4.5 Determining Ground-Water Vulnerability

Class I ground waters are characterized in part by the condition of being highly vulnerable to contamination. They represent hydrogeologic settings in the Classification Review Area with a high potential for contaminant entry and transport in the ground-water flow system. In these Guidelines, the Agency is seeking comment on approaches to defining "highly vulnerable" ground water. To assist in framing the discussion, two options are presented. The first relies on a numerical ranking scheme known as DRASTIC whereas the second utilizes a qualitative, non-specific approach.

4.5.1 Option A: DRASTIC

The DRASTIC methodology which forms the core of Option A was developed by the National Water Well Association under contract to EPA's research program (Aller et al., 1985). A DRASTIC assessment allows the ground-water pollution potential of any hydrogeologic setting to be systematically evaluated with existing information anywhere in the Nation. The system focuses on ground-water impacts, not impacts on specific uses for drinking and other purposes.

Detailed instructions for using the DRASTIC methodology are provided in a Robert S. Kerr, Environmental Research Laboratory Report (EPA/600/2-85/018) entitled "DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Setting," (Aller et al, 1985). The reader is referred to this manual for general guidance on using the method.

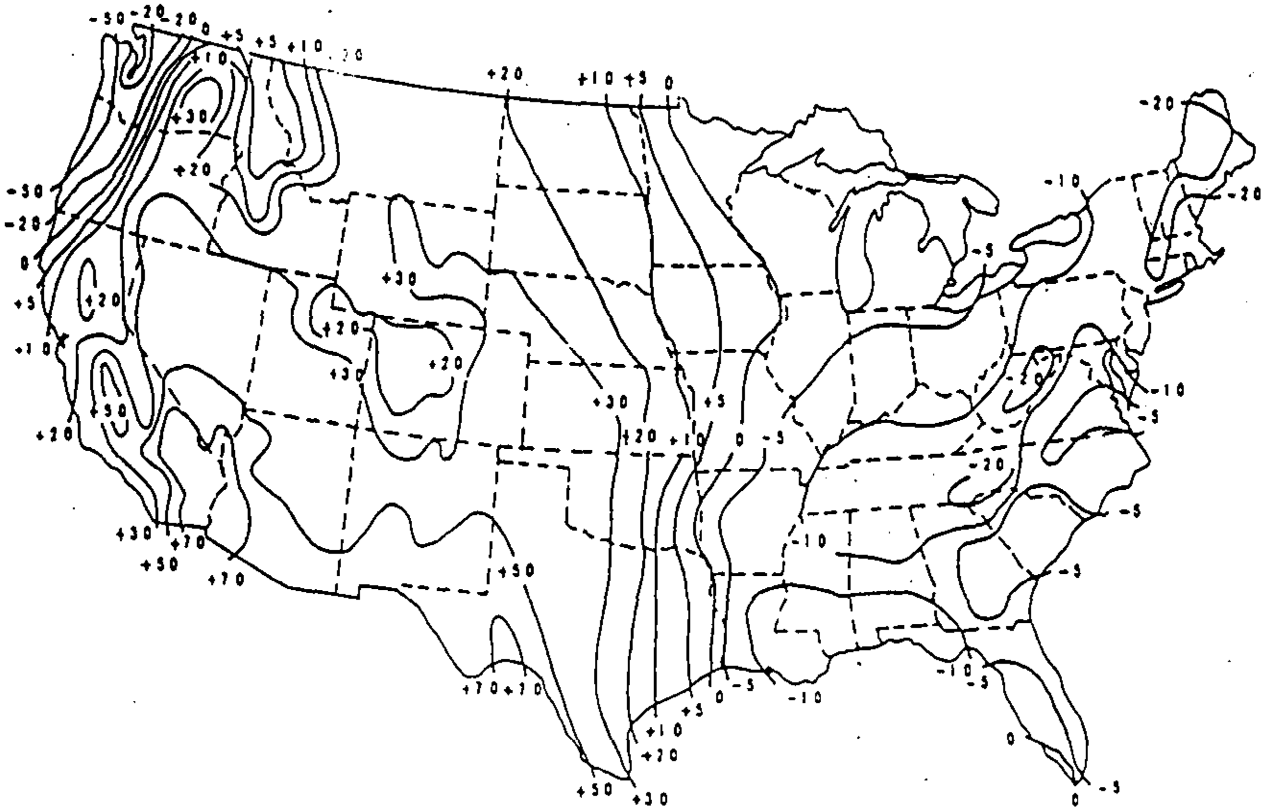
A two-tier DRASTIC criteria is proposed within Option A. The tiers are distinguished according to hydrologic regions. In regions where estimated annual potential evapotranspiration exceeds mean annual precipitation, the DRASTIC criterion for highly vulnerable is 120. In regions where estimated annual potential evapotranspiration does not exceed mean annual precipitation, the DRASTIC criterion for highly vulnerable is 150. Figure 4-18 shows the relationship between annual potential evapotranspiration and mean annual precipitation.

DRASTIC was not developed especially for this classification system, though the concept of using existing data on a reconnaissance basis is similar. It was intended to serve as a screening tool to compare areas larger than 100 acres within a region. The following sections provide a general description of DRASTIC and caveats limiting its application to identify highly vulnerable ground water.

FIGURE 4-18

POTENTIAL EVAPORATION VERSUS MEAN ANNUAL PRECIPITATION IN INCHES

(FLACH, 1973)



\+ Potential Evapotranspiration more than mean annual precipitation

− Potential Evapotranspiration less than mean annual precipitation

4.5.1.1 DRASTIC Methodology

DRASTIC is an acronym representing seven key hydrogeologic factors correlated to the potential for ground-water contamination listed below:

D - Depth to the water table
R - Net Recharge to ground water
A - Aquifer media
S - Soil media
T - Topography (slope of the land)
I - Impact of the vadose zone
C - Hydraulic Conductivity of the subject
ground-water flow system

The DRASTIC methodology consists of several steps leading toward a single DRASTIC index number. In the first step, each factor is given a rating between 1 and 10 (except for net recharge, which is rated between 1 and 9) depending upon the range of parameter values within a hydrogeologic setting. Consider the range of values for depth to water, and corresponding ratings, shown in Table 4-5. A setting with a depth to water of 28 feet would be rated as a 7. (Tables listing the range of values and corresponding ratings for each factor are provided in Appendix D.)

In the second step, each factor rating is multiplied by a factor weight to give a factor index. For instance, the weight for depth to water is 5 and, thus, if the rating is 7, the factor index is 35 (7 times 5). For the final step, the individual factor indices are added together to arrive at the DRASTIC index.

