APPENDIX G

ECONOMIC TESTS FOR DETERMINING CLASS I - IRREPLACEABLE AND CLASS III - UNTREATABLE GROUND WATERS

INTRODUCTION

I. Economic Tests for Class I-Irreplaceable and Class III-Untreatable Ground Waters

Ground-water classes are designed to provide a basis for differential protection of ground waters: Class I ground waters are those warranting higher degrees of control to provide extraordinary levels of protection, and Class III ground waters are those warranting the lesser levels of protection due to their use and value. Protection of ground water has both social benefits and social costs. The principal social benefits of ground-water protection are protection of human health and the environment and preservation of socially and economically-valuable ground-water resources. The social costs of protection result from the loss of the economic and other benefits of using the resource.

The Agency's Ground-Water Protection Strategy is based on the principle that the highest value of a ground water is as a current or potential source of drinking water. Certain ground waters warrant a high level of protection because the value of protecting their use as a source of drinking water far exceeds the potential social costs of protection. Conversely, the value of protecting certain other ground waters is very limited because it would be infeasible or inordinately expensive or impractical to use them as a source of drinking water due to contamination or other factors, and so these ground waters warrant a lower level of protection. The economic tests for Class I-irreplaceable and Class III-untreatable ground waters are designed to identify ground waters that warrant higher or lower levels of protection based on their economic value as a source of drinking water. These tests are, however, only several of many class-determining factors.

The economic test for Class I complement the technical, institutional and hydrogeological assessments of irreplaceability and untreatability. The need to include economic considerations can be illustrated by considering the result of performing classifications without applying the proposed economic tests. Failure to include the economic tests in determining class designations could result in some undesirable Class II designations. For example, ground waters that are replaceable based on technical and institutional criteria, but are highly valuable economic sources of water for a substantial population because they would be excessively expensive to replace, would be designated as Class II (in lieu of Class III) without the economic test. Similarly, a ground water that can be treated to drinking water standards, but only at such excessive expense, by national standards, that its use as drinking water is an extremely remote possibility, would be designated as Class II (in lieu of Class III) without the economic test. Incorporating the economic test would promote more appropriate class designations and corresponding levels of protection in such circumstances.

The economic tests for determining Class I-irreplaceable and Class III-untreatable ground water have similar structures and components. They are both simple, implementable proxies for an exhaustive socioeconomic evaluation of the benefits of protection. These tests are intended for use as "screening" tools only. Classifiers may employ more detailed analyses in making a Class III untreatable classification, depending on the availability of data and site-specific factors. In whichever level of analyses is performed, site-specific factors should be considered in determining the socioeconomic value of protection.

Each test involves comparing site-specific water supply costs with a cost threshold based on local or regional income levels. The cost of a replacement or alternate water supply system is estimated to approximate the value of ground water that is currently used as a drinking water source (a Class I candidate ground water). When the costs of replacement are high, the economic value of protection is high and the ground water, therefore, warrants a high level of protection. Using a similar approach, the cost of using the ground water as a source of drinking water is estimated as a measure of the value of protecting contaminated ground water that is not currently used as a drinking water source (a Class III candidate ground water). In this case, the cost of treating the ground water is inversely related to the value of protection. If this cost is extraordinarily high and other sources are available, the economic value of protecting the ground water is low because the ground water is unlikely to be utilized or provide other beneficial uses and the ground water, therefore, warrants limited protection.

The tests utilize a percentage of local or regional household income as a cost threshold for comparison with the estimated water supply costs to make the class determinations. The use of a local household income measure to establish a cost threshold, rather than a national standard, allows the tests to reflect variations in local economic conditions, and thus, provides a measure of local economic "burden" associated with a particular cost. Variations in cost estimates among ground waters will, in general, be much more significant than variations in income levels for class determinations using these tests.

The percentages of household income proposed as cost thresholds are based on typical water supply costs relative to household income of the service communities. Current data show that annual water supply costs typically range between 0.1 percent and 1.0 percent of household income. Mean or average costs are about 0.3 percent. Therefore, a cost threshold exceeding 0.3 percent of household income will identify inordinately high costs, and so thresholds exceeding 0.3 percent are proposed for both the Class I and Class III economic tests.

The percent threshold proposed for the Class I-irreplaceable ground water test approximates the very highest costs that people pay for a water supply. Water supply cost data show this level to be between 0.7 and 1.0 percent of household income. For Class III, the overall percent threshold is based on more average percentage of household income that people typically pay, i.e., 0.3 to 0.4 percent. For Class III an additional "treatment cost threshold" is also proposed, however, to focus the classification decision on whether or not the ground water is untreatable. If both cost assessments are above this level, the ground water is unlikely to be developed of a source of drinking water or for other beneficial uses. This portion of the test is essential in that, according to the Ground Water Protection Strategy, Class III is reserved for areas of <u>untreatable</u> ground water. Thus, the economic test must focus on this, to avoid designating as Class III, clean ground waters which are merely expensive to develop because of their depth or distance-to-population factors only.

