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INTRODUCTION TO GROUNDWATER MONITORING AT THE FEMP

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Introduction to Groundwater Monitoring at the FEMP

Recognizing that activities at the site have contributed to the local contamination of the Great Miami Buried Valley Aquifer, the Fernald Environmental Management Project (FEMP) monitors over 200 wells for evidence of contamination. As a result of these monitoring efforts, the FEMP has identified a uranium-contaminated plume immediately south of the site. In response, the FEMP has initiated a *removal action* to recover the contaminated groundwater.

The primary focus of this booklet is on the uranium contamination in the groundwater from site activities. In addition, if you have a well that is used in a monitoring program, this booklet will help you interpret the sampling results you receive each month. Other contaminants from the FEMP, local industries, or agriculture are not discussed in this booklet.

This booklet provides only basic information about groundwater, uranium contamination, and the FEMP's monitoring programs. If you have specific questions, please call either the FEMP's Community Relations Office at 738-6934. In addition, you are encouraged to remain involved in local groundwater issues and to attend quarterly community meetings.

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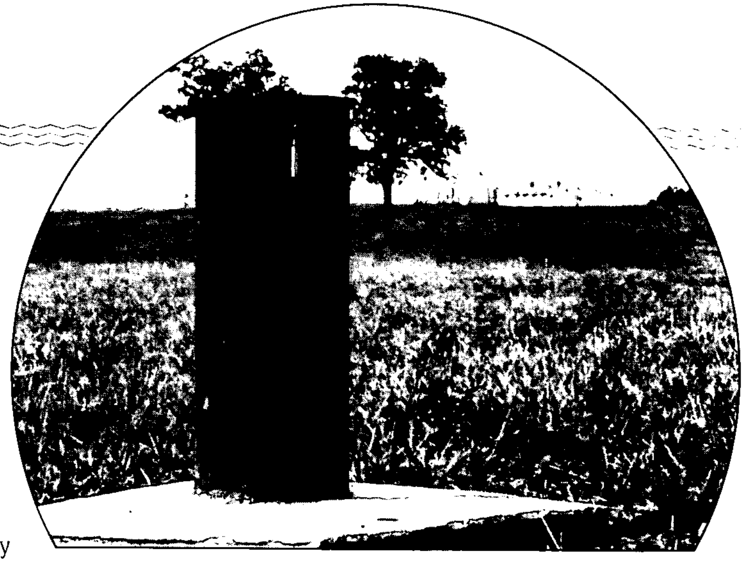
Introduction



The Fernald Environmental Management Project (FEMP) is a U.S. Department of Energy (DOE) facility located about 17 miles northwest of Cincinnati. The facility was constructed in the early 1950s as the Feed Materials Production Center (FMPC). Its mission was to manufacture very pure uranium metals until DOE suspended production in July 1989.

In October 1990, the site's mission officially changed to that of environmental cleanup. To reflect the new cleanup mission at the site, DOE changed the name of the facility to the Fernald Environmental Management Project.

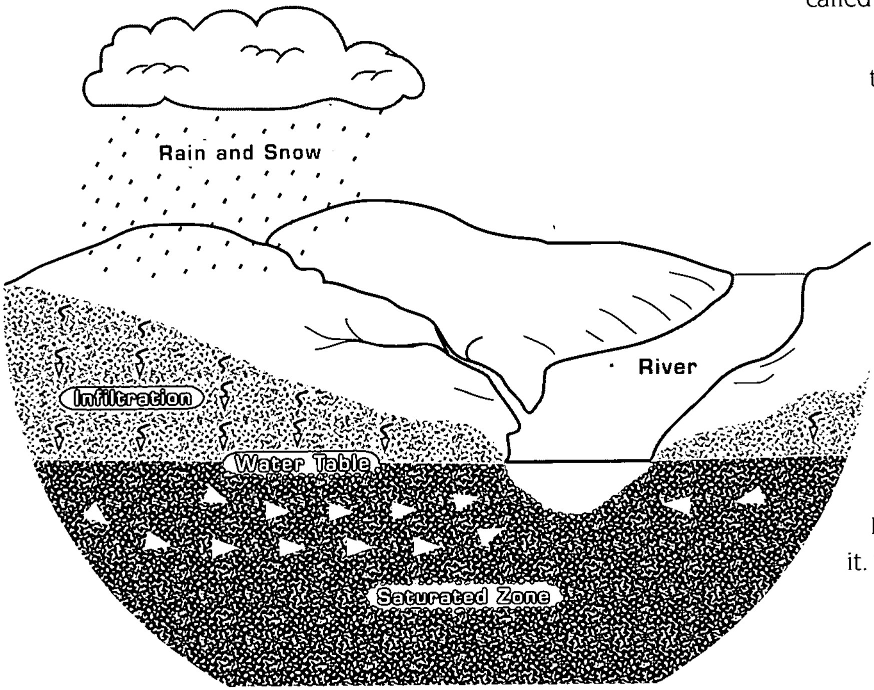
As part of its cleanup mission, the FEMP expanded its environmental studies to find out how uranium production at the facility has affected the surrounding environment. These studies have shown that the manufacturing processes and waste storage and disposal practices at the site have affected the quality of groundwater in the Fernald area.

Understanding Groundwater

Groundwater is any water that lies beneath the land's surface. It is contained in spaces and fractures in the underlying soil and rock. Groundwater in these spaces and fractures is a result of water (mostly in the form of rain and snow) falling on the land and seeping into the soil (*infiltration*). See Figure 1, the groundwater cycle. Gravity pulls the water down through the soil until it reaches an area where all the spaces in the soil are filled with water. This area is called the *saturated zone*.

Figure 1:

Groundwater Cycle



Unlike surface water bodies and streams, the *water table* (the top of the saturated zone) does not normally fluctuate greatly. Only during extended periods of drought or rainy weather will the water table rise or fall much more than a few feet. Because the water table is relatively constant, an aquifer is a year-round source of water.

Groundwater in the saturated zone flows toward water bodies on the surface, such as rivers, streams, and lakes. The rate that groundwater flows is determined in part by the characteristics of the soil holding it. These characteristics include:

- the thickness of the soil,
- the amount of pore space in the soil (*porosity*), and
- the ability of the water to pass through the soil (*permeability*).

Groundwater can become contaminated when infiltrating water passes through a source of contamination or when contaminants themselves move through the soil into the saturated zone.