The degree of confidence in a DRASTIC index number is a function [illegible] reliability of the hydrogeologic information used to rate each factor. In settings where the hydrogeologic information is well established, due to localized ground water and geologic studies, for example, the index will have a narrow confidence band. As in any procedure involving professional judgment, a more experienced or better trained evaluator will provide a more accurate portrayal of ground-water vulnerability to contamination.

4.5.1.2 Application of DRASTIC to the Classification Review Area

DRASTIC can be applied to the Classification Review Area using one of two approaches. In the most general approach, the ranges of each DRASTIC factor can be estimated from available information and a single DRASTIC index generated

TABLE 4-5
DRASTIC RANGE RATING FOR DEPTH TO WATER
(FROM ALLER ET AL, 1985)

Depth to Water (Feet)	
Range	Rating
0-5	10
5-15	9
15-30	7
30-50	5
50-75	3
75-100	2
100+	1
Weight: 5	

for the entire Classification Review Area. The average rating for each factor would be chosen where the range in the values of actual factor parameters spans two or more ratings. For example, if the depth to water across the Classification Review Area ranged from 5 to 30 feet, then two ratings would be bracketed (see Table 4-5), ratings of 9 through 7. An average rating of 8 would be chosen. This approach does not allow for the differentiation between hydrogeologic settings within the Classification Review Area where the range in values of factor parameters may not be so variable.

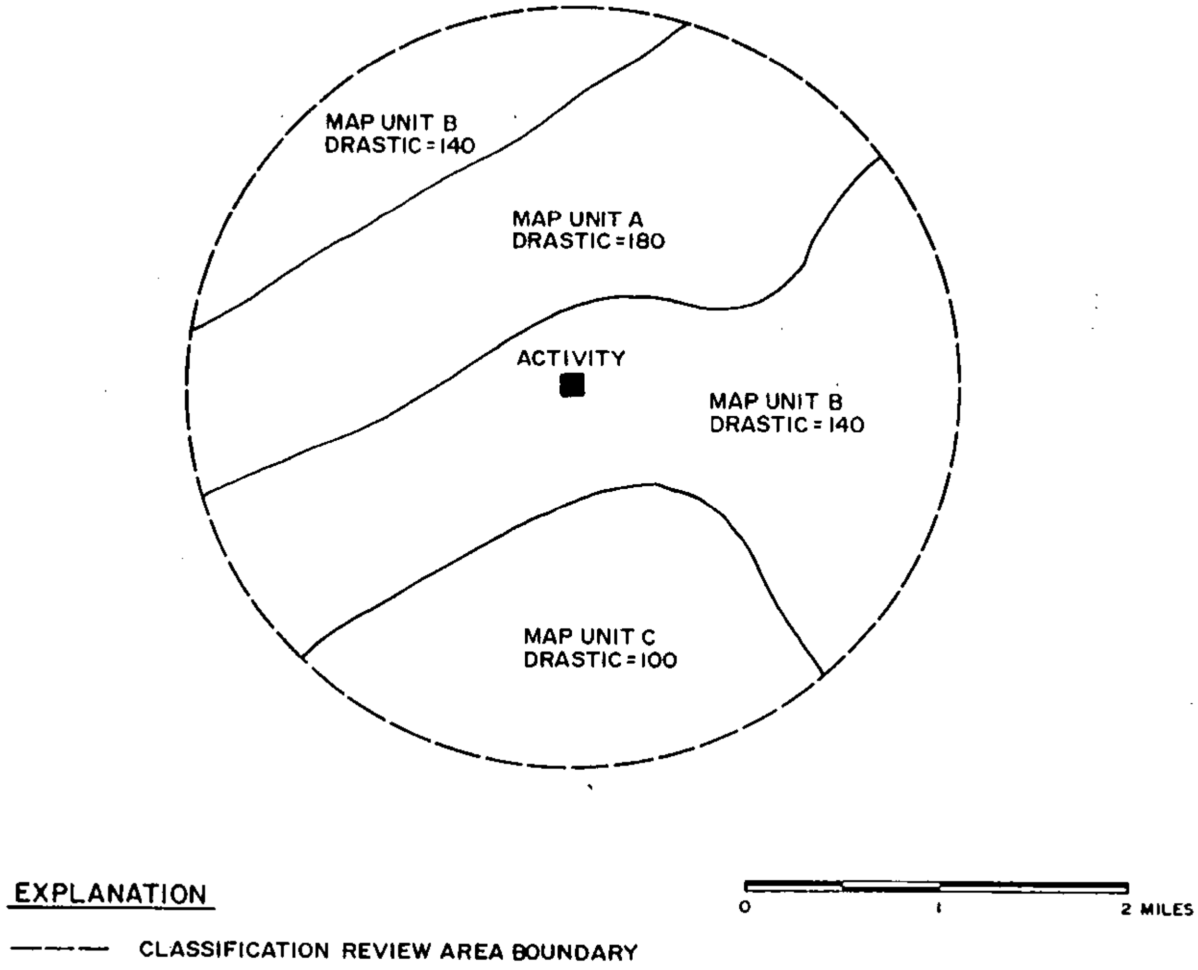
The second approach is to map out the major hydrogeologic settings that have significantly different DRASTIC indices within the Classification Review Area. Differences in DRASTIC indices in the range of 10 to 20 or more index points are considered significant. Where DRASTIC units are mapped out, an area weighted, average index can be computed. However, if the activity occupies any portion of a DRASTIC map unit with an index greater than the "highly vulnerable" criterion, or, if more than 50 percent of the Classification Review Area exceeds the criterion, the setting should be designated as highly vulnerable.

As an illustration of the mapping approach, consider the proposed activity shown in Figure 4-19. Within the Classification Review Area, three hydrogeologic settings have been mapped and labeled: A, B, and C. The DRASTIC index for each hydrogeologic setting is 180, 140, and 100, respectively; while, the area for each setting is 20 percent, 45 percent, and 35 percent, respectively. The weighted average DRASTIC index is calculated as follows:

Map Unit	DRASTIC Index	Proportion of Area	Area Weighted Index
A	180	.20	36
B	140	.45	63
C	100	.35	35
		Weighted Index	134

For this illustration, the map-unit, area-weighted DRASTIC index of 134 is less than the highly vulnerable criterion of 150. If map-unit A had been greater than 50 percent of the Classification Review Area, or, if the activity had occurred in map unit A, the designation of highly vulnerable would have been automatic.

FIGURE 4-19
ILLUSTRATION OF DRASTIC MAPPING



4.5.1.3 Limitations to the Application of DRASTIC

DRASTIC has been designed to account for a number of different conditions, among which are multiple aquifers and confined aquifers. There is also a separate index designed strictly for agricultural analyses.

