEL

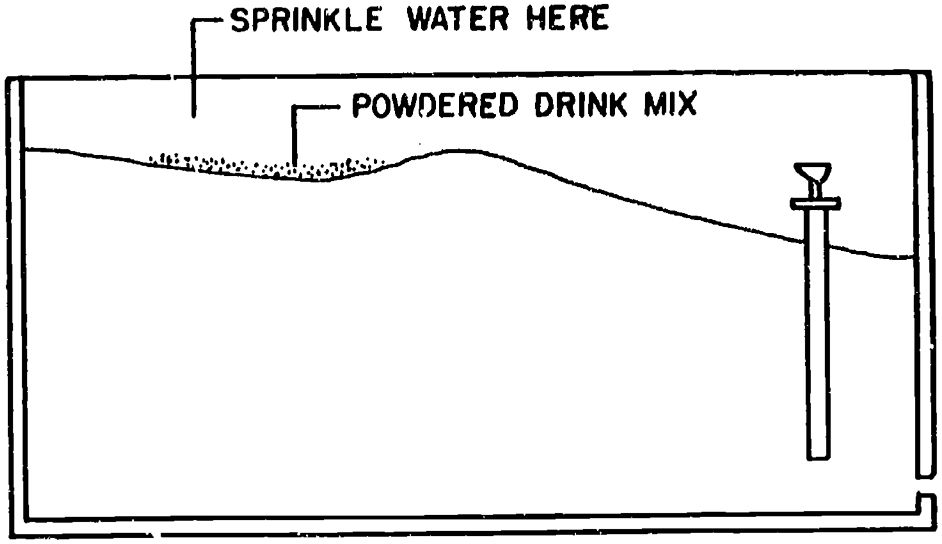

Fig. 2: FERTILIZER / PESTICIDE MODEL

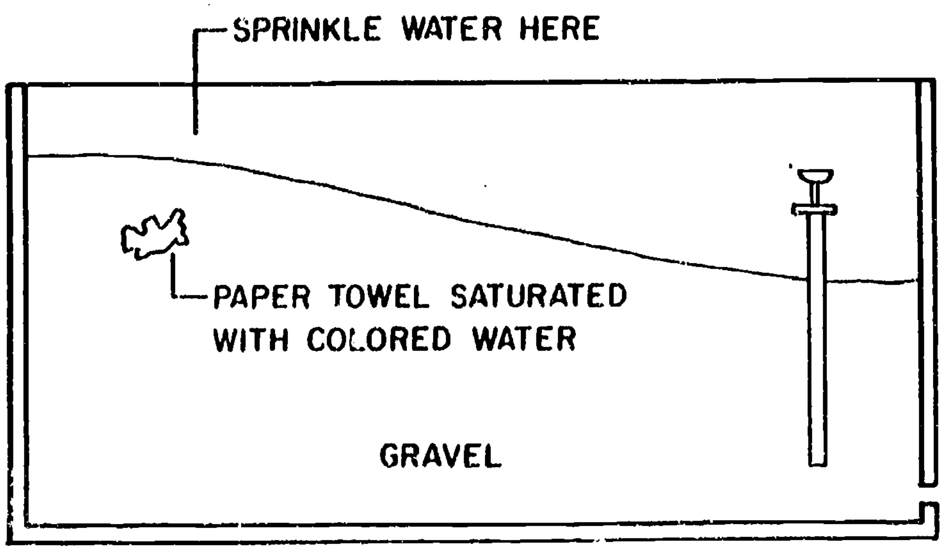

Fig. 3: LANDFILL / ABANDONED WASTE SITE MODEL

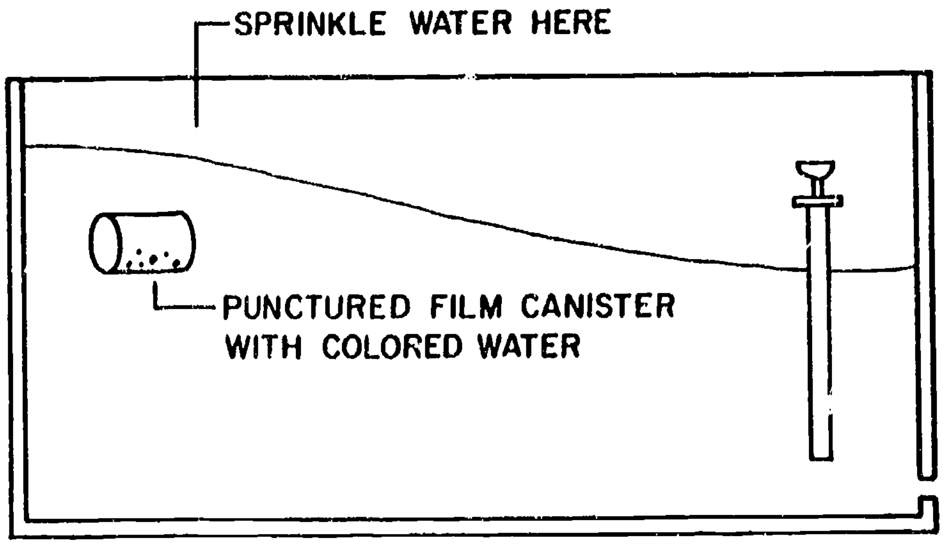

Fig. 4: LEAKING UNDERGROUND STORAGE TANK

GREAT WAYS TO USE THE GROUNDWATER MODEL

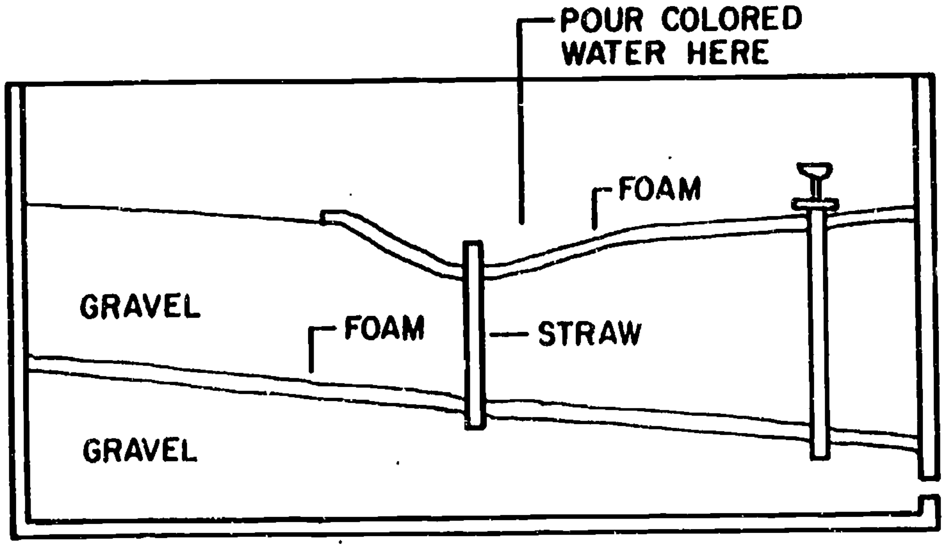

Fig. 5: AG-DRAINAGE WELL MODEL

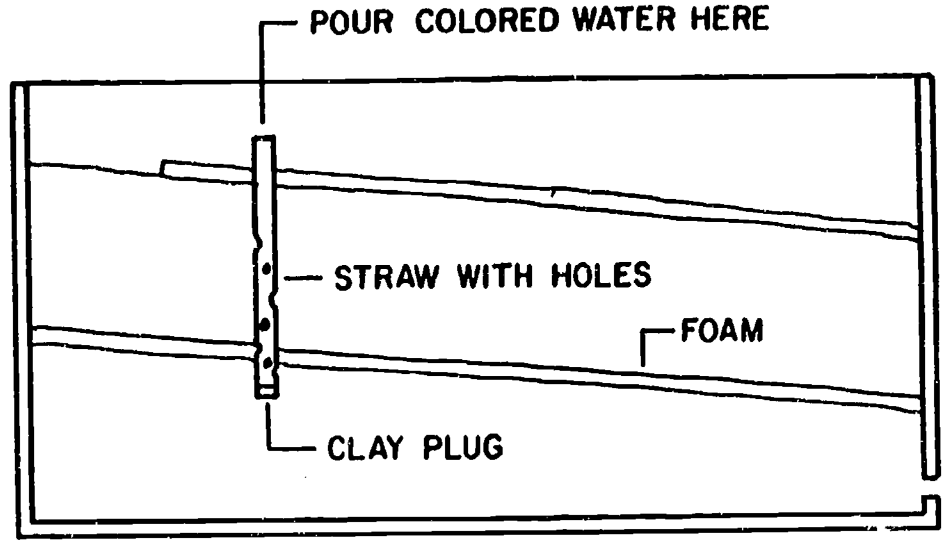

Fig. 6: ABANDONED WELL MODEL

A-3

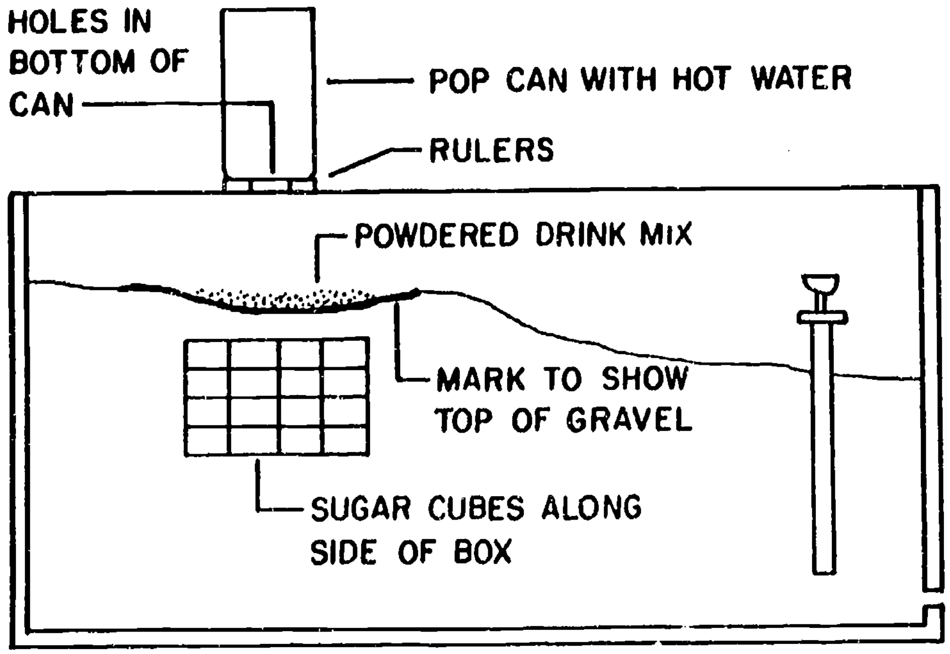

Fig. 7: SINKHOLE MODEL

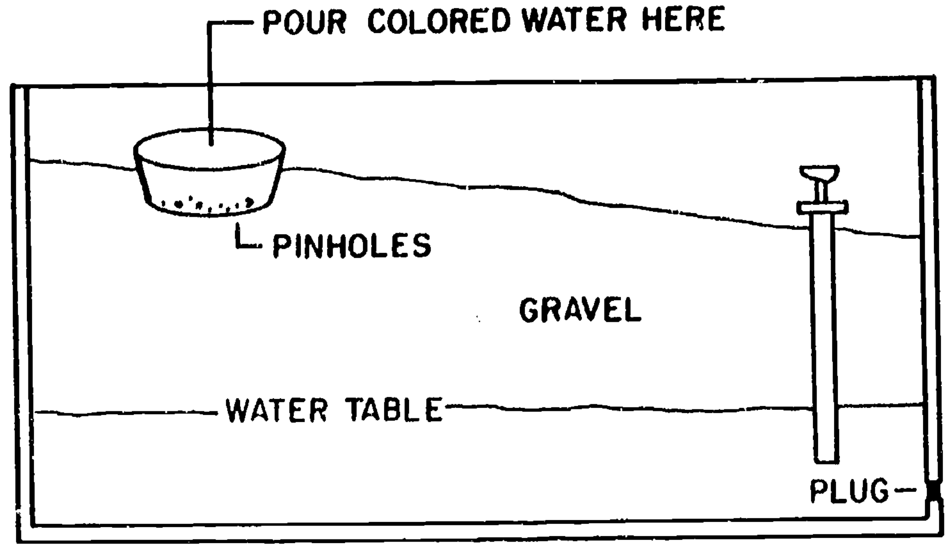

Fig. 8: LAGOON MODEL

Appendix B. Groundwater Project Ideas

Methods of Presentation

Essay
Story
Play
Poem
Editorial
Diary
Pamphlet
Advertisement
Model
Drawing
Poster
Photo display
Slides
Video
Commercial
Survey
Interview
Investigation
Collection
Teach a lesson
Book reports
Bumper sticker
Editorial cartoon
Comic strip
Guest speaker

Suggested Ideas

Each idea can be adapted to one or more methods of presentation. Select an idea from the list below, decide on your method of presentation, and complete one project.

