1998 305(b) Report
Ohio's Ground Water Quality

The 1996 305(b) report made dramatic strides in characterizing the water quality of Ohio's ground water. Subsequently efforts have focused on generally cleaning up the newly established data base and developing standard procedures for organic data entry, data management, statistical analysis, sample tracking, and documenting these procedures and providing the rationale for the methods selected. Some effort was focused on developing graphical analysis and GIS analytical capability, but these efforts have not significantly enhanced our analytical ability beyond that represented in the 1996 305(b) Report. Consequently, we decided that a skeleton 1998 305(b) Report on Ohio's Ground Water Quality would be produced to supplement the 1996 305(b) Report. Our plan is to duplicate the significant progress of the 1996 305(b) Report in the 2000 305(b) Report utilizing new tools and information that are currently being developed by several State Programs.

SOURCES OF CONTAMINATION

Although available data show that much of Ohio's ground water is of high quality and has not been widely impacted by human activities, individual cases of ground water contamination are documented every year. Ohio has a diverse economy and the state uses and produces a range of potential contaminants which are applied, stored, and disposed of on the land. Consequently, ground water quality is threatened by a wide range of contaminants and a wide variety of land use activities across the state.

The 1998 305(b) Guidance requests that Ohio identify the ten (10) main sources of ground water contamination. The ten major sources of contamination are indicated in **Table 5-1** by checks (T). It is important to point out that this approach integrates extent and toxicity of contamination, which is not easy to do for several reasons. Different geographic areas of Ohio have different land use activities, consequently contamination that is a major source in one region may not be a major source when considering the entire State. For instance, coal mine waste piles are a significant contaminant source in southeastern Ohio, but are not in other parts of the state. The significantly variable hydrogeologic settings within the state make the vulnerability of some areas greater than others. The land use activities within the vulnerable areas have a greater potential of impacting the ground water. Both point sources and non-point sources of contamination are distributed through the State but it is hard to evaluate whether the wide spread low concentration non-point sources produce more impact on ground water than more concentrated but less widespread point sources. These points are raised to illustrate the subjective nature of Table 5-1. Ohio EPA staff have tried to integrate these and other factors in a unbiased manner, but other groups may come up with other priority lists. Thus the fact that a contaminant source is not listed as a major contaminant source in the state does not mean that it is not significant locally or even regionally within the state. To provide some additional information, crosses (X) indicate several additional categories of contamination that we considered as potentially top-ten priority sources.

Contaminant Source Discussion

Contamination sources which contain hazardous substances pose the greatest public health threat. However, on-lot sewage systems and mining activities which occur in great numbers or are prevalent throughout large areas of the State can impact large numbers of wells. The vulnerability of the local aquifers also influence the potential for ground water contamination. Generally the shallow, unconfined buried valley aquifers appear to be the most vulnerable of Ohio aquifers. Areas where little soil and/or glacial material cover overlies the carbonate aquifers are also vulnerable. Fortunately the carbonate aquifers are generally overlain by glacial or other surface deposits that reduce the vulnerable nature of limestone aquifers. The bedrock sandstones appear to be the least vulnerable of Ohio aquifers.

The sources of contamination that are identified in Table 5-1 are listed **alphabetically** below. Each source of contamination identified in Table 5-1 is discussed to provide additional information on these threats to Ohio's ground water. This list provides more specific information to enhance Table 5-1.

1. **CAFO - Concentrated Animal Feeding Operations:** It is difficult to identify ground water impacts associated with CAFOs. Nevertheless, the growth of these operations in numbers and size makes them a larger potential source of ground water contamination. In addition, these operations are increasingly visible to the public, both physically and in the media. The ground water threats associated with CAFOs are captured in other categories like manure and fertilizer application and surface impoundments so they are not considered one of the ten highest priority sources.

2. **Fertilizer Applications**: Improper use and handling of fertilizers and animal wastes can cause ground water pollution. Animal waste used as fertilizer and chemical fertilizers contribute to nitrate values in ground water. The association of relatively high nitrate values (still well below the MCL) within buried valley aquifers illustrates the vulnerability of those systems. It can be argued that nitrate values in ground water represent one of the better examples of the widespread distribution of impacted ground water, although it is important to point out that non-agricultural sources also contribute to ground water impacts from nitrate. Analysis of public water monitoring supply data suggests a high incidence of elevated nitrate levels in public water systems in buried valley aquifers, the most vulnerable of Ohio's aquifers.

3. **Hazardous Waste Sites:** Ohio generates a large amount of hazardous waste. Industrial sites or other locations where hazardous waste is generated are not considered hazardous waste sites until hazardous waste has been spilled or released in some other manner. Hazardous waste sites are a serious threat to ground water. Thirty-four waste sites are on the National Priority List of the Superfund program. There are about 180 facilities that have Part A or part B permits under the Resource Conservation and Recovery Act (RCRA Subtitle C) that are required to monitor for contamination in ground water because of their potential to affect ground water quality.

4. **Injection Wells:** Class V injection wells are widespread throughout the State and exhibit a high density in several areas in the State. It is estimated that there are 25,000 - 50,000 class V injection wells in the State of Ohio. The fact that these wells inject water directly

into some of the most vulnerable aquifers in the State is the main cause for concern. The non-point source origin of water flowing into Class V wells is variable and thus difficult to characterize in a state wide analysis. Nevertheless these shallow injection wells provide a direct pathway for non-point source contamination and illegal waste disposal into vulnerable aquifers.