The DRASTIC methodology allows for the depth-to-water rating to be adjusted for confined aquifers. With this technique, different aquifers within the Classification Review Area could receive a different DRASTIC index. Generally, the deeper aquifers will be less vulnerable. However, contaminants entering in a vulnerable recharge area may reach even the deepest aquifer given sufficient time. The system typically favors the uppermost aquifer in determining vulnerability and a single DRASTIC index attributable to the Classification Review Area, or subdivision of the Classification Review Area. This is generally consistent with Agency's philosophy that the primary aquifers threatened by the bulk of EPA regulated programs are those under table conditions. Where the uppermost aquifer is found to be vulnerable, all ground water with a high degree of interconnection to the uppermost aquifer is to be considered highly vulnerable. Confined aquifers with a low-to-intermediate interconnection to the uppermost aquifer are considered less vulnerable.

The DRASTIC method also establishes a separate and different set of factor weights for agricultural activities. Because the Agency has decided to consider vulnerability as independent of activity, only the regular factor weights will be applied.

4.5.2 Option B: Qualitative Assessment

In this option, the user of Guidelines would select the most appropriate operational tools for assessing vulnerability. The selection might be based on factors such as site setting, professional experience of the user, the availability of data, or previous program experience. In some cases, general comparisons of the hydrogeologic setting to others where vulnerability is a concern might suffice. The analysis might end at that point, or a detailed mapping or flow net analyses might commence. Option B is called "qualitative," since these Guidelines would not include referred tests of methods to follow, or other numerical criteria/ decision steps.

There are five general categories of vulnerability methods which have been analyzed in the context of these

Guidelines. Within each of the five broad categories is a series of sub-approaches that could be used. Although discussed in Appendix B, the five are summarized in Table 4-6. As one moves from the "qualitative description" approach through to the "integrative criterion", sophistication generally increases along with cost and complexity. The qualitative approach could include some of the DRASTIC factors as well. Rather than utilize the ranking and weighing scheme discussed in the previous section, or all of the seven DRASTIC factors could be reviewed for a given area, and professional judgment used accordingly.

TABLE 4-6
SUMMARY OF OPERATIONAL METHODS FOR DEFINING THE KEY TERM "HIGHLY VULNERABLE" GROUND WATER

METHODS	EXAMPLES OF "HIGHLY VULNERABLE"	COMMENTS
1. Qualitative description of highly vulnerable hydrogeologic settings	Highly vulnerable settings: a. unconfined aquifers overlain by sandy, highly permeable soils, or b. karst terrain, or c. ground-water recharge areas	Simple to use; requires judgement to match real settings to qualitative descriptions and a need for lengthy process to inventory descriptions of hydrogeologic settings judged to be highly vulnerable.
2. Single independent factor and criteria.	Vadose zone thickness less than 150 feet <u>or</u> hydraulic conductivity $>1 \times 10^{-4}$	Simple to use; difficult to establish single criterion which is realistically applicable across the country.
3. Multiple independent	Vadose zone <150 feet, hydraulic conductivity $>1.0 \times 10^{-4}$ cm/sec, <u>and</u> recharge >5 inches per year	Improvement over single factor; in use by States; assumes each factor equal weight; assumes failure to meet any factor criterion will result in a determination of highly vulnerable; interrelationships between factors is ignored.
4. Numerical rating (weighted and non-weighted). For example, DRASTIC, a rating scheme developed by the National Water Well Association (Aller et al, 1985); other examples: . The hazard-ranking system for CERCLA (40 CFR 300, Appendix A); and . Legrand's standardized system for evaluating waste-disposal site (Legrand, 1980).	DRASTIC index greater than 150 over CRA	A more sophisticated method allowing for factor weighting and a single score or index. Weighted factors are added. States often moved in this direction after considering multiple factor approach; provides for professional judgment in selecting specific ratings; sometimes critized for being too "simplistic" for site-specific geotechnical assessment
5. Integrative criterion. Time-of-travel for a selected distance or time to reach an exposure point.	Average time-of-travel greater than 1/2 foot per day over CRA	Allows for factor weighting and a single score. Considers the interrelationships between factors. Very data intensive. Yields a single score. Not suited to mapping large areas.

4.6 Determination of Reasonable Treatment

The ground-water classification system indicates that Class III ground waters are those which (1) contain greater than 10,000 mg/l total dissolved solids (TDS); (2) are yielded in insufficient quantities to satisfy the needs of an average household; or (3) are so contaminated that they cannot be cleaned up using treatment methods reasonably employed in public water systems. An approach to define the latter based on a comparison to "reference technologies" is provided in this section. An alternative approach, new to this draft, is available for consideration and review. Although the test is somewhat more complete and, perhaps, expensive to perform, it is believed to be more rigorous and definitive in its application. The alternative which can eventually replace, or be used in conjunction with "reference technologies" is fully discussed in Appendix G.

4.6.1 Standards and Criteria for Treatment

The above definition implies that an analysis of treatment methods should consider relevant "standards and criteria" for long-term drinking water use. No one set of such "numbers" are available and thus, some professional judgment may be required.

Under the Safe Drinking Water Act, for example, EPA has issued National Interim Primary Drinking Water Regulations (NIPDWR). These regulations set maximum contaminant levels (MCLs) for a number of inorganic, organic, and microbiological contaminants in drinking water. These values are based on both health factors and technical/economical feasibility. MCLs for selected parameters can be found in Table 4-7.

In addition to MCLs which are enforceable standards, RMCLs or recommended maximum contaminant levels are set reflecting EPA's goal of no known or anticipated adverse health effects. Both RMCL and MCL values are updated periodically. For example, proposed RMCL values for eight volatile organic chemicals are published in the Federal Register (1985). It is the objective of the agency to set MCLs as close to RMCLs as possible.