Groundwater at Fernald: The Great Miami Buried Valley Aquifer

The soil that holds groundwater makes up what is known as an *aquifer*. The Fernald area sits on the Great Miami Buried Valley Aquifer. This aquifer holds a great deal of water and is considered one of the most productive aquifers in the Midwest. It is the principal source of drinking water for Miami Valley residents and also provides water for agriculture and industries in the area.

As shown in Figure 2, the Great Miami Buried Valley Aquifer lies under the Great Miami River and many of its tributaries. The aquifer is over 100 miles long, approximately two miles wide, and 150 to 200 feet deep. Figure 3 shows a cross section of the aquifer in the FEMP area. As shown in this figure, a layer of clay about 100 feet below much of the FEMP divides the aquifer into two sections, referred to as the *upper* and *lower aquifers*.

Figure 2

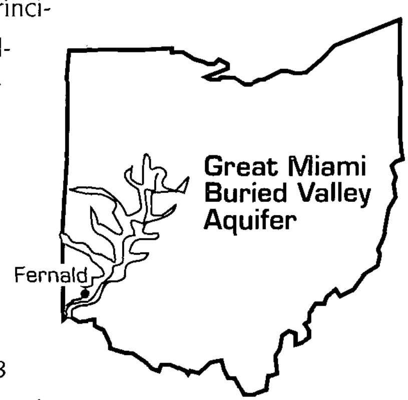
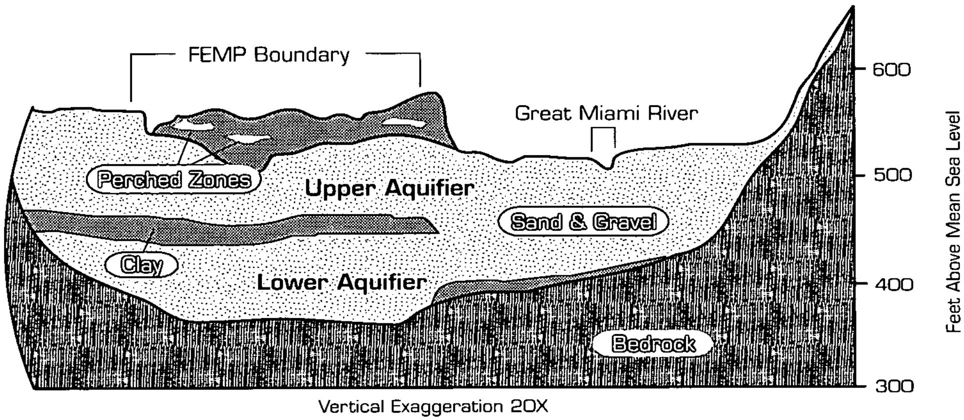


Figure 3:

Cross-Section

of Aquifer



Another clay layer on the surface contains pockets of sand and gravel which take the shape of lenses. Water passes slowly through this layer and collects in these lenses to form what is known as *perched zones*. (See Figure 3.) *Perched zones* are pockets of groundwater that sit above the main aquifer. The perched groundwater is impeded from downward flow by the clay surrounding these zones.

The perched zones within the Great Miami Buried Valley Aquifer are generally small. Some of these zones lie beneath the former uranium production area and contain contaminated water. Because water cannot easily pass through the surrounding clay, movement of this contaminated water is impeded.

Groundwater Flow of the Great Miami Buried Valley Aquifer

Uranium contamination detected in the groundwater at the FEMP has also been found to be gradually moving offsite to the south. Therefore, it is important to track the flow of water through the ground to determine where and how quickly the associated contamination is moving.

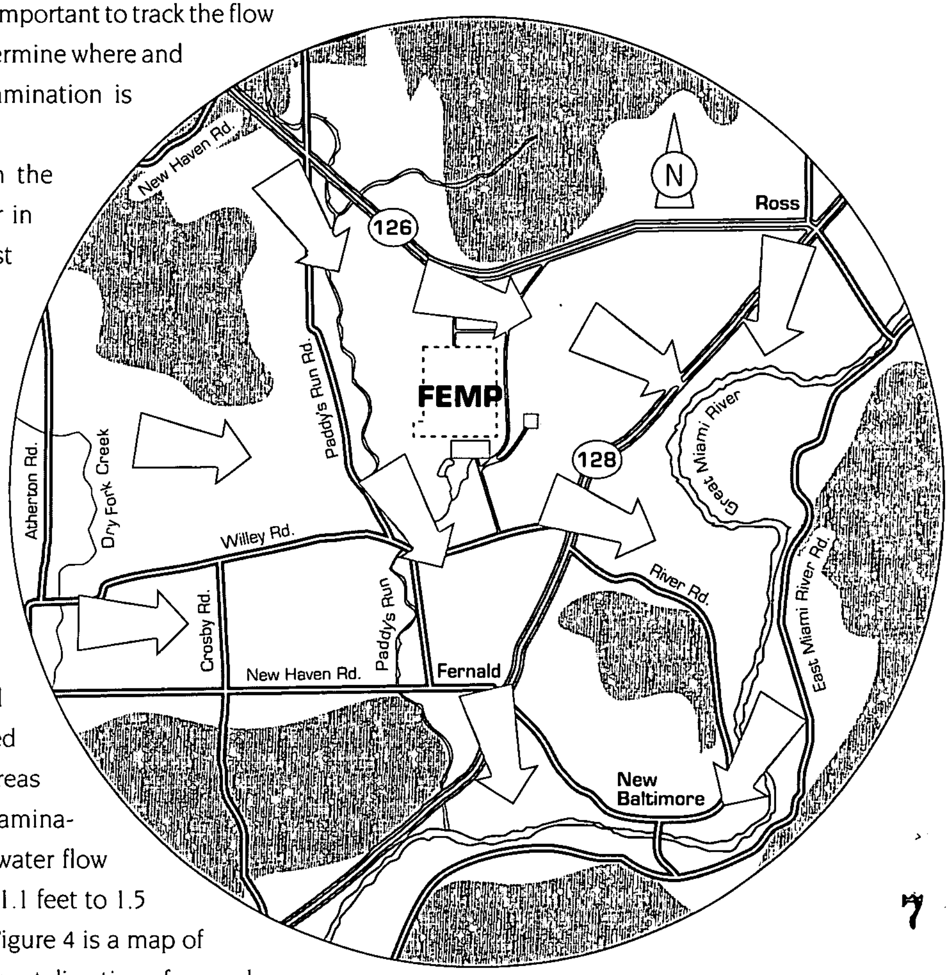
Presently, groundwater from the Great Miami Buried Valley Aquifer in the Fernald area flows to the east and to the south, toward the Great Miami River. Contamination from the site flows with the groundwater. Therefore, wells to the north or west of the site should not show increased concentrations of FEMP contaminants, whereas wells to the south and east may show increased concentrations.