5. **Landfills:** Currently there are about 125 landfills with ground water monitoring in Ohio. In addition there are approximately 200 construction and demolition sites that have submitted license applications but do not have ground water monitoring. Numerous abandoned landfills may pose potential ground water contamination threats and many are included in DERR's Master Sites List which indicates a potentially significant impact of old landfills on ground water quality. The current siting, design, and construction standards for landfills are more stringent than just ten years ago.

6. **Mining and Mine Drainage:** The Pennsylvanian Units that underlie eastern Ohio include significant coal resources and the region continues to produce coal. The relatively high sulfur content of Ohio coal, concerns about acid rain, and clean air standards have resulted in reduction of Ohio coal production. The number of operating coal mines is decreasing more rapidly than total coal production, as production is concentrated in larger underground mines. The disruption of the stratigraphic units and oxidation of sulfides associated with coal as a result of mining, produces the possibility of ground water contamination by acid mine waters. Acid mine waters are considered a significant threat to ground water resources in mined areas.

7. **Salt Storage and Road Salting:** Storage and use of salt as a deicing agent can impact ground water resources. The widespread use of salt or mixtures of salt and sand for deicing roads has been documented as a major contributor of sodium (Na) and chlorine (Cl) contamination of ground water. ODOT is funding an on-going study to evaluate the impact of road salting chemicals on ground water in shallow aquifers. Alternative chemicals like acetate-based deicers in combination with reduced salt usage are being promoted as pollution prevention programs.

8. **Septic Systems**: Tens of thousands of household wastewater systems, primarily septic tanks and leach fields, are present throughout the rural and unsewered suburban areas of Ohio. A number of these systems are improperly located, poorly constructed, or inadequately maintained, and may cause bacterial and chemical contamination of nearby wells. Improperly operating septic systems are considered to be significant contributors to elevated nitrate levels in vulnerable aquifers.

9. **Spills and Leaks:** Leaks and spills of hazardous substances from underground tanks, surface impoundments, bulk storage facilities, transmission lines, and accidents are major ground water pollution threats. More than a thousand leaks and spills that may pollute ground water are reported each year. This release of chemicals into the surface environment is certainly one of the greatest threats to ground water quality.

10. **Storage Tanks, Underground:** The 1994 Non-Point Source (NPS) report documented that ground water contamination at Underground Storage Tanks (USTs) was a major

source of ground water contamination. The large number of USTs and the hidden nature of the storage method contributes to the lack of proper maintenance. In wellhead protection areas USTs are one of the most common potential pollution source identified. The many USTs exempted from Bureau of Underground Storage Tank Regulation (BUSTR) regulations are probably significant contributors to ground water contamination by virtue of their number and limited maintenance.

11. **Surface Impoundments:** Surface impoundments are one of the most common waste disposal concerns at RCRA sites. Consequently surface impoundments constitute a major source for ground water contamination. This is especially true for the older sites where less is known about surface impoundment construction and consequently the probability of fluids leaching to the ground water is greater.

12. **Urban Runoff:** With expanding urban areas, non-point source contamination from urban areas is one of the sources of ground water contamination that is increasing, in contrast with most of the other sources discussed. In addition, the recent practice of constructing storm water retention basins increases the likelihood that urban runoff infiltrates into ground water.

13. **Waste Piles and Tailings:** RCRA facilities have numerous waste piles and tailings that pose a threat to ground water. They have not been included as a major source of contamination because surface impoundments are more numerous.

Although this selection process is somewhat arbitrary, it identifies major sources of ground water contamination in Ohio. Overlap between these source groups, for instance the increased potential for ground water contamination where urban runoff is discharged into a Class V injection well, reflects the interrelated nature of ground water pollution and these sources. The 1994 State of Ohio Non-Point Source Assessment, Ground Water Component Report is consistent with Table 5-1 except above ground storage tanks/drums were identified as a significant source at numerous locations with ground water contamination. Finally we want to emphasize that the location of sources relative to vulnerable aquifers is critical for ground water contamination to occur. For instance, deep injection wells are not considered a major source because in Ohio the waste is not injected into potable waters and the regulations protect the shallower, useful aquifers. To evaluate the potential impact of these contamination sources on a local scale or site specific basis, it is critical that the source distribution is integrated with aquifer sensitivity (through DRASTIC type maps, or other sensitivity measures).

GROUND WATER PROGRAMS

Programs to monitor, evaluate, and protect ground water resources in Ohio are carried out by various Federal, State and local agencies. Ground water related activities at the state level are conducted by the Ohio Departments of Agriculture, Commerce (Division of State Fire Marshal), Health, Natural Resources, and Transportation, Environmental Protection Agency, and Public Utilities Commission. To coordinate state activities related to ground water, the State Coordinating Committee on Ground Water (SCCGW) was created by the directors of these state agencies. The purpose of the SCCGW is to promote and guide the implementation of a coordinated, comprehensive, and effective ground water protection and management program for the state of Ohio. The Ohio EPA - DDAGW is the lead agency in administering the SCCGW.