1. Interview a person who has a contaminated drinking water well.

2. Depict an alternative to landfills that you personally would use. Include the benefits and drawbacks of this alternative. Give some specific examples.

3. Depict changing life styles as a result of unsafe drinking water.

4. Create a motto for a groundwater protection program.

5. Interview the director or engineer in charge of a landfill. Ask about day to day operation, pollution, and future changes anticipated.

6. Interview a farmer who farmed before the time of widespread use of nitrogen fertilizers. Find out about yields, prices, profits, conservation practices and groundwater concerns.

7. Make a collection of rocks and aggregates important in underground aquifers. Make a display.

8. Show how you and your family can help protect the environment from hazardous waste.

9. Depict a farmer's dilemma because of the use of chemicals and concern for groundwater protection.

10. Encourage support for groundwater quality or describe an unsafe practice which threatens water quality.

11. Demonstrate the design and operation of a water treatment plant.

12. Interview an employee of a water treatment or sewage treatment plant. Ask about methods, pollution, and planned changes in operation for the future.

13. Present to the class information obtained from gardener on the benefits of organic gardening methods.

14. You are the mayor of a town who will have a major say in the decision to place or not place a hazardous waste dump site near your town. The town stands to gain a lot of money and other benefits. Describe what you will decide and why.

15. Depict a family who has to abandon their house because of a chemical spill nearby.

16. Show a design for an environmentally safe product sold in a non-polluting package.

17. Organize or participate in a recycling project. Prepare a report on what happens to the materials when they leave your town.

18. Collect a scrapbook of newspaper clippings about groundwater issues.

19. Interview a person involved in the manufacture or distribution of pesticides or fertilizer. Ask about health, pollution and other things.

20. Do some library research in the Guide to Periodical Literature. Depict our throw away society. Discuss the benefits and problems associated with a consumer-oriented, waste-producing lifestyle.

21. Invent and describe new uses for product packaging that you would normally just throw away.

22. Design a resource recovery system for recycling and then incinerating trash.

23. Present rules and guidelines for handling hazardous materials found in the house.

24. Interview a well driller. Ask how they find water and what they have learned about the state's groundwater supply.

25. Read Silent Spring by Rachel Carson, A Sand County Almanac by Aldo Leopold or some other book or magazine article dealing with pollution or water supplies and present a report summarizing the main points.

26. Interview a person who operates a gas station or other business that has an underground storage tank.

Appendix C. Water Quality in Iowa: Surface & Groundwater Perspectives

How does groundwater fit into the total water quality picture in Iowa? How do surface water concerns compare with groundwater?

Comparisons of Surface and Groundwater Quality

The closer water is to the surface, the more susceptible it is to contamination by human activities. This means that surface water is most likely to be polluted, followed by alluvial and other shallow aquifers, and finally by deep aquifers. This is due in part to the filtering effect of the soil and rock layers above aquifers. However, if contaminating activities are not stopped, deeper aquifers may also become more contaminated.

It is not safe to drink untreated surface water in Iowa due to the high risk of getting sick from diseases carried by bacteria or viruses. Public water supplies must disinfect water whether it is from the surface or from groundwater. However, many private wells supply groundwater for drinking without disinfection or other treatment.

Although groundwater has traditionally been cleaner than surface water, **groundwater is much more difficult, and sometimes impossible, to clean up**. Groundwater generally moves much more slowly than surface water, and thus simple flushing usually doesn't work. Also, due to the variability and complexity of underground materials, it is often very hard to predict groundwater movement. This is why Iowa's groundwater protection program emphasizes prevention rather than cleanup.

Surface Water Quality

One way to assess surface water quality is to evaluate the ability of a water body to support its designated uses. All of Iowa's surface waters must meet certain water quality conditions, but more specific chemical and bacterial standards apply to waters designated for particular uses. In Iowa, the major use designations are:

Class A: Primary contact (swimming and water skiing)
Class B: Aquatic life and secondary contact (boating and fishing)
Class C: Drinking water

In 1988, DNR evaluated the ability of Iowa's surface water to support their designated uses. The results in Table C-1 show that most of Iowa's waters are being impacted by pollution to such a degree that their designated uses are only being partially supported.

Table C-1. Percent of Iowa Waters Supporting Designated Uses

Water Type	Fully Supporting	Partially Supporting	Not Supporting
Streams	1%	82%	17%
Lakes	34%	61%	5%
Wetlands	32%	54%	14%
Reservoirs	0%	100%	0%

Waters that either fully or partially support designated uses meet the fishable/swimmable goal of the federal Clean Water Act. These waters support balanced populations of fish and other aquatic life, and they support recreation in and on the water. Waters that partially support designated uses have minor to moderate water quality impacts that may limit the amount of fishing or swimming that occurs there, even though it is safe to do both. Waters identified as "not supporting" designated uses do support aquatic life and/or water-based recreation. However, certain aspects of designated uses in these waters, for example, swimming or fishing for channel catfish, are not supported due to severe water quality impacts.

Run-off from farm fields, including silt, nutrients (or fertilizers), and pesticides, caused the most damage to Iowa's surface water quality. Examples of other pollutants include disease-causing bacteria, metals (such as mercury and copper), and organics.

Fish Kills and Health Advisories

Although no surface water was closed to fishing in 1986 or 1987, 42 fish kills were reported. Only nine were considered to be caused by toxics, and six by ammonia. About half of the fish kills were from naturally-occurring conditions, such as low dissolved oxygen levels, disease, or high water temperatures. Other reported causes included animal wastes, fertilizer spills and industrial waste discharges.

Studies from 1983 to 1987 have shown that samples of channel catfish fillets commonly contain low levels of chlordane, dieldrin, PCB's, metabolites of DDT, Treflan, and the metals cadmium and mercury. Levels of pesticides in fish from streams and rivers have tended to be higher than levels in fish from lakes. Toxics in fish tissue most likely to occur at levels of concern are the pesticides chlordane and dieldrin, and PCB's (polychlorinated biphenyls). Levels of contaminants in fish from most Iowa streams and lakes are well below levels of concern and do not pose health risks to consumers of fish.

In June 1989, a health advisory was issued which recommended people not eat carp taken from the Iowa side of Pool 15 of the Mississippi River near Davenport, Iowa, due to PCB contamination. The only other fishing advisory in Iowa is due to chlordane contamination at Cedar Lake, a privately-owned lake in Cedar Rapids. The warning not to eat any fish from Cedar Lake has been in effect since March 1986.

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Appendix D. Water Quantity Considerations in Iowa

Does Iowa have enough water?

In general, Iowa has been very well off in terms of water quantity, especially compared to western states. Having enough water has not historically been a problem in Iowa, but there is potential for problems where water may be limited in some areas or at certain times. Problems can occur if more water is withdrawn than replaced over a long period of time. These problems fall into three general categories: geologic limitations, drought and local competition.

1. Geologic Limitations
In some places (particularly southern Iowa) there is plenty of groundwater, but it naturally has so many dissolved minerals in it (from being in deep bedrock for so long) that it is less desirable for most purposes. The natural water quality is fair in northwest Iowa and good in the northeastern half of the state. (Refer also to the discussion of natural water quality in the hydrogeology background information.)

2. Droughts
Long periods of drought occur in Iowa about once every 20 years and are the cause of most local and regional shortages and water use conflicts.

3. Local Competition
Isolated pockets of high usage may cause water levels to lower in deeper aquifers in major cities or industrial areas.

People's perception of water availability are also affected by cost. How much are people willing to pay for useable water? First of all, it costs more to dig deeper wells. Secondly, it costs to clean water - whether contaminants are naturally occurring or from human causes.

What can we do to resolve water shortage problems?

1. Protect Water Quality
The most important thing we can do is to prevent water contamination so that we can use the water we do have.

2. Water Allocation
Iowa law has a priority allocation plan which may suspend or restrict water use on a local or statewide basis in the following order (from the lowest to the highest priority):

a. Conveyance across state boundaries.
b. Recreational or aesthetic purposes (such as flooding wildlife areas or pools; washing cars, streets or windows; amusement park-type water rides or turf watering).
c. Irrigation of hay, corn, soybeans, oats, grain sorghum or wheat.
d Irrigation of crops other than those listed above.
e. Manufacturing or other industrial processes.
f. Generation of electrical power for public consumption.
g. Livestock production.
h. Human consumption and sanitation supplied by rural water districts, municipal water systems, or other public water supplies.
i. Human consumption and sanitation supplied by a private water supply.

3. Water Conservation
Water conservation practices are generally used during droughts and there are many practical methods that can be used in homes, industries and for irrigation. For example, the three main places of water use in homes are: the bathroom (75%), kitchen and laundry. Outside uses (such as lawn and garden watering and street and sidewalk washing) are another major factor in some suburban communities. Water is a precious resource that should always be used wisely.

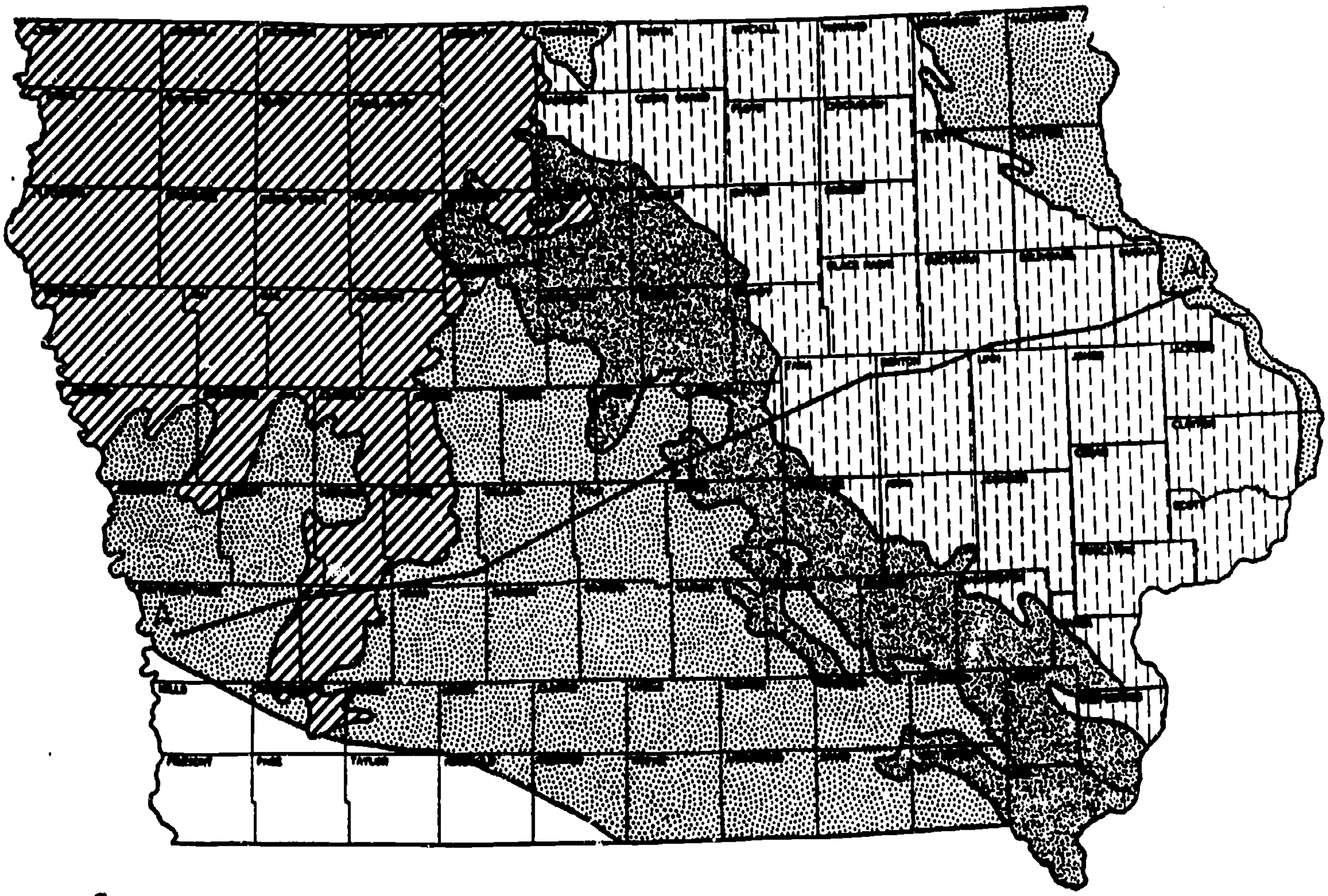
Appendix E: Table E-1
Geologic and Hydrogeologic Units in Iowa