EPA provides drinking water suppliers with additional guidance under the authority of the Safe Drinking Water Act. EPA is now in the process, for example, of developing RMCLs for additional contaminants to serve as guidance for establishing new drinking water MCLs. The Agency is accelerating the pace of both RMCL and MCL issuance. Other chemicals addressed under the Clean Water Act (CWA) may be inter-

TABLE 4-7
RMCL & MCL VALUES FOR SELECTED CONTAMINANTS[1]

Contaminants	RMCL (mg/l)	MCL (mg/l)
Inorganic Species:		
Arsenic	0.05	0.05
Barium	1.5	1
Cadmium	.005	0.010
Chromium	.12	0.05
Fluoride	-	1.4-2.4
Lead	0.020	0.05
Mercury	.003	0.002
Nitrate (as N)	10	10
Selenium	.045	0.01
Silver	-	0.05
Organic Species:		
Benzene	0	-
Vinyl Chloride	0	-
1,1-Dichloroethylene	0.007	-
1,1,1-Trichloroethane	0.20	-
p-Dichlorobenzene	0.750	-
Trihalomethane	-	.1
Lindane	-	0.004

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[1] Sources: Federal Register, Vol. 50, No. 219, Nov. 13, 1985. p 46889, p 46958, p 46957.
Guidance on Feasibility Studies Under CERCLA, June 1985, U.S. EPA, Cincinnati, Ohio

mittently encountered in a water system, and are believed to pose a risk for the near term, yet are currently unregulated in drinking water. The guidelines for these are developed by the Office of Drinking Water in the form of Health Advisories. The health advisories are not mandatory for public water systems, but provide information for emergency situations. (Health Advisories are available on some contaminants where no MCLs or RMCLs are published, Table 4-8.) They are calculated at three exposure levels: one day, seven or ten days, and longer term (1 to 2 years). A margin of safety is factored in to protect the most sensitive members of the general population (U.S. EPA, 1985; Federal Register, 1985).

Finally, the RCRA program in developing its Alternate Concentration Limits (ACLs), and in responding to the land disposal bans portion of the RCRA amendments of 1984, will be examining the applicability of other sets of criteria and standards for both carcinogenic and non-carcinogenic contaminants. These will likely be useful for addressing the large number of contaminants without current MCLs, RMCLs, or health advisories.

4.6.2 Treatment Technologies

Many different treatment technologies are currently used for treating surface and ground waters which serve as public drinking water supplies. These technologies can be classed into five general categories: volatile organic chemicals removal; non-volatile organic chemicals removal; metals removal; non-metallic inorganic chemicals removal; and disinfection. Some technologies are effective in reducing only a few types of contaminants, while others may efficiently treat several contaminant classes simultaneously. Although most processes are designed to treat a single "class" of contaminants, many will provide some beneficial, non-design removal of other contaminant classes. (Appendix E briefly describes each of several generic treatment technologies with reference to their appropriate usage and limitations.)

4.6.2.1 Regional Availability of Reference Technologies

Table 4-9 presents the use of various treatment technologies by EPA Region. Most of the reference technologies are currently in use at public water supply systems in all regions of the country, however, not necessarily in hazardous-waste applications (e.g., carbon adsorption is sometimes used in taste and odor applications and not for removal of volatile organics). The exceptions to this are

TABLE 4-8
HEALTH ADVISORIES FOR SELECTED CONTAMINANTS IN WATER

CHEMICAL	Health Advisories mg/l 1-day	10-day	Longer Term
Benzene		0.23	0.07
Carbon Tetrachloride	0.2	0.02	
Chlordane	0.0625	0.0625	0.0075
1,1-Dichloroethylene	1.0		0.07
1,2-Dichloroethylene	4.0	0.4	
1,2-t-Dichloroethylene	2.7	0.27	
Dichloromethane	13	1.3	0.15
Ethylene glycol	19.0		5.5
Formaldehyde	0.030	0.030	
n-Hexane	13	4.0	
p-Diozane	5.68	0.598	
Methyl Ethyl Ketone	7.5	0.75	
Polychlorinated biphenyls (PCB)	0.125	0.0125	
Tetrachloroethylene	2.3	0.175	0.02
Toluene	21.5	2.2	0.34
1,1,1-Trichloroethane			1.0
Trichloroethylene	2.0	0.2	0.075
Xylenes	12	1.2	0.62

[a] Total trihalomethanes refers to the sum concentration of chloroform, bromodichloromethane, dibromochloromethane, and bromoform.

TABLE 4-9
APPLICATION OF TREATMENT TECHNOLOGIES IN PUBLIC WATER SUPPLY SYSTEMS, BY EPA REGION[a]

	Number of Systems Identified									
	I	II	III	IV	V	VI	VII	VIII	IX	X
Technologies Applied in All Regions										
Aeration[b]	6	28	21	58	96	9	40	8	17	2
Carbon Adsorption	7	12	8	4	13	3	1	4	4	2
Chemical Precipitation	28	55	67	109	227	25	96	35	37	12
Chlorination	43	99	96	161	292	70	86	64	119	55
Flotation[e]	30	64	94	186	217	58	90	70	80	31
Fluoridation	30	38	42	97	211	15	57	23	9	12
Granular Media Filtration	20	48	61	107	185	32	65	44	62	24
Technologies Applied in Some Regions										
Air Stripping[c]	3	3	4	2	0	0	0	0	2	0
Desalination	0	0	0	5	0	6	0	1	8	20
Ion Exchange	0	5	3	2	28	1	2	2	0	1
Ozonation	0	0	1	2	0	0	0	0	0	0
Technologies Generally Not Applied[d]										
Distillation	0	0	0	0	0	0	0	0	0	0
Wet Air Oxidation	0	0	0	0	0	0	0	0	0	0
Biological Treatment	0	0	0	0	0	0	0	0	0	0

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[a] This table is based primarily on data available in the 1981 AWWA Survey of Public Water Supply Systems, and supplemented with case studies drawn from the available literature. The data reflect only the use of the technologies in water utilities, and to not represent usage patterns of those technologies for wastewater or industrial process water treatment. Data describing 1500-1600 public water systems were consulted.

[b] The AWWA Survey includes air stripping in this category.

[c] Plants were identified independent of the AWWA survey.

[d] No evidence of application of these technologies was found in the set of 1500-1600 public water systems examined.

[e] Includes technologies using skimming, diffused air, diffused oxygen, and pressurized gases.

desalination, ion exchange, and ozonation; these treatment technologies may be considered reasonably employed in certain Regions. Air stripping, which is most often used for removal of volatile organic solvents from ground waters, should be considered "available" for Class III analyses, despite its limited use in public water supply systems.

Other treatment technologies may be applicable in the future, but are not now considered readily available or reasonably employable. Distillation techniques have long been employed for treating industrial process water, for example, but is generally reserved for such water, for example, but is generally reserved for such areas as water-short islands. Biological treatment techniques have been used for in situ clean up of ground waters and although efforts to develop biological treatment technology is not applicable or reasonably employable. Wet air oxidation techniques are used in industry for removal of organics from process wastewater. Efforts to develop this technology for application in water treatment are also underway, but the techniques should not be considered reasonably employable.

The reference list of these technologies are used to define the set of available water treatment technologies. A partial bibliography of resources and references is given in Appendix E.