The ground water related activities of the **Ohio EPA** are directed toward ground water quality monitoring and assessment, and prevention, evaluation, and remediation of ground water pollution from existing and proposed waste disposal sites. The Ohio EPA-DDAGW functions as a technical support unit for other programs of Ohio EPA by providing technical expertise on local hydrogeology and ground water quality. Specific activities of the ground water staff include: waste disposal, treatment, and storage site investigations; ground water complaint response; the review of plans and site feasibility reports to insure adequate ground water protection; and surveillance at land disposal sites and facilities. The Division also maintains a statewide ground water quality monitoring program, oversees activities associated with injection wells (Class I and V), carries out the State public water supply supervision program, and is the lead office in developing and implementing Ohio's Source Water Protection Program. Legal authority to support Ohio EPA ground water functions is included in Sections 6109, 6111, 3734, and 3745, Ohio Revised Code (ORC). Other divisions and units within Ohio EPA also have major ground water responsibilities including the Divisions of Surface Water, Solid and Infectious Waste, Hazardous Waste Management, and the Division of Emergency and Remedial Response.

The Ohio EPA Division of Emergency and Remedial Response (DERR), Voluntary Action Program (VAP) is being implemented. The VAP process has developed a classification system for the state's ground water which may shift the state premise of protecting all ground water equally to a differential protection for ground water with an emphasis on protecting critical resources. It is uncertain what the ripple effect of these new rules will be, but one effect has been the promotion of development of unified ground water rules and approaches across programs.

The **Ohio Department of Natural Resources (ODNR)**, Division of Water is responsible for the quantitative evaluation of the resource. Specific functions include: ground water mapping; administering Ohio's well log and drilling report law; special hydrogeologic investigations; water quantity assessment; and technical assistance to municipalities, industries, and the general public regarding local geology, well drilling, and water development. Statutory authority for these activities is contained in Section 1521 and 1523, O.R.C.

The ODNR's Division of Oil and Gas, acting under authority of Section 1509, O.R.C., administers rules and regulations to manage oil and gas reserves and to control pollution from activities associated with petroleum production. Major functions which directly relate to ground water protection include regulating well drilling, well casing, and well abandonment techniques; and regulating storage and disposal practices for associated waste fluids. The Division also administers the State's underground injection control programs for mineral extraction wells, enhanced oil recovery operations, and brine disposal (Class II and III injection wells).

Other divisions within ODNR also have ground water related responsibilities. The Division of Reclamation, under authority of Sections 1513 and 1514, O.R.C., oversees mining activities in the State and may require ground water monitoring and follow-up corrective actions around newly permitted coal strip mining areas. The Division of Soil and Water Conservation (Section 1511, O.R.C.) is responsible for developing programs for abating water pollution associated with soil erosion and animal waste handling activities. The Geological Survey Division collects, interprets, and disseminates information on

Ohio's bedrock and glacial geology. On-going programs of geologic mapping, geophysical testing, and test drilling provide a better understanding of the geologic framework of Ohio aquifers.

The **Ohio Department of Health (ODH)** is responsible for programs to regulate the siting, design, operation, and maintenance of private residential water supply systems and sewage disposal systems, which may have direct impacts upon local ground water quality and drinking water safety. ODH has developed rules governing specific well construction practices and a well permit system, both of which are administered in cooperation with local health departments. Local health departments and ODH investigate complaints of private wells which are suspected of being contaminated. Programs of the Ohio Department of Health are mandated by Section 3701 O.R.C. and include a registration program for private water system contractors.

The Division of State Fire Marshal in the **Ohio Department of Commerce** is responsible for registration of underground storage tanks for petroleum products and development of rules for underground tank installation, testing, and abandonment. State Fire Marshal Staff investigate and direct UST removal and associated ground water clean-up activities in conjunction with local fire departments.

The **Ohio Department of Agriculture's (ODA)** Pesticide Regulation Section administers programs for regulating agricultural pesticides and oversees pesticide applicator training programs. The department carries out limited testing of wells located at bulk pesticide storage and handling facilities, and has identified contaminated wells at some sites. The ODA is the lead agency in developing the State Management Plan for pesticides to protect Ohio's ground waters from pesticide contamination. In addition, various ODA divisions sample wells for pathogens that produce water used in food processing.

Table 5-2 summarizes the active ground water programs and activities across the state. The format for this table is provided in the Guidance for 1998 305(b) Reports. Individual programs that are parts of the activities listed are managed by various divisions within larger agencies. Many of the programs or activities listed have several state agencies that are responsible for specific aspects of the listed activities. The fact that numerous agencies are identified as managing elements of ground water related programs illustrates why the State Coordinating Committee for Ground Water plays such an important communication role. For instance, well abandonment is regulated by several agencies; ODH oversees private wells but public wells are overseen by Ohio EPA, while oil and gas wells are regulated by ODNR. Current regulations for private and public wells require that boreholes not converted into wells be sealed. It is not always clear when an unused well should be sealed. Ohio EPA has the authority to prescribe regulations for the drilling, maintenance, and abandonment of wells as deemed necessary by the director to prevent the contamination of underground waters in the state, as identified in the Ohio Revised Code 6111.42. This Ohio EPA authority does not apply to private wells which are regulated by the Ohio Department of Health and local health departments. As with many developing environmental programs, a cooperative approach for well abandonment is is being instituted. The usefulness of the SCCGW is illustrated by creation of a SCCGW Work Group to draft “Technical Guidelines for Sealing Unused Wells.” This document, drafted to promote sealing of unused wells, was completed and published in the first quarter of 1996.