Groundwater in the Fernald area travels very slowly as compared to surface water; therefore, some areas may not see the effects of the contamination for years. The natural groundwater flow rates in this area are estimated at 1.1 feet to 1.5 feet per day in the upper aquifer. Figure 4 is a map of the Fernald area that shows the present direction of ground-

Figure 4:

Groundwater Flow

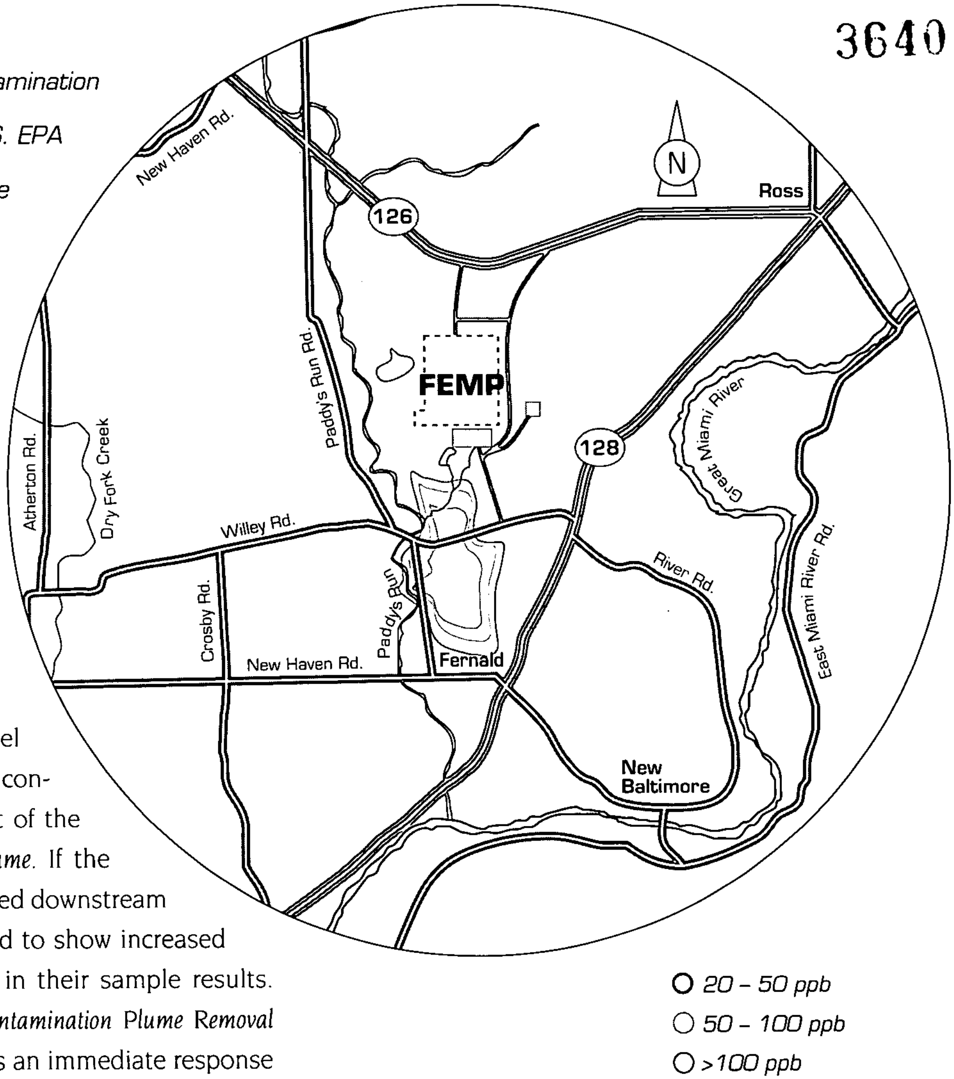
in the Fernald Area



Bedrock (no groundwater flow)

Figure 5:

Uranium Contamination above the U.S. EPA Standard in the Upper Aquifer



water flow. Since the contamination moves in about the same direction as the water, we can track the movement of the contamination by monitoring the movement of the groundwater.

Figure 5 maps the uranium contamination above the U.S. EPA standard in the upper sand and gravel aquifer as of December 1991. The contaminated area shown here is part of the *South Groundwater Contamination Plume.* If the plume is not controlled, wells located downstream from this plume would be expected to show increased contaminant concentration levels in their sample results. However, the *South Groundwater Contamination Plume Removal Action* (see page 22) was initiated as an immediate response to restrict further southward movement of the plume.

Groundwater Monitoring Programs at the FEMP

The FEMP has several ongoing groundwater monitoring programs to determine exactly how fast the contamination is moving and where it is going. These monitoring programs also help the FEMP measure the effect of cleanup groundoperations at the site.

The FEMP uses different sampling and analysis programs to provide different types of information and fulfill various requirements. Information gathered through the monitoring programs includes concentration levels for different contaminants as required by regulatory agencies such as the DOE, Ohio EPA, and U.S. EPA. Using this information, scientists can:

- detect the presence of contamination in the groundwater,
- determine the nature and extent of contamination in the groundwater, and
- determine the direction(s) and rate of groundwater flow.

Each FEMP groundwater monitoring program is composed of a series of monitoring wells which have been placed in strategic locations. For example, the FEMP Comprehensive Groundwater Monitoring Program regularly collects water samples from over 200 wells onsite and in the surrounding area. In fact, this program is the largest and most encompassing source of information about groundwater in the Fernald area.

In addition to FEMP sampling programs, other water samples may be taken for various studies conducted by state agencies such as the Ohio Department of Health. For information about other well samples not conducted by the FEMP, contact the FEMP Community Relations Office at 738-6934.