4.6.2.2 Treatment Efficiencies

Evaluation of treatment efficiencies for a single contaminant or group of contaminants requires the evaluation of interferences and interaction of contaminants. General background data on treatment performance indicate ranges of values for efficiency. For example, *EPA's Treatability Manual for Priority Pollutants* (U.S. EPA, 1980), presents examples of typically achievable contaminant removal efficiencies for a range of contaminants and technologies.

More precise determination requires pilot testing or comparison by experts with other similar waste streams. Appendix E indicates the general level-of-success the various treatment technologies have with frequently encountered waste streams. Removal efficiencies are not reported in the literature for all contaminants, as experience using certain technologies is not available.

Contaminant concentration, physical conditions (e.g., pH, temperature), solution chemistry, and the presence of competing or interfering contaminants can all contribute to the large variations in removal efficiencies that are reflected in the literature. For situations in which a more accurate assessment of treatment efficiencies is desired, the user of these guidelines may wish to refer to a partial bibliography of sources listed at the end of Appendix E.

Table 4-10 lists some of the major advantages, disadvantages, and limitations associated with each treatment process. For developing process configurations, it is usually desirable to remove the contaminants first that they may interfere with subsequent processes. For example, if a system uses both granular media filtration for solids removal and ion exchange for softening, the filtration stage should precede the ion exchange stage in order to assure that potential resin-fouling solids are eliminated from suspension. As another example, plants with solvent contamination will air strip or carbon adsorb the organics prior to chlorination, to prevent the formation of halogenated organics which are less efficiently removed.

4.6.3 Methodology for Determining Treatability

To determine if a ground water can be cleaned up using treatment methods reasonably employed by public water systems, the permit reviewer may wish to follow the steps described below.

1. Describe the contamination problem.

The description of the contamination problem should include information on the natural or background water quality, the extent of contamination, and the physical factors influencing both ground water and treatment. The natural quality of a ground water may be inferred from historical data or by comparison to background ground waters in the site vicinity.

Contaminants in the ground water of concern should be specified and the range in concentrations noted. In particular, if the type and concentration of contaminant vary spatially, this should be indicated as it has design implications for treatment configurations. The analyses used and the range of sampling and measurement error should also be provided to assist the reviewer in understanding the degree of certainty of contamination. It is important to address the areal extent of contamination to be sure it meets the basic notion that contamination is not related to an individual facility or activity.

The physical parameters of concern include flow patterns, climatology, and other site-specific issues. Many of

TABLE 4-10
DESCRIPTION OF TREATMENT PROCESS

	Air Stripping/Aeration	
Advantages	Disadvantages	Limitations
Low capital and O&M	Temperature sensitive (cold) contaminants	Removes only volatile
High removal efficiencies for some contaminants	May result in air pollution or a need for Emission Control	Suspended solids in influent may lead to removal efficiency loss due biological growth (air stripping only)
Pretreatment is generally not required for ground water		
Equipment can be purchased off the shelf		
	Carbon Adsorption	
Advantages	Disadvantages	Limitations
Low energy requirements	Management of spent can be expensive and problematic - Regeneration - Disposal - Replacement	For organics removal where concentrations are high, frequent carbon regeneration necessary
High removal efficiencies for a wide range of contaminants over a broad concentration range	High capital and operating costs	Suspended solids should not exceed 50 mg/l Oil and grease should not exceed 10 mg/l Requires steady hydraulic loading

TABLE 4-10 (Cont.)

Advantages	Disadvantages	Limitations
Equipment is readily available and easy to operate	Generates large quantities of sludge which must be treated and disposed	Frequent laboratory testing is required to maintain high efficiencies
Low energy requirements	Effluent quality may vary considerably due to uncontrollable circumstances	pH dependent
Low capital and O&M costs		No concentration limit
	Desalination[1]	
Advantages	Disadvantages	Limitations
Excellent removal of charged anions and cations	High energy requirements	Suspended solids must be low to prevent fouling
Good removal of high molecular weight organics	Requires extension pilot analyses for each system	Operating temperatures must be between 65°F and 85°F
Effective treatment for removal of dissolved solids	Highly sophisticated instrumentation and control	
	Generates a concentrated brine which may require further treatment	
	Pretreatment almost always required	
	High capital and O&M costs	

[1] Reverse osmosis, ultrafiltration

TABLE 4-10 (Cont.)

	Granular Media Filtration (e.g., sand filters)	
Advantages	Disadvantages	Limitations
Highly reliable	Process generates a backwash which must	Influent suspended solids should not
Relatively simple; easy to operate and control		Requires fairly steady hydraulic loading
Multiple media can be used to improve efficiencies		

	Ion Exchange	
Advantages	Disadvantages	Limitations
Synthetic resins can tolerate a wide range of temperature and pH	General concentrated regenerant brine which must be disposed	Influent concentrations should not exceed 4,000
Can remove a variety of cationic and anionic inorganic and organic contaminants	Generates concentrated regenerant brine which must be disposed	S.S. should not exceed 50 mg/l
Low energy requirements	Generally, but not always high capital and O&M	Influent should not contain chemical oxidants (e.g., ozone)

TABLE 4-10 (Cont.)

	Ozonation	
Advantages	Disadvantages	Limitations
Reduces chemical residuals generated (particularly, no chlorinated hydrocarbons	[illegible] capital and high energy	Treats only contaminants which can be oxidized
No dissolved solids generation	Requires high level of training and safety precautions for operation	Does not remove iron-cyanide complexes
Easily implemented	May require substantial	Narrow range of removal - e.g., not effective for contaminants with density greater than water
Usually highly effective for hydrocarbons with densities near or less than water	Generates large quantities of sludge to be treated and disposed	
Low capital & O&M		
Low energy requirements		

the treatment processes are highly sensitive to temperature fluctuations; therefore, ambient temperature ranges become important in selecting appropriate technologies or housing requirements. The climate in the area of concern, including data on the freeze/thaw cycles, and any storm or wind events that may affect the treatment processes must also be considered. Other site-specific considerations may become important on a case-by-case basis.

2. Determine the desired effluent quality

To determine the desired quality of the treated water following completion of all treatment processes, acceptable concentrations for each contaminant must be addressed. Relevant Federal Criteria include the MCL, the RMCL, and the longest-term Health Advisory for each contaminant. These values are sometimes unavailable for certain contaminants due to insufficient data.

3. Define the applicable treatment technologies

For each contaminant present, certain treatment technologies may be particularly applicable. Refer to Table 4-8 and Table 4-9 and supplementary information in Appendix E to identify regionally available removal technologies for each contaminant. This list of technologies should be considered the universe of available processes for treating the ground water.