Summary of Ground Water Contamination

In the 1996 305(b) report Table 5-3 of the 305(b) Guidance, Ground Water Contamination Summary, was completed for the state. Case studies were used as illustrations of water quality for specific aquifer settings, but Table 5-4 of the 305(b) guidance was not completed for these case studies. We are not prepared to complete 305(b) Guidance Tables 5-3 and 5-4 for specific statewide aquifers at this point, but we will be able to complete these tables for at least two statewide aquifers that will cover about 50 % of the state for the 2000 305(b) report. Several state wide projects are underway that will provide much of the necessary information to describe individual or stacked groups of aquifers. We have decided that it makes sense to wait for the tools and information necessary to complete this analysis properly, rather expend the effort now, for a product of limited value. Efforts over the past two years have contributed to the characterization of Ohio ground water and a couple examples of these efforts are provided below.

Three main aquifers provide water to public water supplies in Ohio. These aquifer include: unconsolidated clastics, including sand and gravel aquifers distributed across the state in buried valleys; consolidated clastics, including sandstone aquifers in the eastern portion of the state; and consolidated carbonates, including limestone and dolomite aquifers, in the west and north west. The clean up and QA/QC of the header data for the Ambient Database has provided confidence that data queried from the database is correctly associated with aquifer types. Consequently, average values for ambient samples were generated and are listed by parameter and aquifer type in Table 1. The results for the listed parameters are provided for each of the major aquifer types. The locations of the ambient wells are indicated in Figure 1.

Major anions and cations from ambient data were plotted on a Piper diagrams. More than 90 % of the ambient well-water chemistry data plots within the shaded areas of the Piper Diagram in Figure 2. Although not evident from Figure 2 the carbonate aquifers tend to be higher in Ca and Mg than the clastic aquifers. The carbonate aquifers also have the widest range of carbonate + bicarbonate and sulfate + chloride values due to the presence of evaporites within the carbonate stratigraphic sequence. These trends were expected due to water - host rock interaction, but the ambient data provides solid documentation of the trends.

Over the past reporting period, the ambient wells were sampled and analyzed for Tritium. Tritium is the radioactive isotope of hydrogen (^3H) with half-life of 12.43 years. Tritium concentrations in the atmosphere of the northern hemisphere reached their maximum beginning in 1953 and continuing through the early 1960's due to nuclear weapons testing. Tritium may be used to determine if ground water has been in contact with atmospheric recharge in the last 50 years. If tritium concentrations are below the detection limit of 0.8 tritium units, it may be concluded that ground water has not been recharged with post-1953 “bomb enriched” tritium. Figure 3 shows the distribution of tritium concentrations and the percent of each of the three main aquifer types in a histogram (each aquifer type adds up to 100%). Ground water with concentrations less than detection (0.8 tritium units) is relatively isolated from the atmosphere suggesting little to no mixing of meteoric water, indicating non-sensitive aquifers. These sites with no detection of tritium also tend to be associated with deeper wells. The large portion of carbonate aquifers that are included in the <0.8 tritium units bar, illustrates that they are more likely to be isolated than sandstone or unconsolidated (sand and gravel) aquifers. The sand and gravel aquifers are the smallest portion of the <0.8 tritium units bar and they dominant the histogram in the detection range of 6-15 tritium units. This confirms that the sand and gravel aquifers are the most sensitive aquifer type in the state. This tritium data provide solid data support for the empirical relationships used to suggest the relative sensitivity of the major aquifer types in Ohio.

Ongoing Water Quality Characterization Activity

The ODNR, Division of Water, will complete statewide aquifer maps by the end of 1999 which will provide the basis for identifying aquifer boundaries. Resource characterization of hydrgeologic parameters for aquifers in Ohio, the initial step for completion of the SWAP assessments, will be well underway and will provide valuable information to describe statewide aquifers. The Ambient database will be fully operational with most of the organic data entered and the efficiency of GIS links to the ambient data and aquifer maps will be much improved which will promote GIS analysis of the water quality data. This combination of data resulting from state water quality programs will provide for the kinds of water quality analysis that the U.S. EPA is promoting in the 305(b) Guidance.

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TABLE 5-1. Major Sources of Ground Water Contamination

Contaminant Source	Ten Highest Priority Sources (T)	Factors Considered in Selecting a Contaminant Source	Contaminants
Agricultural Activities			
Agriculture chemical facilities			
Animal feedlots			
Drainage wells			
Fertilizer applications	T	A, B, C, D, E	E (J, K, L)
Irrigation practices			
Pesticide applications			
On-farm agricultural mixing and loading procedures			
Land application of manure (unregulated)			
Storage and Treatment Activities			
Land application (regulated)			
Material stockpiles			
Storage tanks (above ground)			
Storage tanks (underground)	T	A - E	C, D, H
Surface impoundments	T	A, C, D, E	C, D, H
Waste piles	X		
Waste tailings	X		
Disposal Activities			
Deep injection wells			
Landfills	T	A - E	A-D, H, J, K, L
Septic systems	T	A - E	E, H, J, K, L
Shallow injection wells	T	A - E	C, D, G, H
Other			
Hazardous waste generators			