Figure 6: FEMP Groundwater Monitoring Programs

	Comprehensive Groundwater Monitoring Program	Remedial Investigation/Feasibility Study (RI/FS) Sampling	Radiological Environmental Monitoring Program		
			REMP Routine Sampling	REMP Special Sampling	State Route 128
Which Wells are Being Sampled	Monitoring Wells Owned by FEMP	Monitoring Wells Owned by FEMP	Water-Supply Wells Owned by Property-Owners	Water-Supply Wells Owned by Property-Owners	Water-Supply Wells Owned by Property-Owners
Who Samples	FEMP Technicians	Independent Contractor	FEMP Technicians	FEMP Technicians	FEMP Technicians
For What	Radionuclides, Water Quality Indicators, Metals, Toxic Organics	Selected Radionuclides, Hazardous Substance List (HSL) published by U.S. EPA	Uranium, Metals	Uranium	Uranium
How Often	Quarterly	After two rounds of sampling, will be turned over to the Comprehensive Program	Quarterly Monthly Bi-weekly Metals Annually	By Property-Owner or Tenant Request	Quarterly (Began April 1991)
Who Gets the Report	Property-Owner, Tenant, DOE, Ohio EPA, U.S. EPA	Property-Owner, Tenant, DOE, Ohio EPA, U.S. EPA	Property-Owner, Tenant, DOE, Ohio EPA, U.S. EPA	Property-Owner, Tenant, DOE, Ohio EPA, U.S. EPA	Property-Owner, Tenant, DOE, Ohio EPA, U.S. EPA

Acting together, the FEMP groundwater programs are part of a groundwater monitoring system to identify where the groundwater is contaminated, what it is contaminated with, and where it may go. Additional wells are installed when it is discovered that addition information is required.

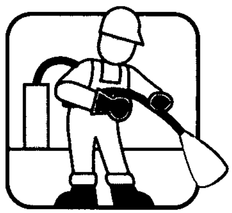
Figure 6 provides a summary of the various groundwater monitoring programs currently in place at the FEMP. The groundwater sampling process followed for these monitoring programs is essentially the same. Figure 7 on pages 10 and 11 shows the steps common to all groundwater monitoring programs.

Figure 7: Steps Common to All Groundwater Sampling Processes

Preparing for Sampling

All sample bottles, storage containers, and paperwork — including the chain-of- custody form which tracks the handling of the samples throughout the process — are prepared before samples are collected. In addition, all equipment used in the sampling process is cleaned, checked, and reset or calibrated to ensure that it is in proper working condition.

Purging the Well



Before collecting the sample, stale water is pumped from the well. Purging the well ensures that the sample water is representative of the physical and chemical properties of the groundwater in the aquifer at the well location. Otherwise, the sample is simply representative of the isolated water sitting in the well.

Collecting Water Samples

The sampling procedure contains four steps:

1. Groundwater is collected from the well using special pumps or tubes and poured into prepared bottles.

2. General characteristics of the groundwater are measured in the field. The most common parameters measured are temperature, acidity level (pH), and cloudiness.

3. The sample bottles are placed in a storage container to hold and protect the samples during transport.

4. The sample is logged onto the chain-of-custody form.

Shipping Samples to Lab

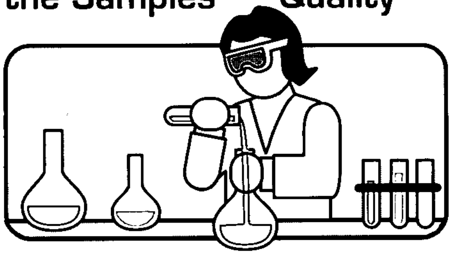
Once the samples have been collected, they are preserved on ice in shipping containers along with the chain-of-custody forms and shipped to the laboratory. (Laboratories performing sample analyses include onsite, government, and independent commercial laboratories.)

Sample Processing at the Lab

At the laboratory, the shipping container is opened; the samples are counted, inspected, and logged; and the chain-of-custody form is signed. This processing ensures that all samples are accounted for and tracked throughout the various tests and analyses.

Analyzing the Samples

Assuring Laboratory Quality

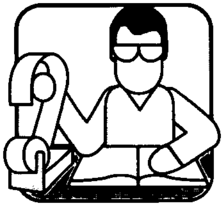


Samples are analyzed using approved methods. For most substances, there are approved U.S. EPA, DOE, or Nuclear Regulatory Commission methods for testing. These methods include specification of the equipment and the procedures to be used for testing.

During sample analysis, Quality Assurance (QA) activities are performed to confirm laboratory results. These QA activities include:

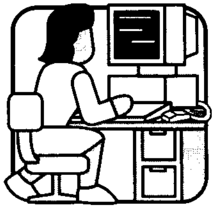
- separate analysis of duplicate samples (to evaluate consistency),
- analysis of *spiked samples* which are samples with known amounts of uranium (to check for accuracy of sample results), and
- audits of laboratory procedures (to confirm that proper methods are being used).

Validating Results at the FEMP



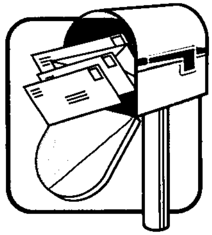
The results of the lab analyses and the Quality Assurance documentation are sent to the FEMP where the data are validated, that is, checked to ensure that the approved lab procedures were followed and that the calculations are correct.

Recording Results at the FEMP



Once the FEMP validates the data, they are entered into a computer database at the site.

Mailing Results to Property Owners and Tenants



Finally, sample results are mailed to the owners and tenants where wells were sampled.

The chain-of-custody (COC) form is the written record of sample bottle possession and transfer. From the time sample bottles arrive at the laboratory until results are reported, the sample bottles must be in the custody of a responsible person at all times. Every person who accepts the sample signs the COC form and becomes the sample custodian. The sample custodian assures that the samples have not been tampered with or tainted.

Water Quality and Standards

The quality of groundwater is important to everyone. Individuals, farmers, industries, and commercial enterprises all rely on groundwater for many uses, such as drinking, bathing, irrigation, and manufacturing.

Groundwater can become contaminated with health-threatening substances. Health-threatening contaminants are those that may cause illness or injury to a person if ingested.

The health threat of a contaminant is determined by considering:

- the substance's effect on the body,
- the substance's behavior inside the body,
- how rapidly and effectively the body clears itself of the substance, and
- what organs or parts of the body are affected by the substance.

Similar studies of a substance's effect on the environment are also conducted.