4. Compile regionally available process configurations

Before assessing ground water treatability, the permit reviewer must define a set of treatment process configurations that may be used to remove contaminants from the ground water. These process configurations should be developed considering efficient contaminant removal to the minimum level required. Any combination of the treatment processes should be considered readily available nationwide.

5. Evaluate treated water quality

To evaluate typically achieved water quality using any given treatment process configuration, the concentration of specific contaminants in the ground water/influent, levels of background water quality parameters (pH, TDS, etc.) and the removal efficiencies of each contaminant using each treatment process ideally should be known.

Background data/manuals on treatability developed by EPA can be consulted for initial guidance on treatment performance. For example, typical removal efficiencies are indicated in EPA's Treatability Manual for Priority Pollutants (U.S. EPA, 1980). A qualified water treatment engineer could also determine the relative effectiveness and a probably range of effluent quality levels achievable for many frequently encountered contaminant mixes. Interference effects possibly, from adverse levels of various contaminant combinations, background water-quality parameters (e.g., pH, or heavy metals, varying concentrations), can affect the efficiency of treatment processes. Because of this, in complex mixtures or where little experience exists, the lack of bench or the pilot scale treatability studies may limit the ability of the engineer in developing an estimate.

6. Determine if desired water quality is met.

Once the approximate effluent concentration of each contaminant has been evaluated for a given treatment process, these can be compared to the appropriate water quality standard. If all effluent concentrations are less than the desired water quality, the ground water can be cleaned up using treatment methods reasonably employed in public water supply systems. If some effluent contaminant concentrations exceed desired water quality, the treatment process configuration does not adequately clean the ground water, and an alternative configuration should be evaluated for contaminant treatability. If all available treatment process configurations do not remove contaminants to the levels which meet desired water quality, the ground water cannot be cleaned up using treatment methods reasonably employed in public water supply systems. These will then be candidates for Class III.

4.6.4 Sample Problem

The following example is illustrative in nature and is not meant to represent conditions at any specific facility.

A permit applicant has asked to site a facility in Region IV, and has made the claim that the site location will only affect Class III ground water. The chemical contaminants in the ground water, listed in Table 4-11, are apparently from multiple sources and occur throughout the Classification Review Area.

The desired water quality levels are listed in Tables 4-7 and 4-8. For cadmium and selenium the applicant defines the desired maximum effluent contaminant concentrations to be equal to the MCLs as presented in Table 4-7. For carbon tetrachloride, desired effluent quality is derived from the ten-day Health Advisory (the only available), while for

TABLE 4-11
EFFLUENT QUALITY WORKING TABLE FROM SAMPLE PROBLEM

Contaminant	WQ_i[a]	WQ_d[b]	Treatment Process Removal Efficiencies[c] Process A	Process B	Process C	Process D	Process E	Process F	WQ_o[d]	Desired Water Quality Achieved?
Process Configuration A			Air Stripping	Chemical Precip.	Filtration	--	--	--		
Trichloroethylene	8.2	0.075	98	60	7				0.066	Yes
Tetrachloroethylene	20.0	0.2	98	95	0				0.02	Yes
Carbon Tetrachloride	65.0	0.02	98	95	90				0.007	Yes
Toluene	110.0	0.34	95	75	65				0.48	No
Cadmium	0.5	0.01	0	90	70				0.015	No
Selenium	2.0	0.01	0	70	60				0.24	No
Process Configuration B			Air Stripping	Chemical Precip.	Filtration	Desalination	--	--		
Trichloroethylene	8.2	0.075	98	60	7	7			0.066	Yes
Tetrachloroethylene	20.0	0.02	98	95	0	80			0.004	Yes
Carbon Tetrachloride	65.0	0.02	98	95	90	7			0.007	Yes
Toluene	110.0	0.34	95	75	65	50			0.24	Yes
Cadmium	0.5	0.01	0	90	70	60			0.006	Yes
Selenium	2.0	0.01	0	70	60	97			0.007	Yes

[a] *WQ_i = the influent contaminant concentration, in mg/l*

[b] WQ_d = the desired maximum effluent contaminant concentration, in mg/l

[c] Removal efficiencies report in percent

[d] WQ_o = the calculated effluent contaminant concentration, in mg/l

toluene, trichloroethylene, and tetrachloroethylene a long-term Health Advisory was used.

The treatment processes that most readily removes such volatile organics such as carbon tetrachloride, tetrachloroethylene, and toluene include carbon adsorption and air stripping. Metals, such as cadmium and selenium, can be removed using chemical precipitation, desalination, and ion exchange. Granular media filtration would probably be considered for removal of residual particulate matter, following a chemical precipitation step, particularly if desalination, carbon adsorption, or ion exchange processes followed. All of these processes are currently in use in public water supply systems in Region IV.

Achievable effluent quality must be evaluated for each treatment process configuration to determine if the ground water can be treated to meet desirable levels. Process and contaminant specific removal efficiencies are provided for all six contaminants. (Please note: these values are to illustrate the process and are not intended to be actual efficiencies.) As indicated by calculated WQ_O values and comparing them with WQd values (Table 4-10), treatment process configuration A can result in removal of trichloroethylene, tetrachloroethylene, and carbon tetrachloride to acceptable levels. However, levels of cadmium, selenium, and toluene following treatment using process configuration A can not meet the desired water quality. Therefore, the applicant must consider an additional treatment process configuration.

Removal efficiencies for the process configuration B including air stripping, chemical precipitation, filtration, and desalination can achieve acceptable water quality levels for all contaminants. Thus, according to this methodology, this ground water is not Class III because it can be cleaned up using treatment methods reasonably employed in public water supply systems.

An alternate economically-based test for determining the treatability of potential Class II ground water is proposed in Appendix G.

4.7 Ground-Water and Surface-Water Interaction

Interconnected ground water and surface water may be managed or regulated for different, and sometimes conflicting, uses. The Agency recognizes that the interconnection and interaction between ground water and surface water necessitates coordination between efforts to classify and manage both kinds of water resources.

Two conditions involving the interaction between ground water and surface water deserve consideration in ground-water classification. One condition is the recharge of ground water from a surface-water body. The other is the discharge of ground water to surface water.