	AGE	ROCK UNIT	DESCRIPTION	HYDROGEOLOGIC UNIT	WATER-BEARING CHARACTERISTICS
Cenozoic	Quarternary	Alluvium	Sand, gravel, silt and clay	Surficial aquifer	Fair to large yields
		Glacial drift (undifferentiated)	Predominantly till containing scattered irregular bodies of sand and gravel		Low yields
		Buried channel deposits	Sand, gravel, silt and clay		Small to large yields
Mesozoic	Cretaceous	Carlile Formation Granerous Formation	Shale	Aquiclude	Does not yield water
		Dakota Group	Sandstone and shale	Dakota aquifer	High to fair yields
	Jurassic	Fort Dodge Beds	Gypsum, shale	Aquitard	Does not yield water
Paleozoic	Pennsylvanian	Virgil Series Missouri Series	Shale and limestone	Aquiclude	Low yields only from limestone and sandstone
		Des Moines Series	Shale; sandstones, mostly thin		
	Mississippian	Meramec Series	Limestone, sandy	Mississippian aquifer	Fair to low yields
		Osage Series	Limestone and dolomite cherty		
		Kinderhook series	Limestone, oolitic, and dolomite, cherty		
	Devonian	Maple Mill Shale Sheffield Formation Lime Creek Formation	Shale; limestone in lower part	Devonian aquiclude	Does not yield water
		Cedar Valley Limestone Wapsipinicon Formation	Limestone and dolomite; contains evaporites in southern half of Iowa	Silurian-Devonian aquifer	High to fair yields
	Silurian	Niagaran Series Alexandrian Series	Dolomite, locally cherty		
	Ordovician	Maquoketa Formation	Shale and dolomite	Maquoketa aquiclude	Does not yield water, except locally in northwest Iowa
		Galena Formation	Limestone and dolomite	Minor aquifer	Low yields
		Decorah Formation Platteville Formation	Limestone and thin shales; includes sandstone in SE Iowa	Aquiclude	Generally does not yield water; fair yields locally in southeast Iowa
		St. Peter Sandstone	Sandstone		Fair yields
		Prairie du Chien Formation	Dolomite, sandy and cherty	Cambrian-Ordovician aquifer	High yields
	Cambrian	Jordan Sandstone	Sandstone		
		St. Lawrence Formation	Dolomite	Aquiclude (wedges out in northwest Iowa)	Does not yield water
		Franconia Sandstone	Sandstone and shale		
		Dresbach Group	Sandstone	Dresbach aquifer	High to low yields
	Precambrian	Sioux Quartzite	Quartzite	Base of groundwater reservoir	Not known to yield water except at Manson cryptovolcanic area
		Undifferentiated	Coarse sandstones; crystalline rocks		

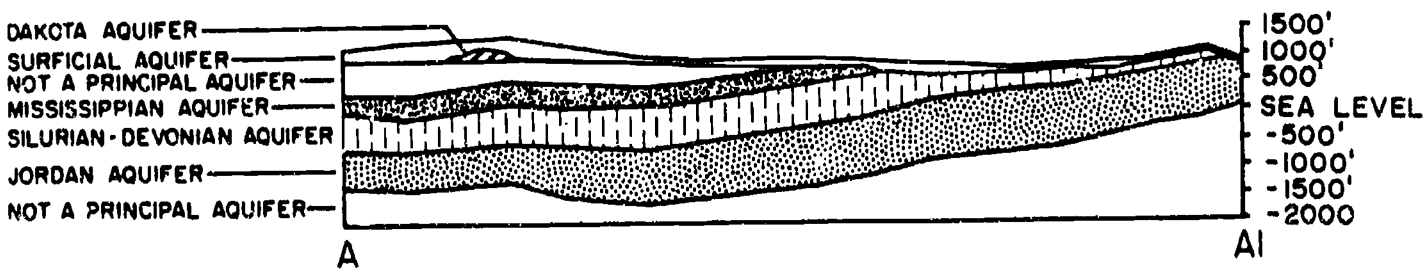
*Adapted from Steinhilber and Horick

Appendix F

Figure F-1. Principal aquifers in Iowa:
a. Geographic distribution of most used aquifers,
b. Generalized cross section.



a.



b.

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Appendix G. Glossary

Acute effect -- condition that occurs rapidly and produces severe or very noticeable symptoms.

Adsorb -- to stick to the surface of something. For example, some chemicals stick to the surface of soil particles.

Agricultural drainage well (or ag-drainage well) -- pipes used to drain water from marshes and wet areas directly into aquifers, usually allowing the land to be farmed.

Aquiclude -- very dence earth material that stores water, but water does not move through it in significant amounts; very dense confining layer.

Aquifer -- zone of porous earth material that contains and yields enough water for wells.

Aquitard -- dense, compact earth material that blocks the easy passage of water; confining layer.

Artesian well -- a well in which water comes from a confined aquifer and is under pressure due to the weight of the water in the confined aquifer. One type of artesian well is a flowing well where water just flows or bubbles out of the ground without being pumped.

BMPs (Best Management Practices) -- methods that provide optimum economic return with minimum adverse effect on the environment.

Band application -- putting a pesticide over or next to each row of plants in a field.

Big Spring Basin -- a 100 square-mile site in northeast Iowa near Elkader that has provided significant groundwater research data for the country. Nearly all of the groundwater in this area comes out at the Big Spring at a fish hatchery, allowing the amounts of contaminants to be measured.

Biodegradable -- able to be broken down into simple substances by microorganisms.

Broadcast application -- spreading a pesticide over an entire field or lawn.

CERCLA -- Comprehensive Environmental Response, Compensation and Liability Act, passed in 1980 by Congress to authorize the first five-year program for the Superfund to clean up hazardous waste sites.

Carcinogen -- something that causes cancer.

Caustic -- destroys tissue or corrodes metal.

Chronic effect -- condition that occurs over a long period of time. Cancer and arthritis are two examples of chronic disease.

Composting -- process by which bacteria and other organisms break down organic material, such as kitchen scraps, leaves, lawn clippings and manure into material, to be used as a soil conditioner.

Confined aquifer -- an aquifer with a confining layer above it.

Confining layer -- dense, compact earth material that blocks the easy passage of water; aquitard.

Crop residue -- pieces of plants left on the ground after harvest.

Crop rotation -- growing different crops in recurring succession on the same land.

Curbside recycling -- program where residents separate their garbage before collection into at least recyclable and non-recyclable materials.

d-RDF (densified refuse-derived fuel) – burnable part of waste that has been compacted into three-inch pellets which can be burned for a source of energy.

EPA – Environmental Protection Agency, a federal agency which oversees, among other things, the quality of our country's air and water, and the cleanup of hazardous waste sites.

Epidemiology – the study of how diseases correlate with exposure to different factors (such as environmental contaminants).

FIFRA – Federal Insecticide, Fungicide and Rodenticide Act which regulates pesticide use and commerce.

Glacial till or glacial drift – unsorted deposits by a glacier, made of materials of all sizes from clays to boulders.

Groundwater –water under the ground that saturates the earth materials.

Groundwater Protection Act – bill passed by the Iowa legislature in 1987 which focused on preventing several types of groundwater contamination.

HHM – household hazardous materials.

Hazardous waste – waste that causes special problems to people or the environment because it is caustic, explosive, infectious, toxic, or radioactive.

Herbicide – chemical used to kill unwanted plants; a type of pesticide.

Hydrologic cycle – water cycle.

IFM or IFMDP – refers to the Integrated Farm Management Demonstration Project through Iowa State University which demonstrates such things as different energy and environmental benefits through tillage, nutrient, pesticide and water management.

Incineration – the burning of waste.

Infiltration -- the flow of water into the soil.

Inorganic – matter that is not animal or vegetable. Most inorganic compounds do not contain carbon and are from mineral sources.

Insecticide – chemical used to kill insects; a type of pesticide.

Integrated Pest Management (IPM) – program that emphasizes pest prevention whenever possible. Sample strategies include timing field work to disrupt the pests' environment, field scouting for pests, using natural enemies, and using chemicals only when it pays to do so.

Karst – land with fractured limestone bedrock where water seepage can make pits and holes, and carry contaminants quickly from the surface to groundwater.

Landfill (sanitary landfill) – method of disposing of solid waste on land by keeping the waste at the smallest practical volume and covering it with a layer of earth.

Leachate – liquid waste; can be formed when water percolates through buried waste. It can contain hazardous chemicals that can contaminate groundwater.

Legume – plant, such as clover, alfalfa, or soybeans. Bacteria on the roots of legumes can change nitrogen in the air into a form which can be used by most plants, thus reducing the need for fertilizer.

Methemoglobinemia (blue baby syndrome) – a disease which affects infants who have drunk water with a high nitrate concentration. The baby's skin turns blue because the blood cannot carry oxygen as well. This disease, if undiagnosed, can be fatal, but is easily corrected once identified.

Nonpoint source pollution – water pollution from many, widespread places that are hard to identify; for example, farm chemicals leaching through the soil or running off the land.

Nonrenewable resource – substance such as oil, gas, coal, copper, and gold, which, once used, cannot be replaced, at least not in this geological age.

Nutrients – chemicals that help plants grow, such as nitrogen and phosphorus.

Organic – matter from living organisms. Also refers to any chemical containing carbon.

PCBs – polychlorinated biphenyls. A class of chemicals related to DDT; used widely in the plastics and electrical industries until they were found to be potent environmental poisons.

ppb – parts per billion; a common unit for measuring chemicals in water. 1 ppb = 1 ug/l (microgram per liter). 1000 ppb = 1 ppm.

ppm – parts per million; a common unit for measuring chemicals in water. 1 ppm = 1 mg/l (milligram per liter).

Pathogenic – disease-causing.

Percolation – the flow of liquid down through porous material such as soil or rocks.

Permeability – the ability of sediment or rock to transmit water or other liquids.

Pesticide – chemical used to destroy, control or repel unwanted plants or animals. Pesticides most commonly include herbicides (to kill weeds) and insecticides (to kill insects), as well as chemicals to control fungi, rodents and algae.

Photodegradable – capable of being broken down by light.

Point source pollution – water pollution from one place that is easy to identify; for example, a chemical spill or a pipe discharging contaminants into a stream.

Porosity – the percentage of the total volume of a material that is open space.

RCRA – Resource Conservation Recovery Act; an EPA program to manage hazardous materials, tracking them from "cradle to grave" (production to disposal).

RDF (refuse-derived fuel) – waste which has had metals and other nonburnable items removed so the remaining "fluff" can be burned as a source of energy.

Recycle – process where material is processed to be used again in its original form or in a similar form.

Reuse – to extend the life of an item by repairing or modifying it or by creating new uses for it.

SARA – Superfund Amendments and Reauthorization Act, a bill passed by Congress in 1986 to extend the Superfund to pay for cleaning up hazardous waste sites.

Saturated zone – area under the ground where all the spaces are filled with water, known as groundwater.

Sinkhole – a depression in the landscape where limestone has been dissolved, allowing water to flow directly from the surface to groundwater.

Superfund – a large fund of money administered by the EPA to help clean up the nation's worst hazardous waste sites.

Sustainable agriculture – (defined by the Groundwater Protection Act as): the appropriate use of crop and livestock systems and agricultural inputs supporting those activities which maintain economic and social viability while preserving the high productivity and quality of Iowa's land. There are many different definitions for sustainable agriculture, but most include the ideas that farming methods: reduce the costs of purchased inputs, minimize the impact on the environment, and sustain a profit.

Synergism – condition in which a whole effect is greater than the sum of its parts. For example, the combined effects of several groundwater contaminants may be greater than their individual toxic effects.