The ultimate goal of these studies is to identify the lowest levels of contaminants that can cause illness or injury so that appropriate limits can be established. These limits are based upon the best information available; however, different conditions of exposure can lead to some uncertainty. Exposure conditions may vary because of:

- the type of exposure, that is, eating, drinking, or inhaling;
- the duration and frequency of exposure;

- the population exposed, for example, people versus animals; and
- the illnesses observed, for example, cancer or poisoning.

To allow for these variations, safety factors are built into the regulatory standards when studies differ from any of the actual conditions listed above. The limits (or maximum amounts considered safe) are set below the lowest levels of exposure which could result in illness or injury. Therefore, the standards are somewhat conservative to better protect people's health and the environment.

While other contaminants have been detected in groundwater in the Fernald area, the contaminant of most concern at the FEMP is uranium because it was the primary material being processed onsite and because of its radioactive nature.

Uranium

Uranium occurs naturally in the earth's crust, but it can also be introduced into the environment and become concentrated by man's activities, as at the FEMP. Long-term exposure to uranium has been linked to illness and injury because of the toxic nature of uranium and its radioactivity.

Specifically, the adverse health effects of uranium are:

- damage to the kidneys from poisoning and
- kidney and bone cancer from radiation.

The concern over uranium, as opposed to other radioactive materials, is generally limited to situations where it gets inside of the body. Alpha particles, the type of radiation given off by uranium, cannot pass through materials such as paper, clothing, or the outer layer of skin but may damage living cells once within the body. Therefore, the major health concern for uranium exposure is people drinking water or eating food with high concentrations of uranium.

Standards for Drinking Water

Because groundwater can become contaminated, the U.S. EPA has established drinking water standards for all public water systems. These standards set concentration limits for specific substances in drinking water. These substances can be naturally occurring or put in the water by man or man-made processes.

In addition to the U.S. EPA standards, DOE issues guidelines for hazardous substances at its sites, and the Nuclear Regulatory Commission (NRC) issues standards for radioactive substances in the environment. When multiple standards exist for a substance, the FEMP uses the most conservative.

Recently, the U.S. EPA proposed a standard for uranium of 20 parts per billion (ppb); this standard is lower than the previously used DOE guideline of 30 ppb. (See the units of measure definitions on the next page for the definition of parts per billion.) The U.S. EPA standard is proposed to protect people from both uranium's toxic and cancer-causing effects. It is set lower than the lowest concentration known to have caused illness, specifically kidney damage.

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Understanding Your Well Sampling Results

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The groundwater sampling results you receive from the FEMP provide information that you can use to monitor the amount of uranium in your well. While the results you receive for one month will indicate to some degree whether or not your groundwater is contaminated, long-term tracking (one year or more) of these results will provide a better picture of the condition of the groundwater.

Different units of measure are used to report the laboratory results of contaminant levels in your groundwater. The groundwater sampling results you receive from the FEMP show concentrations of contaminant levels in parts per billion (ppb), milligrams per liter (mg/L), and picocuries per liter (pCi/L).

To help you better understand the results you receive, this section provides information about:

- some possible reasons why you may see variations in your monthly results, and
- various trends you may observe in your monthly results.

An explanation of how you can use a graph to track your monthly results is also provided in this section.

Units of Measure for Concentrations in Liquid

ppm or mg/L

Parts per million (ppm) or milligrams per liter (mg/L) are equal to one pound of substance dissolved in 999,999 pounds of water

ppb or µg/L

Parts per billion (ppb) or micrograms per liter (µg/L) are equal to one pound of substance dissolved in 999,999,999 pounds of water

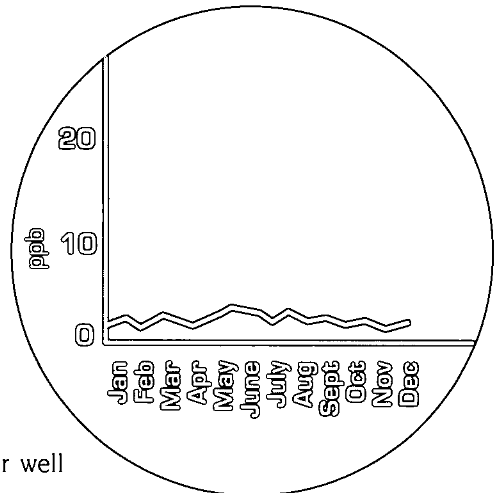
pCi/L

Picocuries per liter (pCi/L) is a unit of measure for radiation decay. A curie is equal to 37 billion disintegrations per second. A picocurie is one trillionth of a curie. Therefore, a picocurie is equal to .037 disintegrations per second (about one every 27 seconds).

Variations in Your Well Sampling Results

The groundwater monitoring results you receive from the FEMP may vary slightly from month to month. One cause for these variations is changes in the environment, such as:

- changes in the rate or direction of flow,
- weather, and
- seasonal changes.



Changes in the rate or direction of groundwater flow may cause a substance to move toward or away from your well, resulting in variations of the concentration levels. In addition, weather and seasonal changes such as heavy rainfall can either dilute the substance or move it toward your well.

Another cause for variations in your well sampling results is variation in sampling and laboratory techniques. While standardized procedures and processes for collecting and analyzing samples are used, different laboratories are used and equipment changes. Even the best equipment doesn't give exactly the same results every time. Finally, because technicians and scientists are working with such low concentrations, the small variations from equipment and techniques may seem large. Quality Assurance/Quality Control (QA/QC) programs help minimize variations in sample results.

Trends in Your Well Sampling Results

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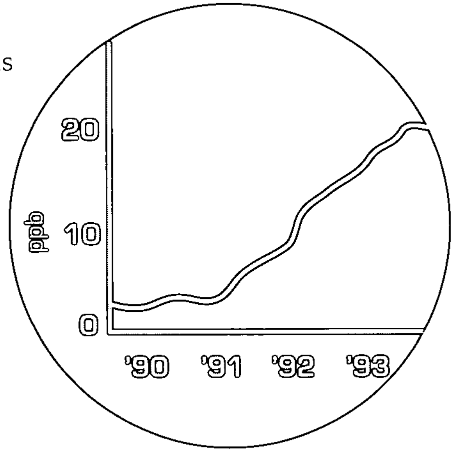
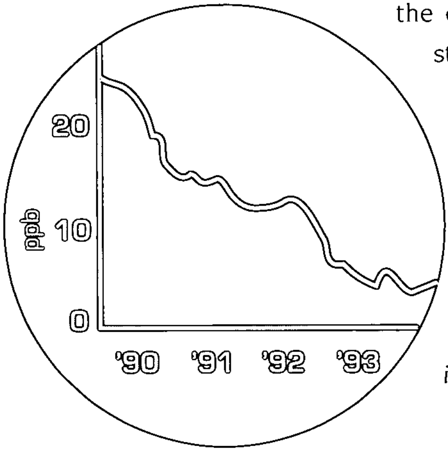
Trends are patterns showing the changes in your groundwater quality over time.