Contaminant Source	Ten Highest Priority Sources (T)	Factors Considered in Selecting a Contaminant Source	Contaminants
Hazardous waste sites	T	A - E	A, B, C, D, H, I
Large industrial facilities			
Material transfer operations			
Mining and mine drainage	X		
Pipelines and sewer lines			
Salt storage and road salting	T	C, D	G
Salt water intrusion			
Spills	T	A - E	A, B, C, D, E, H, I, J, K, L
Transportation of materials			
Urban runoff	T	B, D	A, B, C, D, G, H
Small-scale Manufacturing and repair shops			
Other sources (please specify) CAFOs	X		

T - Highest priority
X - Potentially high priority

FACTORS
A - Human health and/or environmental risk (toxicity)
B - Size of the population at risk
C - Location of the sources relative to drinking water sources
D - Number and/or size of contaminant sources
E - Hydrogeologic sensitivity
F - State findings, other findings
G - Other criteria (please add or describe in the narrative)
H - Geographic distribution/ occurrence
I - Other criteria (please add or describe in the narrative)

CONTAMINANTS
A - Inorganic pesticides
B - Organic pesticides
C - Halogenated compounds
D - Petroleum compounds
E - Nitrate
F - Fluoride
G - Salinity/brine
H - Metals
I - Radionuclides
J - Bacteria
K - Protozoa
L - Viruses
M - Other (please add or describe in the narrative)

TABLE 5-2. Summary of State Ground Water Protection Programs

Programs or Activities	Check (T)	Implementation Status	Responsible State Agency
Active SARA Title III Program	T	E	OEPA
Ambient ground water monitoring system	T	E	OEPA
Aquifer vulnerability assessment	T	CE	ODNR, OEPA
Aquifer mapping	T	CE	ODNR
Aquifer characterization	T	CE	ODNR, OEPA
Comprehensive data management system	NA	Note [a]	
EPA-endorsed Core Comprehensive State Ground Water Protection Program (CSGWPP)	NA	UD	SCCGW
Ground water discharge permits	T	E	ODNR
Ground water Best Management Practices			
Ground water legislation	T	E [b]	ODNR, OEPA
Ground water classification	T	E [b]	OEPA
Ground water quality standards	T	E [b]	OEPA
Interagency coordination for ground water protection initiatives	T	E	SCCGW
Nonpoint source controls	T	E,UD	OEPA
Pesticide State Management Plan	T	CE	ODA
Pollution Prevention Program	T	E	OEPA
Resource Conservation and Recovery Act (RCRA) Primacy	T	E [c]	OEPA
State septic system regulations	T	E	ODH
Underground storage tank installation requirements	T	E	SFM
Underground Storage Tank Remediation Fund	T	E	SFM
Underground Storage Tank Permit Program	T	E	SFM

[a] Data management occurring on agency level.

[b] Developed through VAP Program (Voluntary Action)

[c] RCRA Primacy on all but RCRA corrective actions.

Programs or Activities	**Check (T)**	**Implementation Status**	**Responsible State Agency**
Underground Injection Control Program	T	E [d]	OEPA, ODNR
Vulnerability assessment for drinking water/wellhead protection/SWAP	T	E, CE	OEPA, ODNR
Well abandonment regulations	T	E, UD [e]	OEPA, ODH, ODNR
Wellhead Protection Programs (EPA-approved)/ Source Water Protection Program	T	E,UD	OEPA
Well installation regulations	T	E	OEPA, ODH

E - Established
CE - Continuing Effort
UD - Under Development

OEPA - Ohio Environmental Protection Agency
ODNR - Ohio Department of Natural Resources
SCCGW - State Coordinating Committee on Ground Water
ODA - Ohio Department of Agriculture
ODH - Ohio Department of Health
SFM - State Fire Marshall (Division of Department of Commerce)

[d] Ohio EPA regulates Class I and V injection wells, ODNR regulates Class II and III injection wells.

[e] Technical guidance for sealing unused wells prepared by SCCGW recently printed.