Synthetic Organic Compound (SOC) – a type of human-made chemical not naturally found in groundwater, including pesticides, solvents and by-products of chlorination.

TCE – trichloroethylene, a toxic industrial solvent.

Till – to plow or work the land in preparation for raising crops.

Conservation tillage – leaving protective crop residues on the soil surface; reduces soil losses from wind and water erosion by 50 percent.

No-till – planting a crop without prior seedbed preparation into sod, crop residue, or an existing cover crop and eliminating subsequent tillage operations.

Ridge till – farming using a ridge of soil for each row of crops. Allows for reducing pesticide use by banding, and other positive effects on the soil, weed control, energy conservation and farm labor.

Toxic – poisonous.

Transpiration – loss of moisture from plants into the air.

Unconfined aquifer – an aquifer without a confining layer above it. The top surface of water in an unconfined aquifer is the water table.

Unsaturated zone – the space above the water table where some of the pore spaces are not filled with water. (also known as the zone of aeration).

Water table – the top surface of groundwater, lakes and streams.

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Appendix H. Potential Hazards of Household Products Classified To Chemical Type

Product Type	Possible Ingredients	Potential Hazards
	HOUSEHOLD PRODUCTS	
Asphalt/ Roofing Tar	**Petroleum solvents	Associated with skin and lung cancer; irritant to skin, eyes, nose, lungs; entry into lung may cause fatal pulmonary edema (excess fluid in lung tissues).
Batteries	Mercuric oxide (in mercury batteries)	Ingestion may be fatal.
Bleach	Sodium hypochlorite	Corrosive, irritates or burns skin, eyes, respiratory tract; may cause pulmonary edema or vomiting and coma if ingested; contact with other chemicals may cause chlorine or chloramine fumes.
Disinfectants	Sodium hypochlorite	Corrosive, irritates or burns skin, eyes, respiratory tract; may cause pulmonary edema or vomiting and coma if ingested.
	Phenol	Flammable; very toxic; respiratory, circulatory or cardiac damage
	Ammonia	Vapor irritating to eyes, respiratory tract and skin; possible chronic irritation.
Drain Cleaner	Sodium or potassium hydroxide	Caustic; irritant; inhibits reflexes; burns to skin, eyes; poisonous if swallowed due to severe tissue damage.
	Hydrochloric acid	Corrosive, irritant; damage to kidney, liver and digestive system
	Trichloroethane	Irritant to nose and eyes; central nervous system depression; liver and kidney damage if ingested.
Flea Powder	Carbaryl	Very toxic; interferes with human nervous system; may cause skin, respiratory system, cardiovascular system damage.
	Dichlorophene	Skin irritation; may damage liver, kidney, spleen and central nervous system
	**Chlordane and other chlorinated hydrocarbons	Very slow biodegradation; accumulates in food chain; may damage eyes, lungs, liver, kidneys and skin.
Floor Cleaner/Wax	Diethylene Glycol	Toxic; causes central nervous system depression and kidney, liver lesions
	**Petroleum Solvents	Highly flammable; associated with skin, eyes, nose, throat, lungs
	Ammonia	Vapor irritation to eyes, respiratory tract and skin; possible chronic irritation.
Furniture Polish	**Petroleum distillates or Mineral spirits	Highly flammable; moderately toxic; associated with lung cancer; irritant to skin, eyes, nose, throat, lungs; entry into lungs may cause pulmonary edema.
Inks	**Glycols	Toxic; poison by skin absorption, ingestion and sometimes inhalation; eye irritant; stupors; kidney damage; anemia.

Product Type	Possible Ingredients	Potential Hazards
Inks	**Alcohols	Volatile and flammable; methanol is very toxic if swallowed; eye, nose and throat irritation.
	**Glycol ethers	Highly flammable.
Metal Polish	**Petroleum solvents	Highly flammable; associated with lung and skin cancer; irritant to skin, eyes, nose, throat, lungs.
	Oxalic acid	Potential damage to respiratory system, lungs, skin, kidneys, skin and eye irritant.
Mothballs	**Chlorinated aromatic hydrocarbons (dichlorobenzene)	Flammable; accumulate in the food chain; vapor irritating to skin, eyes, throat; dichlorobenzene is a suspected carcinogen.
	Napthalene	Possible damage to eyes, blood, liver, kidneys, skin, central nervous system; suspected carcinogen.
Nail Polish	**Aromatic hydrocarbon solvents	Flammable; very toxic; skin contact may cause irritation to chemical pneumonitis (lung inflammation); may cause kidney, liver, blood, central nervous system damage.
	Acetone	Moderately toxic; flammable; may cause respiratory ailments.
	Ethyl and butyl acetate	Moderately toxic; may cause central nervous system depression, damage to eyes, skin, respiratory system.
Oven Cleaner	Sodium or potassium hydroxide (lye)	Caustic; irritant, inhibits reflexes, burns to skin, eyes; poisonous if swallowed due to severe tissue damage.
Paint Thinner	**Chlorinated aliphatic hydrocarbons	Slow decomposition; liver and kidney damage.
	**Esters	Toxicity varies with specific chemical; causes eye, nose and throat irritation.
	**Alcohols	Volatile and flammable; eye, nose and throat irritation.
	**Chlorinated aromatic hydrocarbons	Flammable; toxic; accumulate in food chain.
	**Ketones	Flammable; toxicity varies with specific chemical; may cause respiratory ailments.
Paints	**Aromatic hydrocarbon thinners	Flammable; skin irritant; benzene is a carcinogen; possible liver and kidney damage.
	Mineral spirits	Highly flammable; skin, eye, nose, throat, lung irritant; very high air concentrations may cause unconsciousness, death.
Septic Tank Cleaners	Trichloroethylene	Slow decomposition; known animal carcinogen; kidney, liver and spleen damage.
	Methylene chloride	Slow decomposition; liver and kidney damage.
Silver Cleaner and Polish	Denatured ethanol or isopropanol	Moderately toxic; central nervous system depressant.

Product Type	Possible Ingredients	Potential Hazards
Silver Cleaner and Polish	Phosphoric acid	Corrosive; irritant; possible damage to kidney, liver and digestive system.
Spot Removers	Perchlorethylene or trichloroethane	Slow decomposition; liver and kidney damage; perchlorethylene is a suspected carcinogen.
	Ammonium hydroxide	Corrosive; vapor extremely irritable to skin, eyes and respiratory passages; ingestion causes tissue burns.
	Sodium hypochlorite	Corrosive; irritates skin, eyes, respiratory tract; may cause pulmonary edema and skin burns.
Toilet Bowl Cleaners	Sodium acid sulfate or oxalate or hypochloric acid	Corrosive; burns from skin contact or inhalation; ingestion may be fatal.
	Chlorinated phenols	Flammable; very toxic; respiratory, circulatory or cardiac damage.
Water Proofers	**Chlorinated Aliphatic solvents	Slow decomposition; liver and kidney damage.
	**Aliphatic and aromatic hydrocarbon solvents	Flammable; irritant; central nervous system depression; possible liver, kidney, spleen damage.
Window Cleaners	Diethylene glycol	Toxic; causes central nervous system depression and degenerative lesions in liver and kidneys.
	Ammonia	Vapor irritating to eyes, respiratory tract and skin; possible chronic irritation.
Wood Preservatives	**Chlorinated aromatic hydrocarbons	Flammable; toxic; accumulate in food chain.
	Mineral spirts	Pentachlorophenol may be very toxic by ingestion or skin absorption.
	Pentachlorophenol	Irritates skin, eyes, throat; absorbed through skin; damages liver, kidneys, and nervous system.
Wood Putty	Ketones	Flammable; may cause respiratory ailments
	Toluene	Flammable; very toxic; may cause skin, kidney, liver, central nervous system damage; suspected carcinogen.
Wood Stains/ Varnish	Mineral spirits, gasoline	Highly flammable; associated with skin and lung cancer; irritant to skin, eyes, nose, throat, lungs; entry into lungs may cause fatal pulmonary edema.
	Methyl and ethyl alcohol	Flammable; damage to eyes, skin, central nervous system.
	Benzene	Flammable; carcinogen; accumulates in fat, bone marrow, liver tissues.
	Lead	Damage to digestive, genitourinary, neuromuscular and central nervous system; anemia and brain damage.
Wood Strippers	Chlorinated aliphatic hydrocarbons (methylene chloride)	Slow decomposition; liver and kidney damage.
	Toluene	Flammable; skin irritation; narcotic properties; may damage liver, kidneys, central nervous system.

Product Type	Possible Ingredients	Potential Hazards
Wood Strippers	Benzene	Flammable; carcinogen; accumulates in fat, bone marrow, liver tissue.
	AUTOMOTIVE PRODUCTS	
Antifreeze	Ethylene glycol	Very toxic, 3 ounces can be fatal to adult; damage to cardiovascular system; blood, skin and kidneys.
	Methyl alcohol	Damage to eyes, central nervous system.
Auto Batteries	Sulfuric acid	Skin burns; single overexposure may lead to laryngeal or pulmonary edema (excess fluid in larynx or lung tissue).
Car Wax/Polish	Petroleum distillates	Associated with skin and lung cancer; irritant to skin, eyes, nose, lungs; entry into lungs may cause fatal pulmonary edema.
Degreasers	Chlorinated aliphatic hydrocarbons	Slow decomposition; trichloroethylene and perchlorethylene are suspected carcinogens; liver and kidney damage.
Engine, Radiator Flush/Cleaner	Chlorinated aliphatic hydrocarbons	Slow decomposition; liver and kidney damage.
	Acids	Corrosive; irritant, damage to kidney, liver and digestive system; pulmonary edema.
Motor Oil/ Gasoline	Petroleum hydrocarbons (benzene)	Highly flammable; associated with skin and lung cancer; irritant to skin, eyes, nose, throat, lungs; pulmonary edema; benzene is a carcinogen.
	Lead	Damage to digestive; genitourinary, neuromuscular and central nervous system; anemia and brain damage.
Rust Preventers/ Removers	Chlorinated aliphatic hydrocarbons	Slow decomposition; trichloroethylene and perchlorethylene are suspected carcinogens; liver and kidney damage.
	Potassium dichromate	Very toxic; highly corrosive to skin and nervous membranes; if ingested may cause coma, liver damage.
	PESTICIDES	
Herbicides 2,4-D;2,4,5-T; 2,4-5-TP (Silvex)* MCPA, MCPB	Chlorinated Phenoxys	May be contaminated with dioxin, which is deadly and mutagenic; irritation to skin, eyes, throat.
Herbicides (Paraquat*, Diquat)	Dipyridyl	Toxic, causes skin, eyes and throat irritations; causes lung, kidney and liver damage, death.

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Product Type	Possible Ingredients	Potential Hazards
Herbicides (Dinitrophenol, Dinitroortho-cresal, Binapacryl)	Nitrophenols	Highly toxic; readily absorbed via skin, stains skin yellow; interferes with oxygen transfer in cells; damages liver, kidney, nervous system.
Pesticides (Aldicarb*, Oxamyl, Carbofuran, Methyomyl, Sectran, Propoxur, Carbaryl Sevin)	Carbamates	Interfere with human nervous system.
Pesticides (Endrin*, Aldrin, Dieldrin*, Toxaphene*, Lindane, Benzene Hexachloride*, DDT*, Heptachlor*, Chlordane*, Mirex*, Methoxychlor)	**Chlorinated hydrocarbons	Very slow biodegradation; accumulation in food chain and in fatty tissue; attack nervous system; suspected carcinogens and mutagens.
Pesticides (Phorate, Mevinphos*, Demeton*, Disulfotan, Parathion, Diazinon, Trichlorfon, Ronnel, Axinphos-methyl)	Organophosphorus	Poison by interfering with the nervous system; can be toxic; biodegradable, but not much is known about the breakdown products.
Pesticides (Monvran, Divron, Linvron, Bromacil, Terbacil, Altrazine, Ametryn)	Urea, Uracil, Triazine-based	Low toxicity, but will irritate skin, eyes, throat.
Rodenticides (Warfarin, Coumafuryl, Diphacinone, Pinclone, Valone)	Coumarin	Anticoagulents may cause internal bleeding.

* These pesticides are banned or restricted and should not be used by households.

**Specific compounds of this chemical type are found on "Partial List of Compounds of Chemical Classes."

REFERENCES

1. NIOSH/OSHA Pocket Guide to Chemical Hazards, Frank Mackison, Scott Scricoff, Lawrence Patridge, Editors, September, 1978.