Upward Trends Upward trends occur when the concentrations of contaminants in your well steadily increase. Concentrations of contaminants in your groundwater can increase as a plume of contamination moves toward the well.

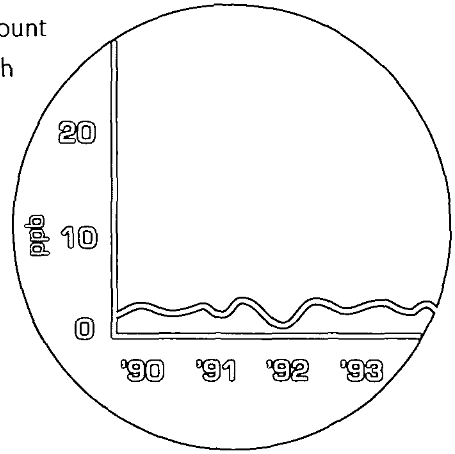


Downward Trends Downward trends occur when the concentrations of contaminants in your well steadily decrease. One reason that concentrations of contaminants in your water can decrease is if the contamination source is removed.



The FEMP is currently pursuing a removal action to intercept the flow of groundwater into the South Groundwater Contamination Plume. For more information about this removal action, see the section called *What the FEMP is Doing to Solve the Problem* on page 22.

Steady State Steady states occur when the concentrations of substances in your well remain about the same. You can still expect to see a small amount of variation in your results from month to month because of the variations discussed on page 16. However, you will not observe a steady increase or decrease over a period of several months or years.



Tracking Your Well Sampling Results

To help you better understand the well sampling results you receive, you should track your results regularly to monitor any changes or trends. You can use the graph on pages 20 and 21 to plot your monthly results. (The years are left blank on this graph so you can photocopy and re-use the form.)

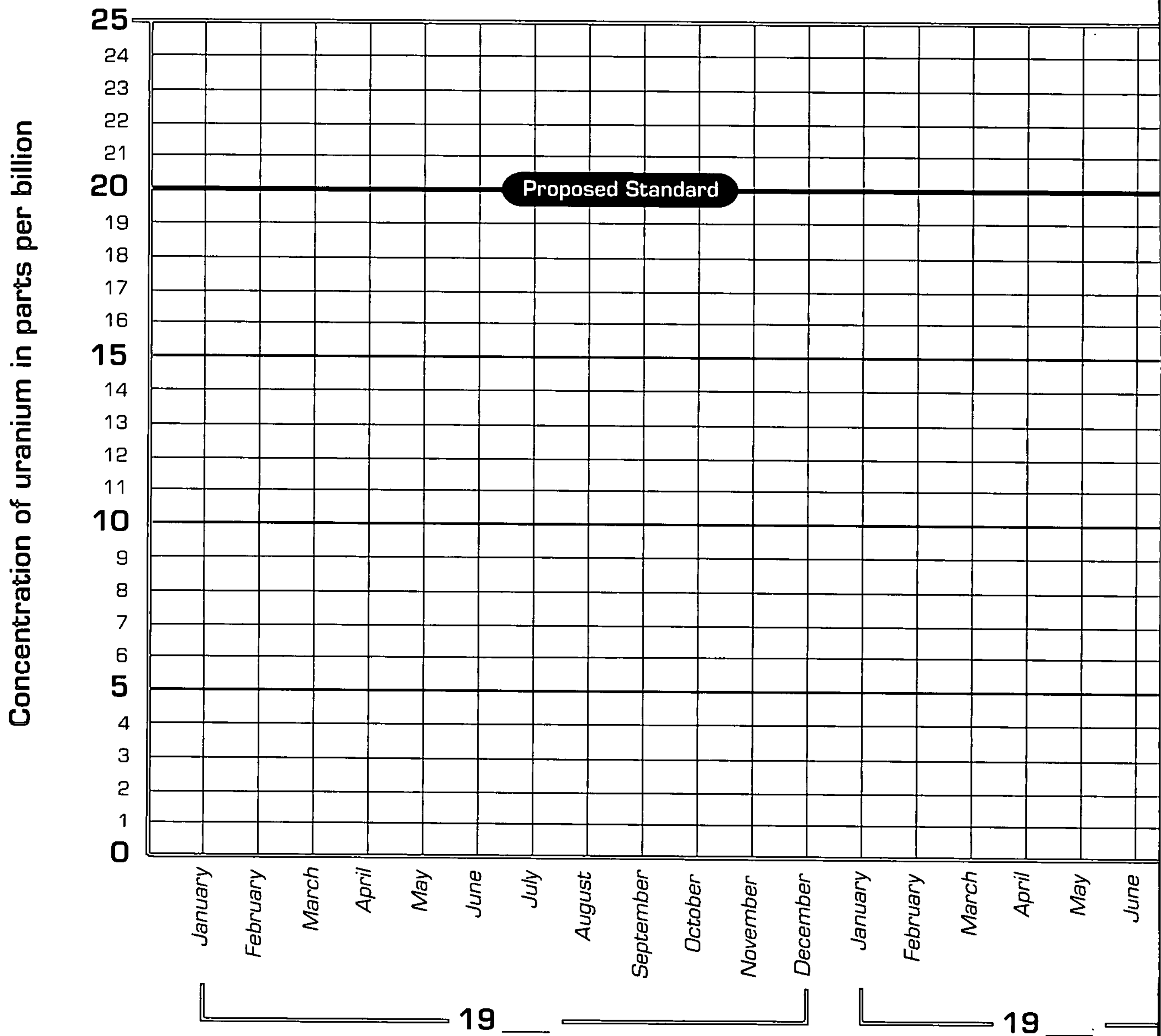
The horizontal line at the bottom of this graph represents the months of the year over a three-year period. The vertical line on the far left represents the various concentrations of uranium found in the groundwater. The range of concentrations shown on this graph are from 0.00 ppb to 25.0 ppb. The dark horizontal line at 20 ppb is the U.S. EPA proposed standard for uranium in drinking water.