Table 1. Ambient Data Summary by Aquifer Type as of February 16, 1999

Parameter/units	Aquifer Type	# Samples	Minimum	Maximum	Average
Alkalinity, total	Uncon.Clastics	2259	<1.00	1500.00	268.93
mg/l	Consol. Clastics	283	<5.00	520.00	211.23
	Consol. Carbonates	598	68.00	468.00	281.88
Aluminum	Uncon.Clastics	867	84.00	2850.00	203.41
ug/l	Consol. Clastics	174	<200.00	234.00	200.31
	Consol. Carbonates	220	<200.00	412.00	200.46
Ammonia	Uncon.Clastics	2255	<0.01	42.00	0.28
mg/l	Consol. Clastics	290	<0.03	295.00	1.57
	Consol. Carbonates	593	0.01	4.00	0.36
Arsenic, total	Uncon.Clastics	1941	<2.00	200.00	5.76
ug/l	Consol. Clastics	252	<2.00	53.00	3.26
	Consol. Carbonates	515	<2.00	30.00	4.00
Barium	Uncon.Clastics	1886	15.00	1430.00	187.36
ug/l	Consol. Clastics	232	<15	1920.00	117.05
	Consol. Carbonates	531	7.00	1000.00	78.03
Cadmium	Uncon.Clastics	1330	<0.02	610.00	0.71
ug/l	Consol. Clastics	248	<0.20	2.00	0.22
	Consol. Carbonates	464	<0.20	10.00	0.27
Calcium	Uncon.Clastics	2372	<2.00	366.00	96.31
mg/l	Consol. Clastics	307	<1.00	184.00	67.46
	Consol. Carbonates	614	<1.00	490.00	127.57
Chloride	Uncon.Clastics	2338	1.30	941.00	40.61
mg/l	Consol. Clastics	303	1.00	530.00	36.79
	Consol. Carbonates	575	2.00	244.00	27.92
Chromium, total	Uncon.Clastics	1491	<10.00	110.00	24.90
ug/l	Consol. Clastics	265	<10.00	30.00	23.37
	Consol. Carbonates	514	<10.00	90.00	26.58
Copper, total	Uncon.Clastics	1040	<2.00	1370.00	11.48
ug/l	Consol. Clastics	222	<2.00	93.00	8.84
	Consol. Carbonates	257	<2.00	365.00	11.79
Fluoride	Uncon.Clastics	786	0.04	2.00	0.37
mg/l	Consol. Clastics	162	<0.10	1.00	0.27
	Consol. Carbonates	243	<0.10	3.19	1.29
Hardness	Uncon.Clastics	1325	<10.00	1240.00	368.24
mg/l	Consol. Clastics	154	<10.00	676.00	244.27
	Consol. Carbonates	327	<7.00	1720.00	522.72
Iron, total	Uncon.Clastics	2328	<2.0	145000.00	1482.28
ug/l	Consol. Clastics	301	0.35	330000.00	3403.47
	Consol. Carbonates	607	<30.00	96700.00	1332.82
Lead, total	Uncon.Clastics	1929	<1.00	1590.00	4.22
ug/l	Consol. Clastics	258	<2.00	40.00	2.53
	Consol. Carbonates	461	<2.00	167.00	3.38
Magnesium	Uncon.Clastics	2376	<1.00	100.00	29.29
mg/l	Consol. Clastics	308	<1.00	76.00	21.86
	Consol. Carbonates	617	<1.00	134.00	50.54
Manganese	Uncon.Clastics	2068	5.30	10880.00	241.88
ug/l	Consol. Clastics	271	9.00	1740.00	216.15
	Consol. Carbonates	505	<10.00	950.00	32.41
NO2+NO3 as N	Uncon.Clastics	1804	<0.01	135.00	1.05
mg/l	Consol. Clastics	241	<0.05	4.00	0.26
	Consol. Carbonates	495	<0.01	31.00	0.39

Nickel	Uncon.Clastics	964	<1.00	100.00	34.69
ug/l	Consol. Clastics	198	<20.00	144.00	35.05
	Consol. Carbonates	256	<20.00	100.00	35.94
Phosphorus, total	Uncon.Clastics	1522	<0.02	10.00	0.10
mg/l	Consol. Clastics	192	<0.05	4.40	0.18
	Consol. Carbonates	367	0.04	2.00	0.09
Potassium	Uncon.Clastics	1949	0.70	67.00	2.57
mg/l	Consol. Clastics	263	<0.50	610.00	5.12
	Consol. Carbonates	494	<0.05	23.00	3.13
TDS	Uncon.Clastics	2210	<10.00	2970.00	476.18
mg/l	Consol. Clastics	285	<10.00	2480.00	429.01
	Consol. Carbonates	560	0.44	2240.00	750.03
Selenium	Uncon.Clastics	1110	<0.20	20.00	2.13
ug/l	Consol. Clastics	221	<2.00	10.00	2.05
	Consol. Carbonates	255	<2.00	7.00	2.10
Sodium	Uncon.Clastics	2372	2.00	315.00	27.28
mg/l	Consol. Clastics	308	4.00	346.00	47.47
	Consol. Carbonates	616	<5.00	231.00	37.89
Strontium	Uncon.Clastics	953	15.00	40900.00	2001.18
ug/l	Consol. Clastics	185	<10.00	7480.00	452.46
	Consol. Carbonates	266	<30.00	59300.00	17419.60
Sulfate	Uncon.Clastics	2334	4.00	1130.00	80.34
mg/l	Consol. Clastics	304	0.60	1110.00	91.90
	Consol. Carbonates	612	<5.00	3150.00	287.50
TOC	Uncon.Clastics	1218	<0.50	75.00	4.03
mg/l	Consol. Clastics	222	<1.00	19.00	3.37
	Consol. Carbonates	332	1.00	73.00	3.71
Tritium	Uncon.Clastics	108	<0.8	42.00	9.03
T.U.	Consol. Clastics	26	<0.8	22.00	8.34
	Consol. Carbonates	44	<0.8	14.00	4.22
Zinc	Uncon.Clastics	1086	2.73	2930.00	30.08
ug/l	Consol. Clastics	224	<10.00	1600.00	33.33
	Consol. Carbonates	256	<10.00	1120.00	47.44
pH, field	Uncon.Clastics	1281	5.75	8.90	7.30
	Consol. Clastics	137	5.86	9.00	7.20
	Consol. Carbonates	459	6.20	12.90	7.35
pH, lab	Uncon.Clastics	452	6.38	9.00	7.44
	Consol. Clastics	70	6.10	9.00	7.16
	Consol. Carbonates	95	6.90	8.30	7.42