2. Clinical Toxicology of Commercial Products, Marion Gleason, et al., 1969.

3. Toxicants in Consumer Products, Susan Ridgley, Seattle, WA. Household Hazardous Waste Disposal Project, 1982.

4. A Guide to the Safe Use and Disposal of Hazardous Products, Metropolitan Area Planning Council, 1982.

Notes:

1. The potential health hazards listed in this table are symptoms of acute poisoning and may be experienced as a result of high exposure or direct ingestion.

2. This table has been reviewed for accuracy by the Department of Environmental Quality Engineering, Division of Hazardous Waste and the University of Massachusetts, Department of Health and Safety.

This table was taken primarily from Dyckman, C., Luboff, C. and Smith- Greathouse, L., "Household Hazardous Waste Disposal Project" Report 1D, Sleuth, Metro Toxicant Program, Seattle, WA, August 1982.

PARTIAL LIST OF COMPOUNDS OF CHEMICAL CLASSES

Alcohols--methanol (wood alcohol), ethanol (grain and rubbing), isopropyl (rubbing alcohol), butanol, amyl alcohol

Aldehydes--formaldehyde, other aldehydes

Aliphatic hydrocarbons--butane, pentane, hexane, heptane

Alkalies--ammonia, lime (calcium oxide), potassium hydroxide, sodium hydroxide, sodium silicate

Aromatic hydrocarbons--benzene, toluene (toluol), xylene (xylol); aromatic solvent naphtha; styrene, phenol (carbolic acid)

Chlorinated aliphatic hydrocarbons--(halogenated hydrocarbons, chlorinated paraffins) carbon tetrachloride, chloroform trichloroethylene (TCE), trifluoroethane, perchloroethylene, trichloroethane (methyl chloroform), methylene chloride (dichloromethane), dichloropropane

Chlorinated aromatic hydrocarbons--chlorobenzene, dichlorobenzene, polychlorinated biphenyls (PCBs), chlorinated naphthalenes, chlorinated pesticides (DDT, kepone, etc.)

Chlorofluorocarbons--fluorocarbons, fluorinated hydrocarbons, halogenated hydrocarbons

Esters--methyl acetate, ethyl acetate, butyl acetate

Ethers--ethyl ether, isopropyl ether, glycol ether

Glycols--methyl cellosolve, ethylene glycol, diethylene glycol, carbitol

Ketones--Acetone, methylethyl ketone, hexane, MIBK, MBK

Petroleum distillates--petroleum ether; gasoline (petrol), white spirits, mineral spirits (Stoddard solvent), kerosene, fuel oil, lubicating oils, petroleum naphtha, lamp oil

Adapted from Household Hazardous Products Handbook, Federation of Ontario Naturalists.

Appendix I. Contacts for Information on Iowa's Groundwater Issues

Groundwater Protection Hotline: 1-800-532-1114.
This toll-free number can be used for questions related to any of the topics listed below. Someone from the Department of Natural Resources office in Des Moines will take your call and refer you to the appropriate people to answer your questions. Telephone numbers are provided below to offices that cannot be reached with the toll-free number.

Abbreviations:

CHEEC	Center for Health Effects of Environmental Contaminants
DALS	Department of Agriculture & Land Stewardship
DNR	Department of Natural Resources
ISU	Iowa State University

Topics	Who to Contact
Abandoned waste sites	DNR Solid Waste/Abandoned Uncontrolled Sites Section
Abandoned wells	DNR Water Supply Section
Ag-drainage well registration	DNR Flood Plain Permits Section
Ag-drainage wells and sinkholes	DALS Soil Conservation Division (515) 281-6146
Aquifers	DNR Geological Survey Bureau (319) 335-1575
Chemical spills	DNR Field Evaluation & Emergency Response Bureau (Emergencies only: (515) 281-8694) (answered 24 hours)
Educational materials on groundwater	DNR Information & Education Bureau
Fertilizer	DALS Laboratory Division (515) 281-8596
Geology of Iowa	DNR Geological Survey Bureau (319) 335-1575
Groundwater newsletter	DNR Information & Education Bureau
Groundwater Protection Act general questions	DNR Planning Bureau
Household hazardous wastes	DNR Waste Management Authority Division
Health issues	Department of Public Health (515) 281-5757 or CHEEC (319) 335-7497
Integrated Farm Management Program	DALS Soil Conservation Division or ISU Extension Service (515) 294-1923 or ISU Ag. Experimental Station (515) 294-4025
Land-applied wastes	DNR Solid Waste/Abandoned Uncontrolled Sites Section
Landfill alternatives (reduction, recycling, reuse, composting, & incineration)	DNR Waste Management Authority Division

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Landfill regulations	DNR Air Quality & Solid Waste Protection Bureau
Pesticides	DALS Laboratory Division (515) 281-6597
Real estate transfer	DNR Legal Services Bureau
Recycling & waste alternatives	DNR Waste Management Authority Division
Toxic Cleanup Days	DNR Waste Management Authority Division
Underground storage tanks	DNR Underground Storage Tank Section
Water: drinking water supply, quality & quantity	DNR Geological Survey Bureau (319) 335-1575 or DNR Water Supply Section
Water quality monitoring of surface & groundwater	DNR Water Quality Planning Section
Water treatment	DNR Water Supply Section
Wastewater (sewage) treatment	DNR Wastewater Permits/Construction Grants Section
Well construction	DNR Water Supply Section

__State Agencies__
The following briefly outlines the role of state agencies that deal with groundwater protection issues.

Department of Natural Resources (DNR)
Wallace State Office Building
Des Moines, IA 50319
(515) 281-5145

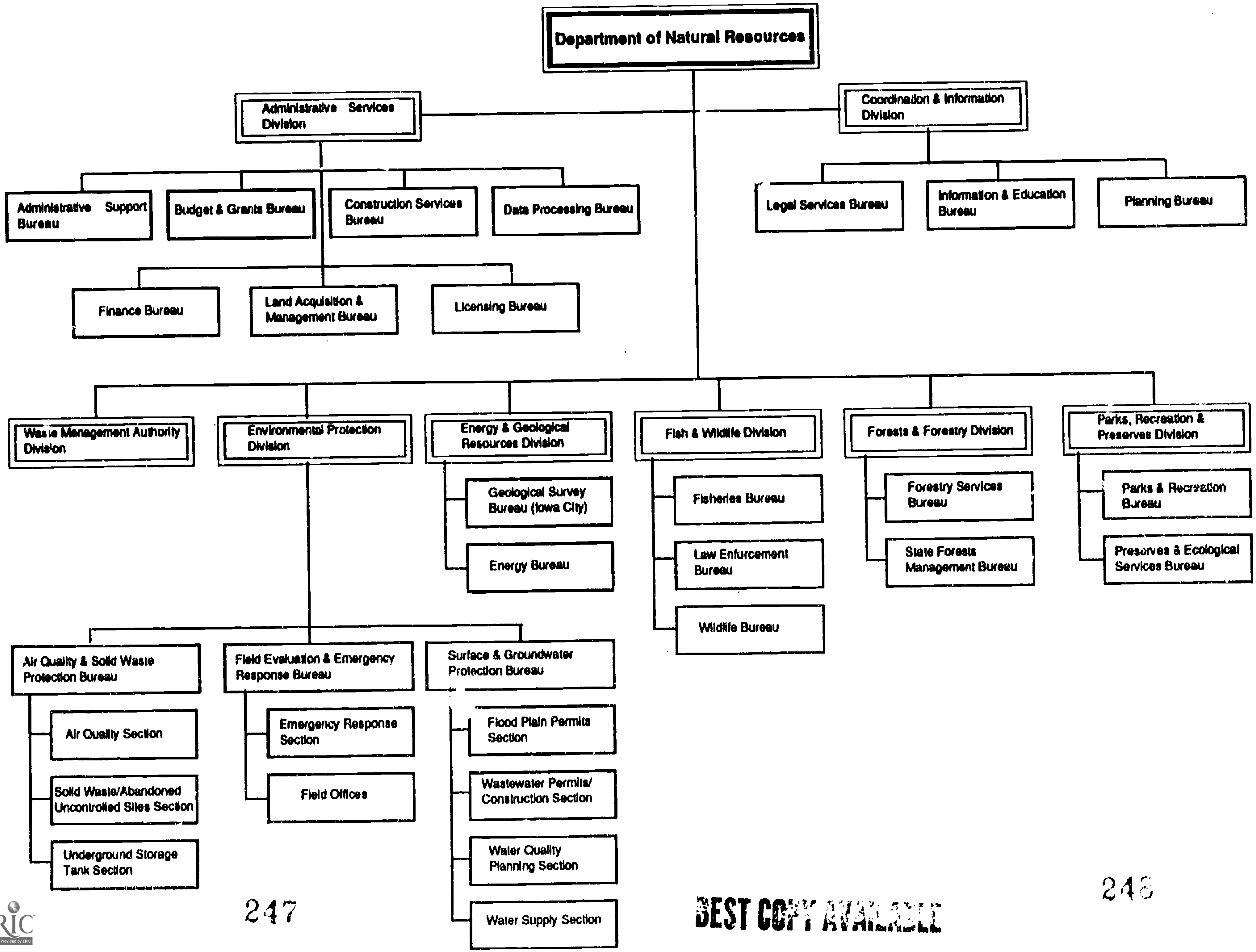
The DNR is the lead agency for implementing Iowa's 1987 Groundwater Protection Act. Several branches of the DNR deal with groundwater protection issues.

With the reorganization of state government in 1986, the Iowa Department of Natural Resources came into being with the merging of the Conservation Commission, the Department of Water, Air and Waste Management, the Iowa Geological Survey, and the energy resources programs of the Energy Policy Council. The main office for each branch of the DNR (shown on the following chart) is in Des Moines, except for the Geological Survey Bureau which is in Iowa City.

Geological Survey Bureau
123 N. Capitol Street
Iowa City, IA 52242
(319) 335-1575.

Department of Agriculture and Land Stewardship (DALS)
Wallace State Office Building
Des Moines, IA 50319
(515) 281-5321

The Department of Agriculture and Land Stewardship consists of six divisions: Administrative, Agricultural Marketing, Regulatory, Agricultural Development, Laboratory, and Soil Conservation.


Department of Natural Resources
Administrative Services Division
Coordination & Information Division
Administrative Support Bureau
Budget & Grants Bureau
Construction Services Bureau
Data Processing Bureau
Legal Services Bureau
Information & Education Bureau
Planning Bureau
Finance Bureau
Land Acquisition & Management Bureau
Licensing Bureau
Waste Management Authority Division
Environmental Protection Division
Energy & Geological Resources Division
Fish & Wildlife Division
Forests & Forestry Division
Parks, Recreation & Preserves Division
Geological Survey Bureau (Iowa City)
Energy Bureau
Fisheries Bureau
Law Enforcement Bureau
Wildlife Bureau
Forestry Services Bureau
State Forests Management Bureau
Parks & Recreation Bureau
Preserves & Ecological Services Bureau
Air Quality & Solid Waste Protection Bureau
Field Evaluation & Emergency Response Bureau
Surface & Groundwater Protection Bureau
Air Quality Section
Solid Waste/Abandoned Uncontrolled Sites Section
Underground Storage Tank Section
Emergency Response Section
Field Offices
Flood Plain Permits Section
Wastewater Permits/ Construction Section
Water Quality Planning Section
Water Supply Section

The **Laboratory Division** regulates fertilizers and pesticides. It assumed the following responsibilities under the 1987 Groundwater Protection Act: 1) the training and testing of pesticide applicators; 2) the licensing of urban pesticide dealers; 3) the notification of adjacent property owners of pesticide application in urban areas; 4) the establishment of a statewide database on pesticide use; and 5) the implementation of an agricultural initiative in best management practices in the use of agricultural chemicals.

The **Soil Conservation Division** works to preserve Iowa's soil, water and mineral resources, including programs to reduce or eliminate groundwater contamination associated with agricultural practices. It also oversees education and demonstration projects to eliminate contaminants through ag-drainage wells & sinkholes.

Department of Public Health (DPH)
Division of Disease Prevention
Lucas State Office Building
Des Moines, IA 50319
(515) 281-5757

Doctors and poison control centers must report cases of pesticide poisoning, blue baby syndrome (nitrate poisoning), and possibly other poisonings or injuries which may or may not be directly related to groundwater contamination to DPH. This agency is also in charge of the Lead in School Drinking Water Program, and will provide technical assistance to schools to determine the lead content in their pipes and water, and provide advice on how to reduce lead levels.