At each stage of the monitoring process, problems may occur which could result in invalid or late sample results. Because of the many steps involved in sampling and analysis, the techniques used by the sampling and laboratory technicians have the greatest potential for introducing error. Improper field techniques can contaminate samples or produce samples that do not represent the groundwater quality from the particular well sampled. Other problems, such as improperly cleaned laboratory glassware, can also result in invalid sample results

To plot your monthly sample results:

1. Place a small dot at the point where the month and concentration lines intersect.

2. Repeat for each month for which you receive sampling results.



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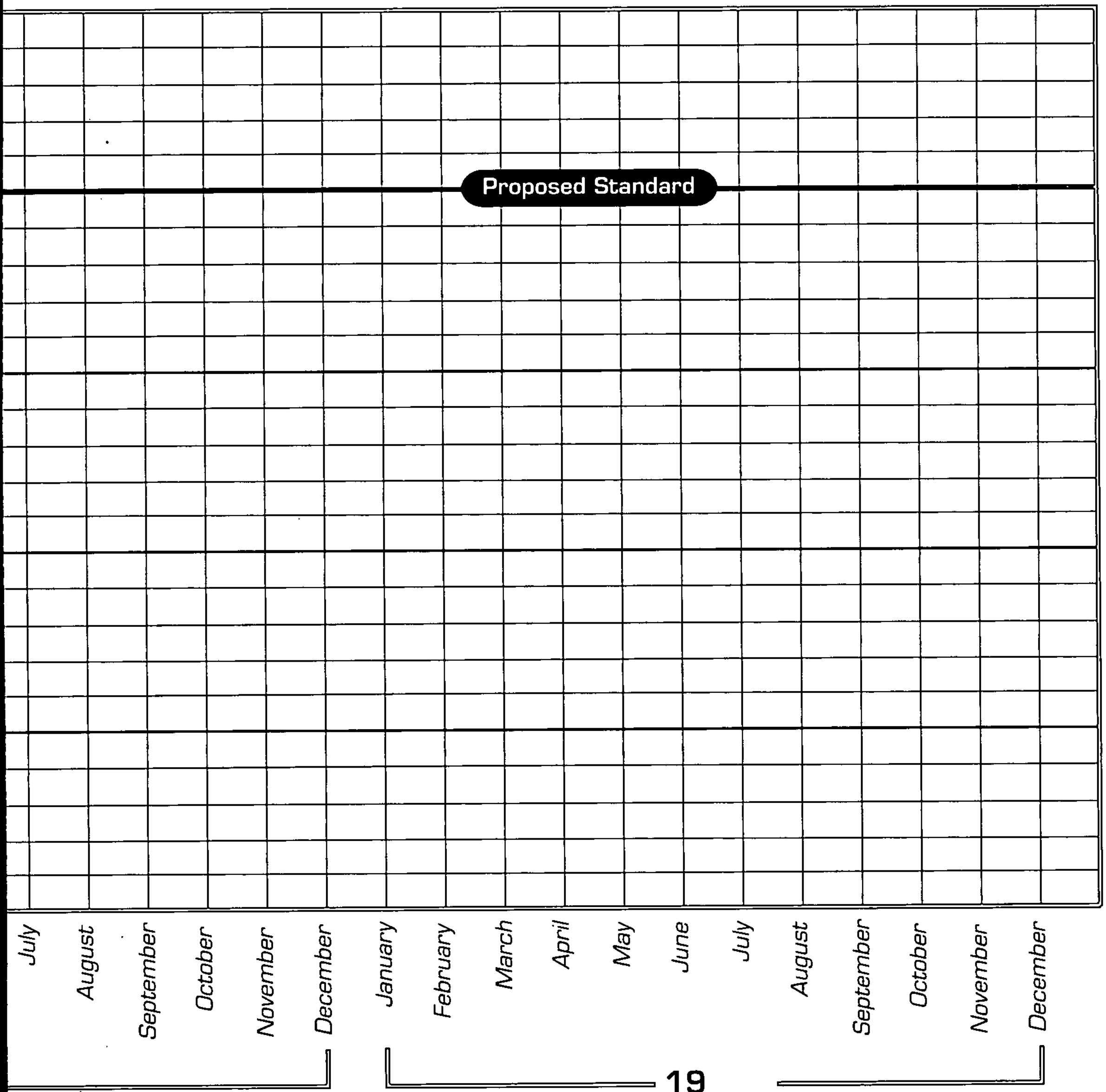
3. Draw lines connecting the dots from month to month to observe any trends in your results.



What the FEMP is Doing to Solve the Problem

The FEMP is currently involved in many activities to remedy contamination at the site. The most extensive activity is the *Remedial Investigation/Feasibility Study* (RI/FS). The RI/FS is an investigation that will lead to the selection of final *remedial actions* for the site. *Remedial actions* are designed to clean up the site.

During the course of the RI/FS, immediate threats to human health and the environment are identified. In response to these threats, *removal actions* are initiated. *Removal actions* are efforts to quickly control specific sources of contamination. The *South Groundwater Contamination Plume Removal Action* is one such removal action.

South Groundwater Contamination Plume Removal Action

Goals of the *South Groundwater Contamination Plume Removal Action* are:

- to limit access and exposure to contaminated groundwater,
- to protect the groundwater environment, and
- to control plume migration farther south.

Because of the magnitude of the project, the removal action has been divided into five parts.

In part one of this project, the FEMP will supply an alternate water source to a local industry whose well water showed concentrations of uranium greater than 30 ppb.