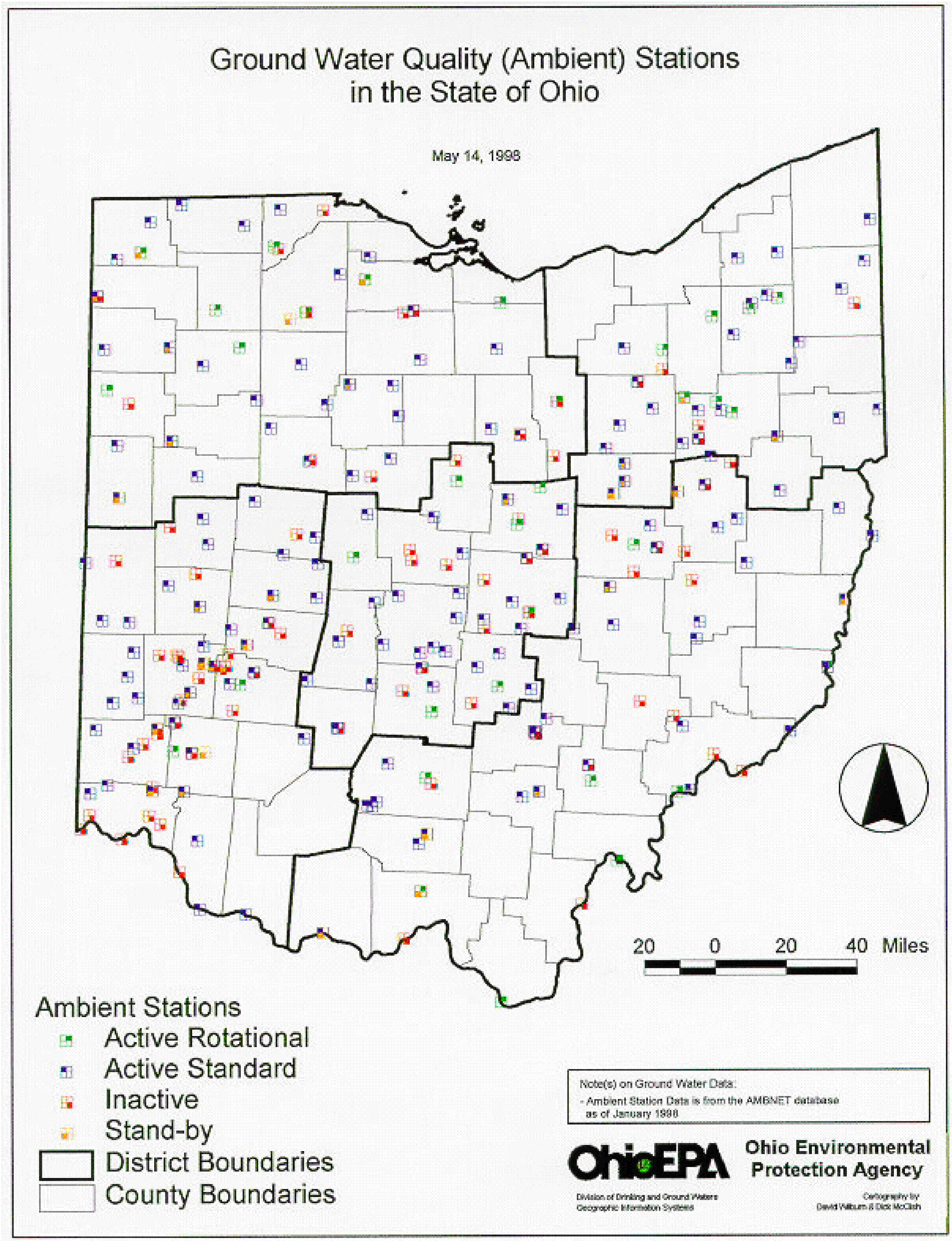

Figure 1. Ground Water Quality (Ambient) Stations in the State of Ohio

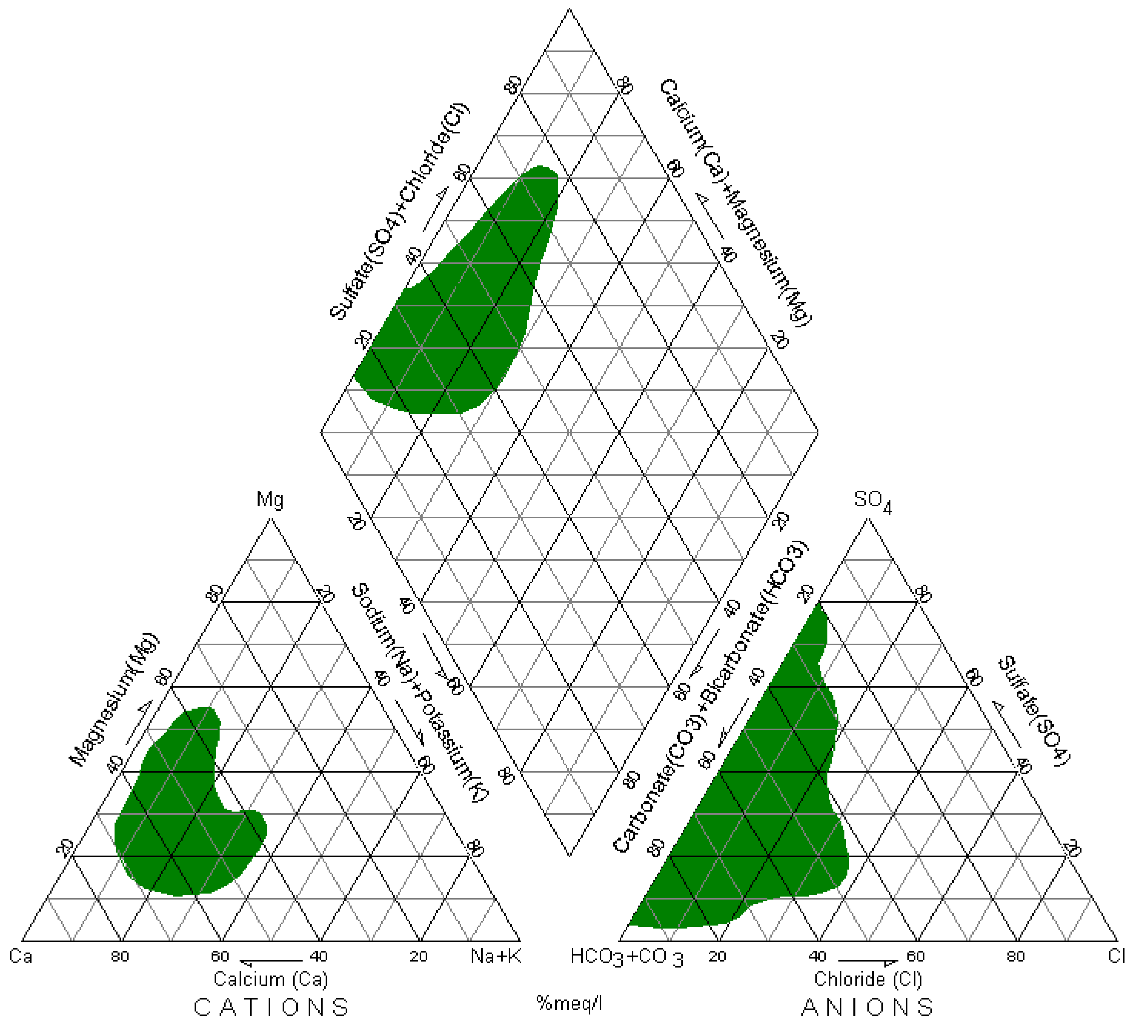