The following three centers were created by the 1987 Groundwater Protection Act.

Leopold Center for Sustainable Agriculture
3203 Agronomy
Iowa State University
Ames, IA 50011
(515) 294-4270

This research and education program operates a competitive grants program to develop and promote agricultural systems that combine responsible stewardship of natural resources with farm profitability.

Center for Health Effects of Environmental Contamination (CHEEC)
5118 Westlawn
University of Iowa
Iowa City, IA 52242
(319) 335-7497

This center does a variety of research on exposure to environmental contaminants and assessing the risk to human health. For example, they may make use of data from existing cancer and birth defect registries and develop similar recording systems for other diseases which are suspected to be caused by exposure to environmental toxins.

Iowa Waste Reduction Center (IWRC)
University of Northern Iowa
75 Biology Research Complex
Cedar Falls, IA 50614
(319) 273-2079

Formerly the Small Business Assistance Center, it helps Iowa businesses develop safe and economic management practices for solid waste and hazardous substances.

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Appendix J. Publications on Groundwater Issues from the Iowa Department of Natural Resources Geological Survey Bureau

The following publications can be ordered from the Geological Survey Bureau, 123 North Capitol Street, Iowa City, Iowa 52242; phone (319) 335-1575. Please include a check or money order payable to Iowa Department of Natural Resources.

Ordering Code	Publication	Price	Postage/ Handling
WATER ATLASES			
WA-1	The water story in central Iowa, F.R. Twenter, R.W. Coble, 1965, 89 p.	$2.00	$ .95
WA-2	Availability of groundwater in Decatur County, Iowa, J.W. Cagle, W.L. Steinhilber, 1967, 28 p.	$1.35	$ .70
WA-3	Availability of groundwater in Wayne County, Iowa, J.W. Cagle, 1969, 33 p.		Out-of-print
WA-4	Water resources of southeast Iowa, R.W. Coble, J.V. Roberts, 1971, 101 p.	$1.70	$ .95
WA-5	Water resources of south-central Iowa, J.W. Cagle, A.J. Heinitz, 1978, 97 p.	$2.25	$ .95
WA-6	Water resources of east-central Iowa, K.D. Wahl, G.A. Ludvigson, G.L. Ryan, W.C. Steinkampf, 1978, 91 p.	$3.50	$ .95
WA-7	Water resources of north-central Iowa, R. Buchmiller, G. Gaillot, P.J. Soenksen, 1985, 93 p.	$4.00	$ .95
OPEN-FILE COUNTY GROUNDWATER RESOURCES REPORTS			
GWR-4	Groundwater resources of Appanoose County, D.L. Gordon, 1980, 26 p.	$1.00	$ .50
GWR-8	Groundwater resources of Boone County, C.A. Thompson, 1982, 28 p.	$1.00	$ .50
GWR-25	Groundwater resources of Dallas County, 23 p.	$1.00	$ .50
GWR-26	Groundwater resources of Davis County, P.M. Witinok, 1980, 27 p.	$1.00	$ .50
GWR-29	Groundwater resources of Des Moines County, D.L. Gordon, 1980, 27 p.	$1.00	$ .50
GWR-38	Groundwater resources of Grundy County, C.A. Thompson, 1988, 35 p.	$1.00	$ .50

Ordering Code	Publication	Price	Postage/ Handling
GWR-40	Groundwater resources of Hamilton County, C.A. Thompson, 1986, 32 p.	$1.00	$ .50
GWR-42	Groundwater resources of Hardin County, C.A. Thompson, 1988, 37 p.	$1.00	$ .50
GWR-44	Groundwater resources of Henry County, P.M. Witinok, 1980, 27 p.	$1.00	$ .50
GWR-48	Groundwater resources of Iowa County	$1.00	$ .50
GWR-51	Groundwater resources of Jefferson County, 1979, 27 p.	$1.00	$ .50
GWR-54	Groundwater resources of Keokuk County, P.M. Witinok, 1979, 27 p.	$1.00	$ .50
GWR-56	Groundwater resources of Lee County, D.L. Gordon, 1980, 27 p.	$1.00	$ .50
GWR-58	Groundwater resources of Louisa County, D.L. Gordon, 1980, 27 p.	$1.00	$ .50
GWR-59	Groundwater resources of Lucas County, D.L. Gordon, 1980, 26 p.	$1.00	$ .50
GWR-61	Groundwater resources of Madison County, J.C. Prior, 1988, 26 p.	$1.00	$ .50
GWR-62	Groundwater resources of Mahaska County, D.L. Gordon, 1980, 27 p.	$1.00	$ .50
GWR-63	Groundwater resources of Marion County, D.L. Gordon, 1980, 26 p.	$1.00	$ .50
GWR-68	Groundwater resources of Monroe County, P.M. Witinok, 1980, 26 p.	$1.00	$ .50
GWR-77	Groundwater resources of Polk County, C.A. Thompson, 1982, 28 p.	$1.00	$ .50
GWR-85	Groundwater resources of Story County, C.A. Thompson, 1982, 28 p.	$1.00	$ .50
GWR-89	Groundwater resources of Van Buren County, D.L. Gordon, 1980, 27 p.	$1.00	$ .50
GWR-90	Groundwater resources of Wapello County, P.M. Witinok, 1979, 27 p.	$1.00	$ .50
G[illegible]-91	Groundwater resources of Warren County, J.C. Prior, 1988, 26 p.	$1.00	$ .50

Ordering Code	Publication	Price	Postage/ Handling
GWR-92	Groundwater resources of Washington County, P.M. Witinok, 1980, 27 p.	$1.00	$ .50

MISCELLANEOUS MAP SERIES

MMS-3	Mississippian aquifer of Iowa, 3 color sheets with text, P.J. Horick, W.L. Steinhilber, 1973.	$1.00	$ .85
MMS-6	Jordan aquifer of Iowa, 3 color sheets with text, P.J. Horick, 1978.	$2.00	$ .85
MMS-9	Estimated water use in Iowa, 1 color sheet with text, R.C. Buckmiller, R.A. Karsten, 1983.	$2.50	$ .50
MMS-10	Silurian-Devonian aquifer of Iowa, 4 color sheets with text, P.J. Horick, 1984.	$5.00	$1.25

OPEN-FILE REPORTS

OFR 83-1	Additional regional groundwater quality data from the karst-carbonate aquifers of northeast Iowa, G.R. Hallberg, B.E. Hoyer, R.D. Libra, E.A. Bettis III, G.G. Ressmeyer, 1983, 16 p.	$1.00	$ .55
OFR 83-3	Hydrogeology, water quality, and land management in the Big Spring Basin, Clayton Co. IA, G.R. Hallberg, G.E. Hoyer, E.A. Bettis III, R.D. Libra, 1983, 255 p.	$5.00	$1.25
OFR 84-1	Temporal changes in nitrates in groundwater in northeastern Iowa, G.R. Hallberg, R.D. Libra, G.G. Ressmeyer, E.A. Bettis III, B.E. Hoyer, 1984, 10 p.	$1.00	$ .55
OFR 84-2	Part 1 Groundwater quality and hydrogeology of Devonian-carbonate aquifers in Floyd and Mitchell Counties, Iowa, R.D. Libra, G.R. Hallberg, G.G. Ressmeyer, B.E. Hoyer, 1984, p. 1-106.	$3.00	$. 95
OFR 84-4	Hydrogeologic and water quality investigations in the Big Spring Basin, Clayton Co., IA, 1983 water-year, G.R. Hallberg, R.D. Libra, E.A. Bettis III, B.E. Hoyer, 1984, 231 p.	$8.00	$1.50
OFR 84-5	Hydrogeology and water quality of the upper Des Moines River alluvial aquifer, C.A. Thompson, 1984, 170 p.	$6.00	$1.50

Ordering Code	Publication	Price	Postage/ Handling
OFR 85-1	Estimates of rural wells in Iowa, G.R. Hallberg, B.E. Hoyer, M. Dorpinghaus, G.A. Ludvigson, 1985, 18 p.	$1.00	$ .50
OFR 85-2	Part 1 Hydrogeologic observations from multiple core holes and piezometers in the Devonian-carbonate aquifers in Floyd and Mitchell Counties, IA, R.D. Libra, G.R. Hallberg, 1985, p. 1-19.	$1.00	$.50
OFR 86-3	Water resources of the Ocheyedan-Little Sioux alluvial aquifer. (The geology, hydrology, and water-producing potential of this aquifer were evaluated from the Minnesota border to the Woodbury-Monona County line. Seismic refraction surveys were used to define aquifer geometry. Nitrate, bacteria, and limited pesticide a-sampling was done on wells and surface waters.) C.A. Thompson, 1986, 90 p.	$6.00	$1.50
OFR 86-4	Water resources of the Ocheyedan-Little Sioux aquifer, C.A. Thompson, 1986, 115 p.	$5.00	$1.50
OFR 87-1	Water resources of the Rock River alluvial aquifer. (The geology, hydrology, and water-producing potential of this aquifer were evaluated from the Minnesota border to the confluence with the Big Sioux River. Seismic refraction surveys were used to help define aquifer geometry. Nitrate, bacteria, and limited pesticide sampling was done on wells and surface waters.) C.A. Thompson, 1987, 109 p.	$7.00	$1.50
OFR 87-3	An overview of groundwater quality in the Skunk River basin, D.R. Bruner, G.R. Hallberg, 1987, 36 p. Limited copies. Available without charge.		
OFR 88-1	Water quality monitoring of the Nishnabotna River alluvial system. (An evaluation of water quality data with particular reference to nitrate and pesticides.) C.A. Thompson, P.E. Van Dorpe, 1988, 60 p.	$3.00	$1.00

WATER-SUPPLY BULLETINS

WSB-4	Geology and groundwater resources of Webster County, Iowa, W.E. Hale, 1955, 257 p.	$3.00	$ .95
WSB-7	Geology and groundwater resources of Clayton County, Iowa, W.L. Steinhilber, O.J. Van Eck, A.J. Feulner, 1961, 142 p.	$2.75	$ .95
WSB-9	Geology and groundwater resources of Cerro Gordo County, Iowa, H.G. Hershey, D.D. Wahl, W.L. Steinhilber, 1970, 75 p.	$1.10	$ .70

Ordering Code	Publication	Price	Postage/ Handling
WSB-10	Geology and groundwater resources of Linn County, Iowa, R.E. Hansen, 1970, 66p.	$1.50	$. 70
WSB-12	Hydrology of the surficial aquifer in the Floyd River Basin, Iowa, K.D. Wah , M.J. Meyer, R.A. Karsten, 1982, 53 p.	$3.00	$ .95
WSB-13	Hydrogeology and stratigraphy of the Dakota Formation in northwest Iowa, J.A. Munter, G.A. Ludvigson, B.J. Bunker, 1983, 55 p.	$3.00	$ .95

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Appendix K

WATER-RELATED PUBLICATIONS & AUDIO VISUAL MATERIALS
IOWA STATE UNIVERSITY
COOPERATIVE EXTENSION SERVICE

Unless noted otherwise, the following publications can be ordered from Publications Distribution, Printing and Publications Building, Iowa State University, Ames, IA 50011. Price per copy is indicated in parenthesis. (F) indicates that single copies are free.