4.7.1 Ground-Water Discharge to Surface Water

Ground-water discharge to surface-water bodies occurs in many hydrogeologic settings and is the dominant condition in high rainfall areas. Where poor quality ground-water discharges to surface water, a potential to impact the quality of those surface waters exists. The classification system accounts for three conditions where ground water is interconnected to surface waters and where surface-water quality may be degraded:

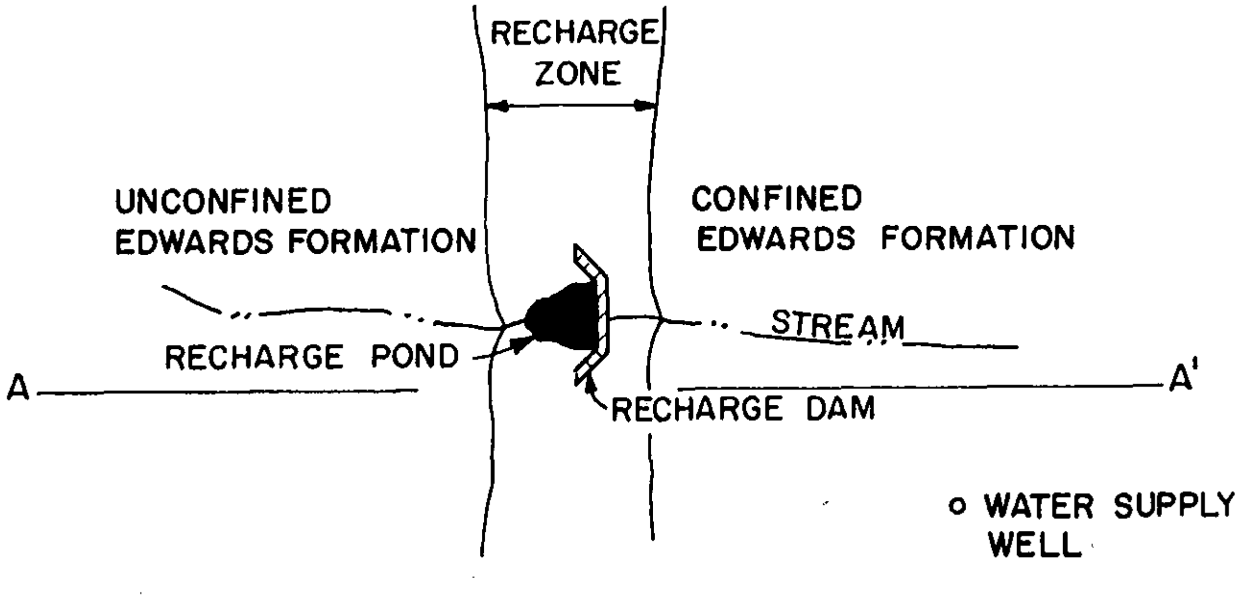
- Class I Ecologically Vital Ground Water - Ground waters providing base flow to, or supporting water levels for, unique terrestrial or aquatic habitats associated with water bodies;
- Class II Current Source of Drinking Water - Ground waters currently used as a source of drinking water, including those ground waters which discharge to a drinking water supply reservoir with a protected watershed
- Class III Ground Waters Not a Potential Source of Drinking Water - Saline or regionally contaminated ground waters that are interconnected to adjacent ground waters or surface waters.

4.7.2 Surface Water Recharge to Ground Water

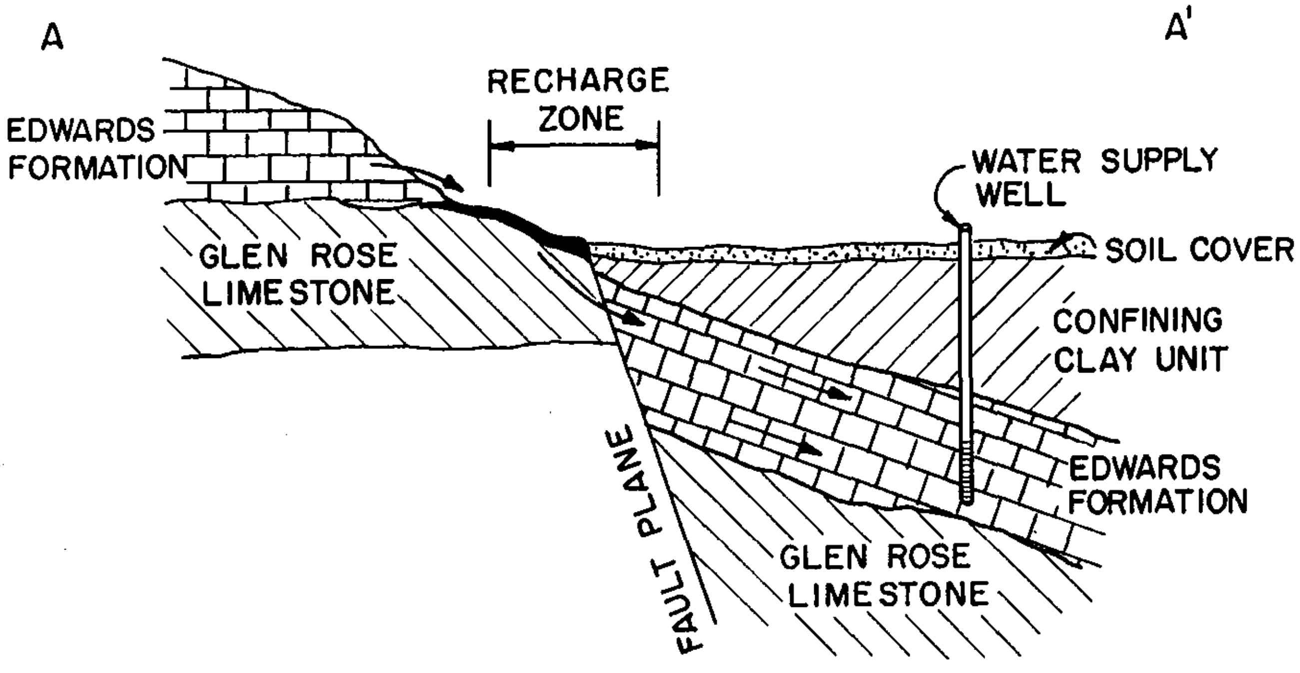
The recharge of ground water from a surface-water body is the natural and prevalent means of ground-water recharge in the drier western states, but can also occur in high rainfall-rich areas due to the pumping or ground water in close proximity to the water body. An example of surface-water recharge to ground water concerns the use of stream impoundments to accelerate recharge. Figure 4-20 shows such an impoundment, referred to as a recharge basin on a stream crossing the recharge zone of the Edwards Aquifer in Texas. Another example is the recharge of Mohawk River waters into a sand and gravel aquifer which supplies well fields serving the cities of Rotterdam and Schenectady, New York, as demonstrated in Figure 4-21. The following Figure 4-22 indicates that the warmer river water enters the aquifer, mixes with the cooler ground water, and is subsequently withdrawn by the wells.

The potential for poor quality surface water to degrade ground-water quality is implied in these examples. They further demonstrate the need to consider surface-water use and quality in managing ground-water quality where surface-water bodies provide significant recharge. The classification system by itself, however, is not intended to be the focus for managing such settings.