Figure 2. Piper diagram showing a composite of the ambient ground water chemistry.

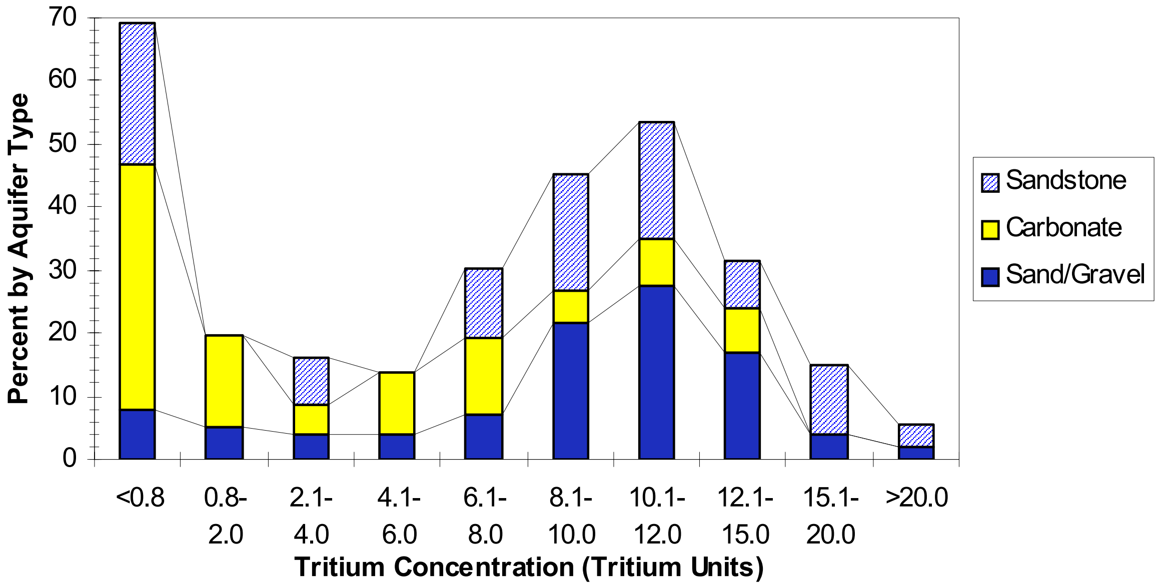

Figure 3. Breakdown of tritium concentrations by percent of aquifer type.