WATER SUPPLY

Good Wells for Safe Water
Pm-840, (Rev.) June 1988, 4 pages. (F) (25¢)

Shock-Chlorinating Small Water Systems
Pm-899, (Rev.) June 1988, 4 pages. (F) (25¢)

Plugging Abandoned Wells
Pm-1328, (Rev.) February 1989, 4 pages. (F) (25¢)

Coping with Contaminated Wells
Pm--1329, (Repr.) April 1989, 6 pages. (F) (25¢)

Abandoned Wells: Open Threat to Your Health and Safety
Pm-1334h, February 1989, 2 pages. (F) (10¢)

Is Your Drinking Water Safe
Pm-1334i, (Rev.) March 1989, 2 pages. (F) (10¢)

Sampling Your Drinking Water
Pm-1335, November 1988, 3 pages. (F) (25¢)

Your groundwater...it's valuable...and vulnerable!
AE-3043, August 1986, 4 pages. (F) (25¢)

WATER QUALITY - GENERAL

Agricultural Drainage Wells in Iowa
Pm-1201, April 1985, 6 pages. (50¢)

Groundwater Contamination in Northeastern Iowa
Pm-1202, April 1985, 8 pages. (50¢)

Prepared by Tom Glanville, Extension Agricultural Engineer, 200 Davidson Hall, Iowa State University, Ames, IA 50011

AGRICULTURE - PESTICIDE & NUTRIENT MANAGEMENT

Broadcast Sprayer Calibration
Pm-817, 1 page. (50¢)

Iowa Agriculture and Water Quality-Soil Information Related to Nonpoint Pollution
Pm-901c, (Rev.) May 1986, 6 pages. (50¢)

Iowa Agriculture and Water Quality-Agricultural Land Use in Iowa
Pm-901d, (Rev.) May 1985, 6 pages. (50¢)

Iowa Agriculture and Water Quality-Plant Nutrients as Potential Pollutants
Pm-901g, (Rev.) Oct. 1985, 6 pages. (50¢)

Crop Rotations--Effect on Yields and Response to Nitrogen
Pm-905, (F) (25¢)

Animal Manure: A Source of Crop Nutrients
Pm-1164, (Rev.) August 1985, 4 pages. (F) (25¢)

Establishing Realistic Yield Goals
Pm-1268, 8 pages. (50¢)

Fertilizer Facts - A Nitrogen Soils Test
Pm-1274g, March 1988, 2 pages. (F) (10¢)

Interpretation of Soil Test Results
Pm-1310, 16 pages. (25¢)

Nitrogen Fertilizer and Groundwater Concerns
Pm-1315, February 1988, 2 pages. (F) (10¢)

Use Pesticides Safely
Pm-1334e, 2 pages. (F) (10¢)

Careful Pesticide Storage: Essential to Your Safety
Pm-1334j, 2 pages. (F) (10¢)

Private Pesticide Applicator Study Guide
No publication number, 116 pages. ($5.00)

Integrated Pest Management Decision Guide
IPM-22, 275 pages. ($10.00)

WATER-RELATED DEMONSTRATIONS

Integrated Farm Management Demonstration Program: 1987 Summary Report
Pm-1305, December 1987, 57 pages. ($1.00)

Integrated Farm Management Demonstration Program: 1988 Progress Report
Pm-1345, December 1988, 96 pages. ($1.50)

Big Spring Basin Demonstration Project
Ext-15, August 1988, (F) Order from Jim Hosch, Clayton County Extension Office, 133 S. Main, Elkader, IA 52043

Ag Nutrient Management Demonstration Programs
Ext-16, September 1988, (F) Order from Agronomy Extension Office, 2104D Agronomy Hall, Iowa State University, Ames, IA 50011

Integrated Farm Management Demonstration Program - Butler County Project
IFM-1, March 1989, (F) Order from Information Service, 103 Morrill Hall, Iowa State University, Ames, IA 50011

Integrated Farm Management Demonstration Program - Upper Bluegrass Watershed Project
IFM-2, July 1989, (F) Order from Information Service, 103 Morrill Hall, Iowa State University, Ames, IA 50011

Integrated Farm Management Demonstration
No number, (F)

HOUSEHOLD WASTE MANAGEMENT

Home Sewage Treatment: Conventional Methods and Equipment
Pm-938, (Repr.) November 1982, 8 pages. (50¢)

On-Site Wastewater Treatment Using Mound-Type System
Pm-986, February 1981, 6 pages. (F) (25¢)

Wastewater Management Districts in Iowa - A new approach to a costly, difficult problem in rural communities
Pm-1028, 7 pages (F) (25¢)

Groundwater Quality - Household Hazardous Wastes: Issues, Concerns, Some Answers
Pm-1330, June 1988, 6 pages (F) (25¢)

Household Hazardous Wastes and Our Water Supply
Pm-1334f, 2 pages (F) (10¢)

Toxic Waste Clean-up Days
Pm-1364, 39 pages. (50¢)

NEWSLETTERS

Big Spring Basin Water Watch
Published every other month. (F) Order from Jim Hosch, Clayton County Extension Office, 133 S. Main, Elkader, IA 52043

Top of the Bluegrass Newsletter
Quarterly Newsletter of the Upper Bluegrass Project, Audubon County. (F) Order from Paul Walther, Audubon County Extension Office, 602 Market St. Audubon, IA 50025

IFM Notes
Occasional Newsletter of the IFM Demonstration Project. (F) Order from Information Service, 103 Morrill Hall, Iowa State University, Ames, IA 50011

Monthly Newsletter of the Farm 2000 Project
(F) Order from Steve Hopkins, Poweshiek County Extension Office, P. O. Box 70, 114 S 3rd St., Montezuma, IA 50171

VIDEO TAPES AND SLIDES SETS

Available for rental from ISU Film/Video Library, 121 Pearson Hall, Iowa State University, Ames, IA 50011 or call (515) 294-1540.

Iowa Well Quality
75420, 11 minutes, ½" VHS, or 3/4 U-MATIC, rent $14.00 plus shipping and handling

Life Force: Concerning Water, Part I
75129, 28 minutes, ½" VHS, or 3/4 U-MATIC, rent $14.00 plus shipping and handling

Life Force: Concerning Water, Part II
75130, 28 minutes, ½" VHS, or 3/4 U-MATIC, rent $14.00 plus shipping and handling

Northeast Iowa Groundwater: How Good? How Long?
S-100, 12 or 15 minutes, 105 or 131 slides, script and audio tape, rent $8.85 plus shipping and handling

Groundwater...Valuable...Vulnerable!
S-91, 20 minutes, 159 slides, script and audio tape, rent $7.60 plus shipping and handling

Appendix L

Recycling Directory -- Selected Listing

These are only the entries for glass, paper and plastic from the Iowa Recycling Directory, prepared by the Waste Management Authority Division (WMAD), of the Iowa Department of Natural Resources.

Every effort was made to check the accuracy and completeness of the entries. No warranty expressed or implied, and no endorsement or any firm, business, organizction or individual is implied by inclusion or exclusion from this listing

Market conditions are in a continual state of change. Those interested in recycling a particular material at a specific location should call ahead to see if the material is being collected only as a service to prevent you from incurring disposal costs or if the material is being purchased for cash.

Glass

Lee Co. SW Commission
RR #1, Box 16
Fort Madison, IA 52627
Ron Mace 319-372-6140
prefer color sorted

NIVC Redemption Center
545 East J Street
Forest City, IA 50436
Ann Powers 515-532-2384
crushed glass

Mason City Recycling Ctr
1410 S. Monroe
Mason City, IA 50401
Dean Hess 515-423-2155
glass

Clarinda Redemption Center
116 East Stewart
Clarinda, Iowa 51632
712-542-3004
color sorted

Paper

City Carton Company Inc.
1415 E. Dunkerton
Cedar Falls, IA 50613
319-277-3464
paper, all types

City Carton Company Inc.
402 Harvey Pl.
Mt. Pleasant, IA 52641
Tim Ockenfels 319-385-7206
all types paper > 500 lbs.

City Carton Company Inc.
3 E. Benton St.
Iowa City, IA 52240
John Ockenfels 319-351-2848
paper all types

J & S Recycle Paper Co
840 Cleveland Ave.
Keokuk, IA 52632
Joe Scott 319-524-6443
any quantity of newsprint, corrugated, office paper, etc.

Paper Recovery Corp
1191 Engleside Dr.
Cedar Rapids, IA 52404
Jim Ledenbach 319-364-5572
paper, pallets, drums, plastics, most material. truckload quantity.

Durbin Paper Stock Inc.
1539 Rockingham Rd.
Davenport, IA 52802
Bill Ellis 319-323-4909
all grades of paper, any qty.

Carroll Enterprise Syst.
314 E. 5th St.
Carroll, IA 51401
Dave Sterns 712-792-6713
corrugated and other paper products.

Cass Co S.W. Commission
RR #4, Box 183
Atlantic, IA 50022
Bill Hoguelson 712-243-5024
all quantities corrugated

Georgia Pacific
823 N. Cedar
Monticello, IA 52310
D. Bohllren 319-465-3543

Paper Stock of Iowa Inc.
2308 Sunset Rd. 1284
Des Moines, IA 50305
Bruce Sherman 515-243-3156

Packaging Corp of America
P.O. Box 117
Tama, IA 52339
515-484-2884
truckload quantity or larger

NIVC Redemption Center
545 East J Street
Forest City, IA 50436
Ann Powers 515-582-2384
any quantity of cardboard collected by sheltered workshop

Waste Systems Corporation
Route 2
Lake Mills, IA 50405
David Bergen 515-592-9182
baled or loose for 14 county area serviced

Container Corp of America
1601 Tri-view Ave.
Sioux City, IA 51103
James McCullough 712-252-3861
baled corrugated in truckload quantities

Scott County Landfill
RR #2 Y48 (P.O. Box 563)
Buffalo, IA 52728
Cindy Turkle 319-381-1300
any quantity corrugated or
high grade office paper

Mason City Recycling Center
1410 S. Monroe
Mason City, IA 50401
Dean Hess 515-423-2155
all types and quantities of paper

Siouxland Recovery
1107 Morgan St.
Sioux City, IA 51105
Richard Hall 712-258-2823
all paper in good quantities

Cimino Recycling
201 SE 6th St.
Des Moines, IA 50265
Bill Best 515-243-1696
all types of waste paper.

Sealright Co Inc.
2925 Fairfax Rd.
Kansas City, MO 66115
J. W. Lindberg 913-321-5002

Capitol Oil Company
729 S. Capitol, #408
Iowa City, IA 52244
Richard Strauss 319-338-8136
any quantities

Lee Co. S.W. Commission
RR#1, Box 16
Fort Madison, IA 52627
Ron Mace 319-372-6140
any quantity drop off

Horizons Unlimited
King & Seventh St, Box 567
Emmetsburg, IA 50536
Marilyn Conlon 712-852-2925
work activity center accepts newsprints

Quality Insulation Mfg.
1930 Easton Blvd.
Des Moines, IA 50316
Betty South 515-266-2677
newsprint any quantity

Midwest Thermal Products
P.O. Box 1090
Hesston, KS 67522
Jim Sunderman 316-327-2131
newsprint in large quantities

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Plastics

Hamilton Co. Cons. Brd.
RR #1, Box 7
Webster City, IA 50595
Jean Eells 515-832-1994
collecting milk jugs for recycling

Polymer Products
RR #3, Box 182
Iowa Falls, IA 50126
Greg Mattson 515-648-5073
end manufacturer, PET, HDPE, other

Plastic Recycling
2nd & Davis
Union, IA 50258
Floyd Hammer 515-486-2266
hdpe, PET

N. E. W. Polymers
Box 220, 112 Fourth
Luxemberg, WI 54217
Vern Vincent 414-845-2326
end manufacturer, HDP

Main Plastics
2600 Commonwealth Ave.
Chicago, IL 60064
Dick Helfenbein 312-473-3553
processor, broker, HDPE other

Poly Pro Products
P.O. Box 69
Thornton, IL 60476
Charlie Ward 312-594-7575
processor, hdpe, ldpe, mdpe, PET truckload quantity

Eaglebrook Plastics
2600 W. Roosevelt Rd
Chicago, IL 60608
Andrew Stephens 312-638-0006
processor, end manufacturer, HDPE, & other

MRC Polymers
1716 W. Webster Ave.
Chicago, IL 60614
Daniel Eberhardt 312-276-6345
processor, PET

FDA Plastics
2001 N. 22nd St. #966
Decatur, IL 62526
Felix Akhimie 217-429-3373
processor, broker, PET, HDPE, other

Interplastic Corp.
2015 NE Broadway St.
Minneapolis, MN 55413
Sharon Fisk 612-331-6850

Century Plastics
Box 51
Hayfield, MN 55940
Stephen Becvar 507-447-3232
need chopped or baled HDPE

Plastic Cyc
4929 S. 29th St
Omaha, NE 68108
Richard Arms 402-731-5580
hdpe, ldpe, ABS, purgins and plastic part rejects/lge. qty

NUCON Corp.
540 Frontage Road
Northfield, IL 60093
Peter Piggot 312-446-6777
end manufacturer, HDPW

Freeman Chemical Co.
217 Freman Drive
Port Washington, WI 53074
Max Stroika 414-284-5541
PET bottles free of base/cap/label 40,000# qty

Midwest Plastics
811 Collins Road
Stoughton, WI 53589
David M. Kolitz 608-873-5402
processor, end manufacturer, hdpe & other