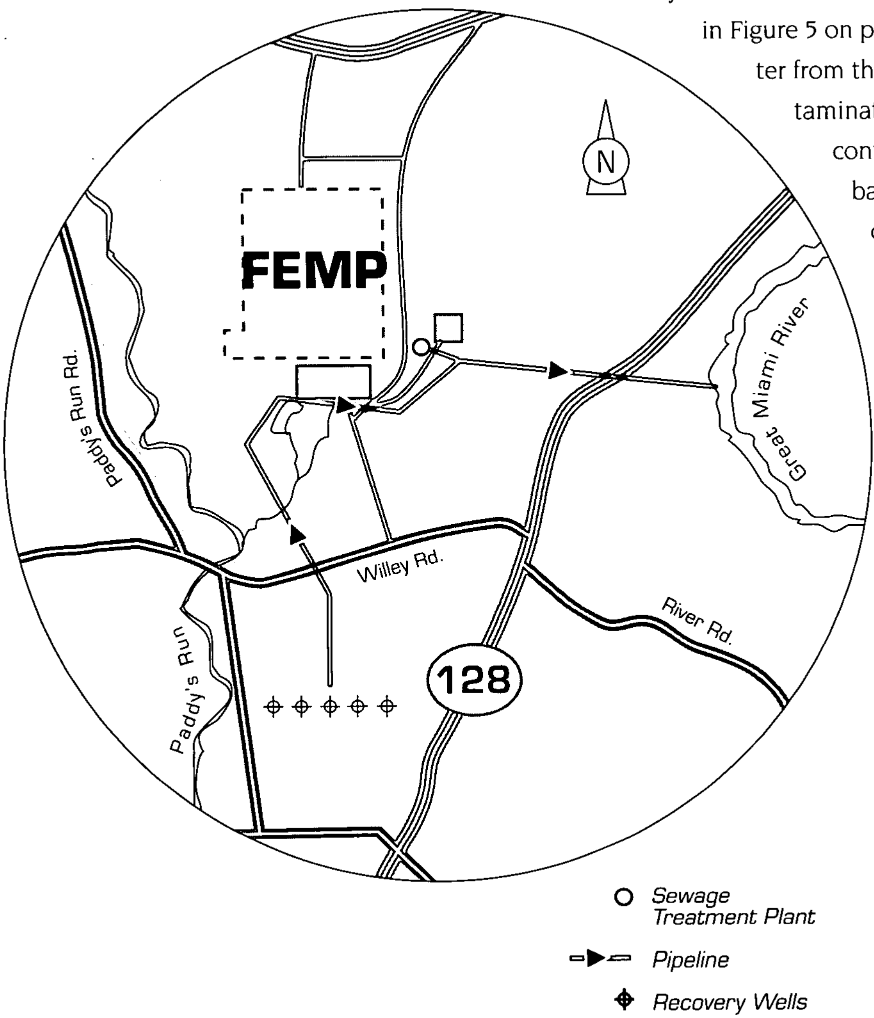
In part two of this project, the FEMP will install recovery wells in the South Plume area. (The South Plume is shown in Figure 5 on page 7.) The FEMP will pump groundwater from these recovery wells to intercept the contaminated water south of the site. Recovered contaminated groundwater will be pumped back to the site for monitoring and discharge to the Great Miami River.

In part three of this project, the FEMP will compensate for discharging contaminated water into the Great Miami River from this and other removal actions by improving its current treatment of onsite wastewater.

Figure 8:

Removal Action

Recovery System



That is, to ensure that the total amount of uranium discharged to the river will not increase, uranium levels equal to or greater than that of the recovered groundwater will be removed from the onsite wastewater. The FEMP will continue to monitor uranium concentrations in its water discharged to the river in order to comply with state and federal regulations.

In parts four and five of this project, the FEMP will continue investigations of the groundwater and frequent monitoring of wells.

Where to Get More Information

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The FEMP Community Relations Office is available to assist you with any questions and concerns you may have about the site. The staff will research your questions with the technical staff and respond to you directly. In addition, the following is a list of resources that provide more information about the FEMP, groundwater, and contamination.

FEMP Resources

For information about the FEMP and activities at the site, refer to:

- The FEMP's Annual Site Environmental Report
- Factsheets

FEMP Community
Relations Office
738-6934

You can receive copies of these and other publications from the FEMP Community Relations Office or at the:

Public Environmental Information Center (PEIC)
JAMTEK Building
10845 Cleves Highway
Harrison, Ohio 45030

The PEIC is open weekdays and Saturdays. Call 738-0164 for hours of operation.

Groundwater Resources

For basic information about groundwater, refer to:

- *Basic Ground-Water Hydrology*, by Ralph C. Heath; U.S. Geological Survey Water Supply Paper 2200, USGS and North Carolina Department of Natural Resources and Community Development; Alexandria, Virginia; 1984.
- *Study and Interpretation of the Chemical Characteristics of Natural Water* by John D. Hem; U.S. Geological Survey Water-Supply Paper 2254; USGS; Alexandria Virginia; 1985.

These publications are available for review at:

United States Geological Survey (USGS)
Water Resources Division
975 West 3rd Avenue
Columbus, Ohio 43212

You can purchase copies of these publications by calling the Books and Reports Sales at 303-236-7476 or by writing to:

Books and Reports Sales
Federal Center
Box 25425
Denver, Colorado 80225

The following publications are available through the *National Ground Water Association* (NGWA) *Bookstore*; 6375 Riverside Drive; Dublin, Ohio:

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- *Applied Hydrogeology* by C.W. Fetter; Charles E. Merrill Publishing Company; Columbus, Ohio; 1980.
- *Groundwater* by Allen R. Freeze and John A. Cherry; Prentice-Hall, Inc.; Englewood, New Jersey; 1979.
- *Groundwater and Wells* by Fletcher Driscoll; Johnson Division; St. Paul, Minnesota; 1986.

For additional resources about groundwater, call the NGWA at 614-761-1711.

For information about private water systems, refer to:

- *Private Water Systems Handbook* by M.L. Palmer; Midwest Plan Services; Ames, Iowa; 1979. (You may obtain copies of this publication through the Ohio Cooperative Extension Service (OCES) for Hamilton County, 11100 Winton Road, Cincinnati, Ohio. You can call the OCES at 825-6000.)
- *Planning for an Individual Water System* by G.E. Henderson; American Association for Vocational Instructional Materials; Athens, Georgia; 1982.

For information about groundwater monitoring, refer to:

- *Practical Handbook of Ground-Water Monitoring* edited by David M. Nielsen; Lewis Publishers; Chelsea, Michigan; 1991.
  (This publication can be obtained through the National Ground Water Association in Dublin, Ohio.)
- *The Status of Groundwater Monitoring in Butler, Clermont, Hamilton, and Warren Counties, Ohio*; Ohio-Kentucky-Indiana Regional Council of Governments; Cincinnati, Ohio; 1988.

Groundwater Contamination Resources

For information about drinking water quality standards, refer to the:

Federal Register
National Primary Drinking Water Regulations
40 CFR Parts 141 and 142

This publication lists federal standards and is available at most public/university libraries. For additional resources, contact the Ohio EPA Public Interest Center at 614-644-2160 or call the U.S. EPA Safe Drinking Water Hotline at 1-800-426-4791.

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