FIGURE 4-20
ILLUSTRATION OF SURFACE WATER RECHARGE TO
GROUND WATER FOR THE EDWARDS AQUIFER, TEXAS



PLAN



CROSS-SECTION

FIGURE 4-21
CROSS-SECTION OF AN ALLUVIAL AQUIFER SHOWING SURFACE WATER RECHARGE FROM THE MOHAWK RIVER

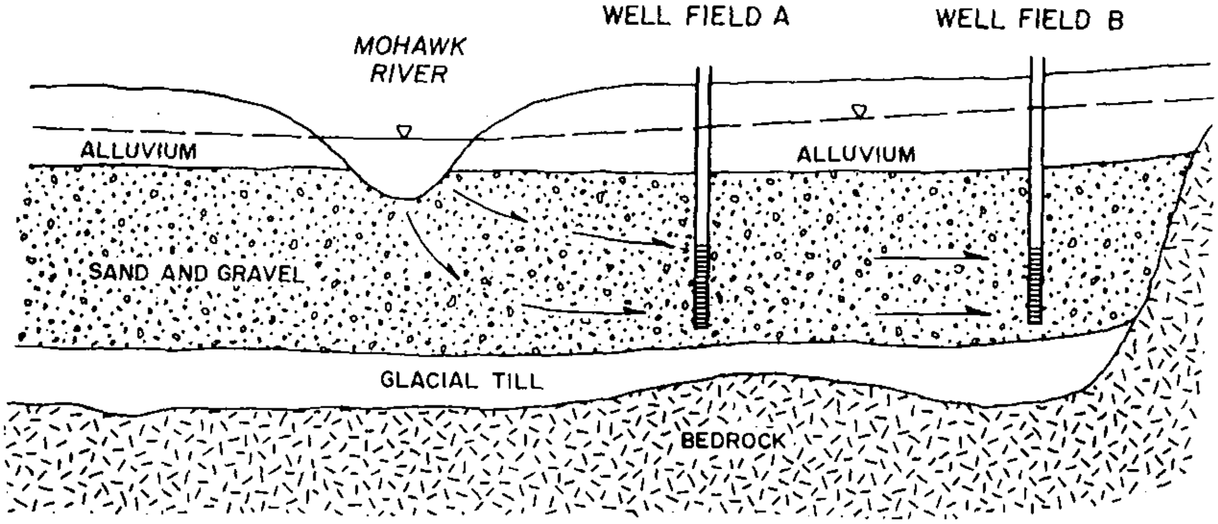
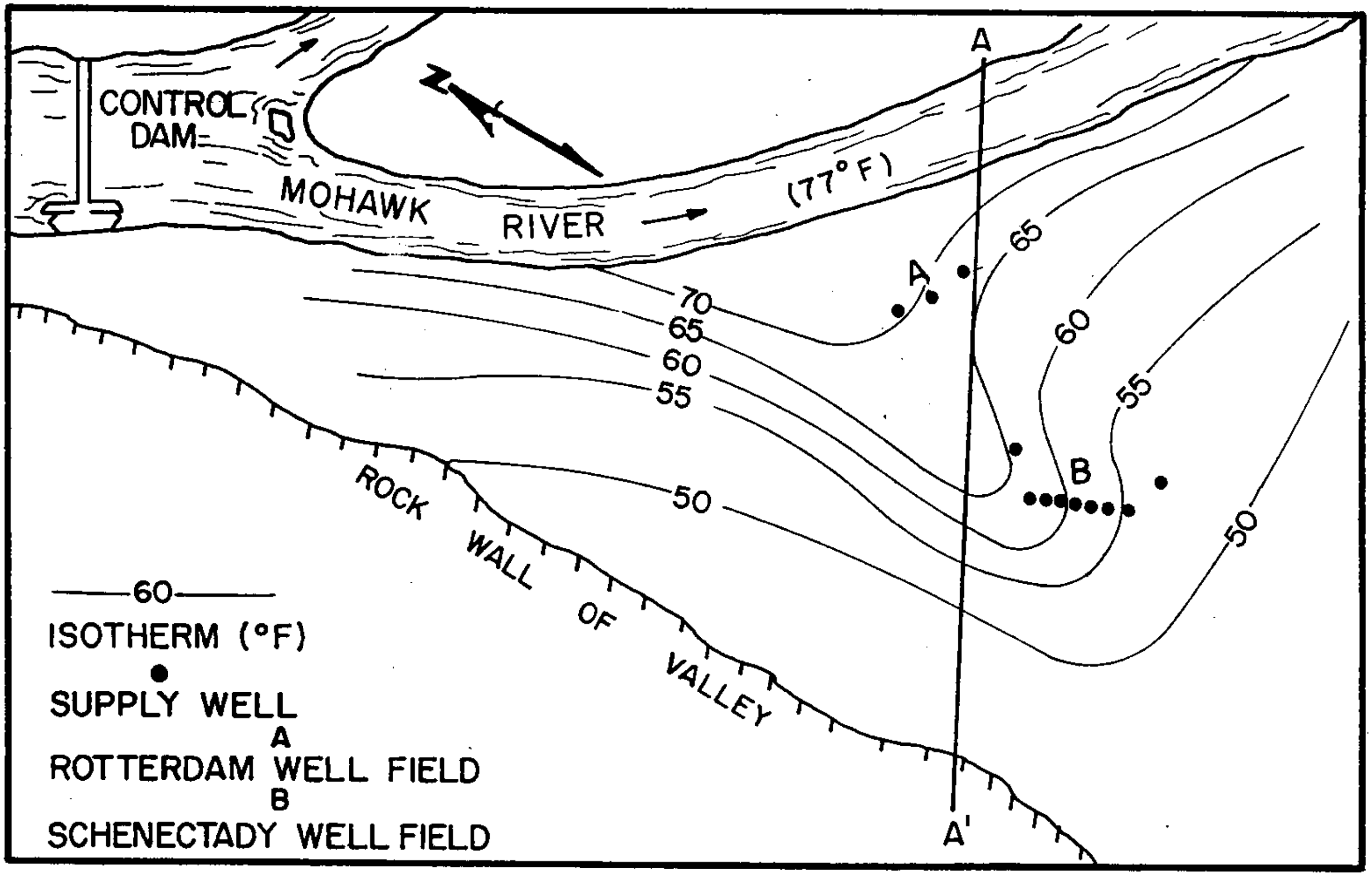


FIGURE 4-22
GROUND-WATER ISOTHERMS OF MOHAWK RIVER BASIN



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