A to Z Full Recycling Co.
403 W. Depot St. #605
Marshfield, WI 54449
James Cherney 715-384-9308
processor, PET, HDPED, other

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Riverside Materials
800 South Lane
Appleton, WI 54912
Mary Stachowicz 414-733-3614
broker, PET, HDPE

Plastic Recycling
Box 182
Iowa Falls, IA 50126
Floyd Hammer 515-648-5073
plastic, film scrap, pet, hdpe trk ld. baled/gran

NCS Plastics
1210 9th St. SW
Cedar Rapids, IA 52404
319-363-2112

Midwest Plastics
811 Collins Road
Stoughton, WI 53589
Dick Helfenbein 312-473-3553
processor, broker, HDPE & Other

Scott County Landfill
RR #2 Y48 (P.O. Box 563)
Buffalo, IA 52728
Cindy Turkle 319-381-1300
HDPE (milk jugs)

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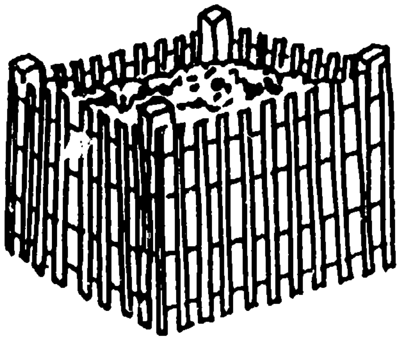
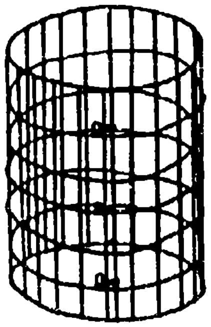
Appendix M

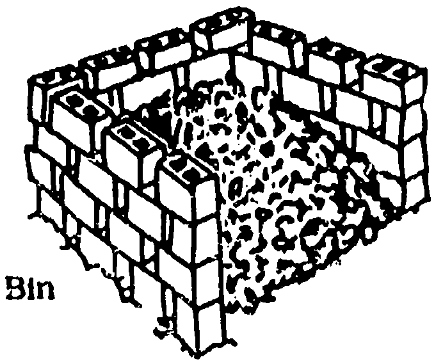
Composting Your Yard Waste in a Holding Bin

Snow Fence Bin





Woven Wire Bin



Block or Brick Bin

Iowa Department of Natural Resources

M-1

Why Compost?

By using compost you return organic matter to the soil in a usable form. The materials used in composting make up 20-30% of all household wastes. By composting these materials you eliminate the costs of disposal at a landfill, save limited landfill space, protect the environment, and improve your own soil all at the same time. Improving your soil is the first step toward improving the health of your plants.

As an added benefit, healthy plants help clean our air, conserve our soil, and beautify our landscapes. Using compost can be easier and cheaper than bagging wastes and if you have a lawn, garden, trees and shrubs or even planter boxes you will always have a need for compost.

Compost, or artificial manure, may be defined as decomposed plant material or vegetable matter. Some soil is mixed through compost, but there is a very high percentage of rotted plant materials. If you want to deal with your yard wastes in an easy, inexpensive and environmentally safe way, a holding bin will work very well.

Compost may be considered as a form of fertilizer, but its most important function, in the vegetable or flower garden, is keeping the soil in good condition by increasing the organic matter content. This improves soil structure by making it more granular. Increasing the organic matter content of a soil increases its productive and water-holding capacities. Plants living in such soil can better withstand drought conditions. Vegetables, flowers, lawns and small fruits grow best in soils that have a high organic content.

Although good yields are possible by adding only mineral fertilizers or only organic materials to the soil, it is generally considered that best results can be obtained by using both. The garden gets the advantages of humus from the organic matter and higher mineral nutrients from the commercial fertilizer. It is not practical to use one as a substitute for the other.

If a good-quality peat is not readily available, compost will make a good substitute. Poor grades of topsoil can be improved by composting with leaves, wood chips, sawdust, and similar materials. Liberal quantities of water and nitrogen fertilizer are needed to hasten decomposition.

Where very large volumes of leaves (40 or more bags) are available for composting, it may not be as feasible to follow the procedure outlined in this pamphlet to obtain rapid decomposition. In such cases, it may not be as practical to add the soil layer to the pile, but the nitrogen fertilizer and water help produce a better quality compost in a shorter time.

M-2

Materials for Making a Compost Pile

There are a large number of plant materials around the yard and garden that can be used in the compost pile. Some of these are leaves, lawn clippings, weeds from the yard and garden, hedge clippings, straw, mulch raked from flower beds, and sawdust. Diseased vegetables and flower plants should not be used.

A section of snow fence or wire fence will make a nice enclosure for the compost pile. Growing flowering vines on the fence or tall annuals around the compost pile will easily conceal it. A pit 2 1/2 feet deep would be more easily concealed and would keep the plant materials moist for more rapid decomposition. Still a third possibility would be to make a framework of boards or concrete blocks (see cover illustrations).

A high-nitrogen, complete commercial fertilizer is a good addition to each layer of the compost pile. The nitrogen is added principally to feed the bacteria that break down or decompose organic matter into compost or humus. Adding nitrogen results in more bacteria, which brings about faster decomposition. The phosphorus and potassium are needed to give a more balanced mineral content to the finished compost.

The following will serve as a guide for adding commercial fertilizer. The quantities given would be applied to each 6- to 8- inch layer of about 25 square feet in area (5 feet by 5 feet).

If materials are mostly sawdust, tree leaves, straw, or crushed corncobs, use:

1 1/2 pints of a 15-15-15 fertilizer or

2 pints of a 12-12-12 fertilizer or

2 1/2 pints of a 10-10-10 fertilizer.

If materials are mostly grass clippings, silage, weeds and similar green materials, use:

1 pint of a 15-15-15 fertilizer or

1 1/2 pints of a 12-12-12 fertilizer or

2 pints of a 10-10-10 fertilizer.

Increasing Surface Area

You can also increase the efficiency of your compost pile by increasing the surface area of the materials. The more surface area the microorganisms have to work on, the faster the materials can decompose. Cutting your garden wastes into smaller pieces by chopping them with a shovel or running them through your lawn mower or a shredding machine will speed their decomposition and improve your pile. Several shovels of coarse sand added to each layer of the compost pile will further help drainage when compost is to be used to improve heavy, tight soils. Equal amounts of the coarse sand and soil may be desirable.

Bones and quantities of animal fats should not be used in the compost pile, as they do not compost easily, and may attract dogs and other animals. Table scraps of vegetables may be used, but they attract flies unless covered with other plant materials such as leaves or grass clippings.

Since many Iowa soils are already neutral (pH 7.0) to somewhat alkaline (about pH 7.3 to pH 7.8), it is not recommended that lime be added to the compost pile. If a soil test shows the soil to be acid, small quantities of agricultural lime or gypsum may be added to each layer of the compost pile. One cupful for each layer 5 feet by 5 feet will usually be sufficient.

Making the Compost Pile

There are no special procedures to follow in preparing compost. With a little experience, each individual will adapt procedures to meet their own needs. An out-of-the-way area that can be screened from view is preferable. It should be convenient as well as accessible to water. Partial shade will tend to retard drying

but will lower temperatures in the composting material, resulting in a slower decomposition rate in spring and fall.

Rectangular compost piles are usually easiest to handle. A 30-foot piece of snow fence would make a compost pile 10 feet long and 5 feet wide. A rectangular trench or framework of boards will serve the same purpose. The enclosure could be divided across the middle to give two sections of equal size. One side can be used while the other side is in the process of decomposition.

Best results can be obtained by putting the compost in layers. Each 6- to 8- inch layer of plant material should be topped with a 1-or 2- inch layer of good garden loam or barnyard manure, plus several shovels full of coarse sand. A topdressing of commercial fertilizer should be added to each layer. Because of the remarkable ability of soil and humus to absorb odors, there will be no disagreeable odor around a compost pile that contains layers of soil.

The bacteria for decomposition require ample moisture. To supply this moisture, each layer of organic matter, soil, and fertilizer should be thoroughly soaked with water. Excessive amounts of water running through the pile will cause leaching of the soluble fertilizer salts and should be avoided. It is very important, however that the compost pile be well supplied with moisture throughout to ensure rapid decomposition.

Hastening Decomposition

Heat is generated during the composting process. The temperatures often reach 150° to 170°F. If the pile is not kept sufficiently moist, the materials may get too hot and the action of fungi will cause it to become "*firefanged*." The resulting product appears to have been burned, is lightweight, and is of no value for compost.

It is desirable to have the higher temperatures **with** the moisture during composting. This serves a practical purpose by aiding in the destruction of some weed seeds and plant diseases.

There are several methods that can be used to speed up the decomposition of the plant materials by bacteria:

- Addition of a high-nitrogen, complete fertilizer;
- Addition of barnyard manure;
- Turning of the compound about once each month during the season, adding some water each time.

Any one of these methods will hasten decomposition, but best results can be obtained by using all three.

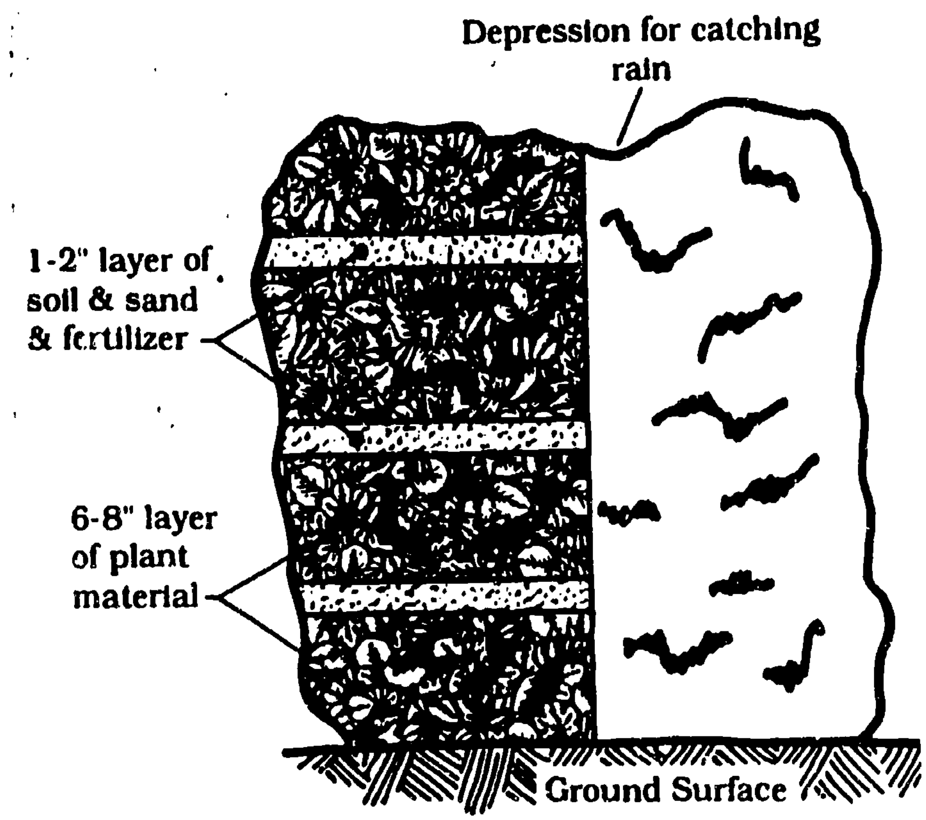
When the Compost is Ready

Compost is ready to use when it is dark brown, crumbly, and earthy-smelling. You can pick it up and it will crumble and sift through your fingers. Let the finished compost stabilize for a few extra days and then you may sift it through a 1/2- inch screen to produce a finer, less lumpy product. To work the compost into your soil, turn your soil, apply 1- to 3- inch layers of compost and work it in well. You may add up to one pound (a heaping double handful) per square foot.

M-4

You have just completed a process that saves money and the environment while requiring little effort.

Cross Section of a Home Compost Pile



Iowa Department of Natural Resources
Waste Management Authority Division
Wallace State Office Building
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Appendix N. Order Form

Any of these materials may be reprinted, providing credit is given to the Iowa Department of Natural Resources.

Quantity	Item	Price	Comment	Total
______	GREAT Notebook	$ 8.00	or free at in-service	____
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Classroom teacher: Yes_____ No_____

If yes, where will you use these materials?

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