The Agency has conducted sensitivity analyses of the effects of varying the thresholds. Varying the percent threshold has the effect of varying the number of ground waters designated as either Class I and Class III under the tests. Increasing the percentage thresholds decreases the number of Class I and Class III designations and visa versa. These analyses show that the percentage thresholds identify inordinately high costs, and set a balance so that the number of Class I or Class III designations that will be made will correctly identify ground waters deserving either higher or lower levels of protection. By setting thresholds at these levels, classifiers would not be overprotective by creating an unnecessarily large Class I group, or underprotective by making too many Class III designations. The analyses indicate that this balance is best achieved by using a different percentage of income threshold for the Class I test than the threshold proposed for the Class III test.

The use of a Class III threshold of between 0.7 and 1.0 percent thus accords with the objective of restricting the Class I designations to "special" ground waters, yet one which results in a sizeable Class I.

In summary, the economic test criteria for Class I are met when:

Water Supply System Replacement Costs (on an annualized basis)	$\geq$	0.7 - 1.0 percent of mean annual household income

A threshold of 0.3 percent to 0.4 percent is proposed for analyzing total system costs in the Class III economic test. Additional "treatment cost" thresholds are being proposed to focus the Class III test on the economic "treatability of the ground waters being classified." Recent studies by EPA's Office of Drinking Water show that ground water drinking-water supplies in water-scarce western states can cost as much as $300 per household per year. An informal survey of water utility rate increases that have been approved in recent years, indicates that rate increases over 100 percent of current rates have been proposed and rarily granted. These data provide indicators of when the additional costs of treating a particular ground water may be inordinately high. Therefore, the economic test criteria for Class III are met when:

> Annualized System Costs of an Alternative Water Supply exceed 0.3-0.4 percent of mean annual household income and
>
> The Treatment Costs of an Alternate Water Supply increase household water rates by more than 100 percent or a total of $300/household/year.

The treatment cost threshold may be adjusted to reflect regional or statewide treatment costs in comparable systems. Classifiers may wish to incorporate more detailed economic analyses which express the tradeoffs and/or benefits of protecting a candidate Class III ground water for future uses.

Ranges of values are being proposed so that classifiers will have the flexibility to apply a threshold value that is most appropriate for the situation. EPA is interested in receiving comments on the use of these economic tests, and/or other threshold values.

II. Rationale for the Economic Test of Irreplaceability (Class I)

The classifier may apply an economic test to determine whether ground waters that currently serve a substantial population (among other factors) warrant the special protection of a Class I designation.

The economic test of ground-water irreplaceability complements the assessment of the availability and suitability of an alternative water supply source by considering the economic feasibility of utilizing the alternative. Economic feasibility is determined by comparing typical costs of drinking water supplies to the income of service communities. The test designates a ground water as Class I-irreplaceable if (among other factors) the cost of utilizing an alternative water source is excessive relative to the income of the service community. Specifically, a potential replacement source is defined to be economically infeasible if the annual cost to a typical household user would exceed a percentage of the mean household income in the community.

The economic test, thus, identifies ground-water sources that are replaceable by technical and institutional criteria, but have a particularly high economic value because potential replacements are very costly, and therefore warrant a high or special level of protection.

Percentage of Income Threshold for the Class I Economic Test

The proposed threshold for the economic test is a range of 0.7 to 1.0 percent of annual household income. This range has been chosen by comparing typical water supply costs to the average annual household income of the service populations. Exhibit A presents data on typical water supply costs relative to national average household income. The data show that costs are typically between 0.1 percent and 0.3 percent of average annual household income. Water supply costs rarely exceed one percent of average household income. These data suggest that the threshold percentage of household income for the economic test should be chosen to exceed 0.3 percent to accord with the objective of identifying ground waters that are particularly costly to replace as sources of drinking water. Furthermore, sensitivity analysis of the effects of employing alternative thresholds on the number of Class I designations indicates that:

- Class I representation is fairly insensitive to economic thresholds between 1.0 percent and 0.5 percent

EXHIBIT A

TYPICAL WATER SUPPLY COSTS
RELATIVE TO NATIONAL AVERAGE HOUSEHOLD INCOME

Typical water supply costs per million gallons[a]	$450 - 1,500
Typical water supply costs per household per year[b]	$ 27 - 90
Average annual household income[c]	$26,500
Typical water supply costs as percentage of average household income	0.1 percent - 0.3 percent

[a]Source: Temple, Barker, and Sloane, Inc. 1982, Inflated to 1984 dollars.

[b]Assumes annual household usage of 60,000 gallons.

[c]Source: Average household income, 1983, Statistical Abstract of the U.S., 1986. Inflated to 1984 dollars.

- At a threshold of 1.0 percent, Class I representation is dominated by non-economic Class I criteria; and

- Class I representation is very sensitive to reductions in the threshold value below 0.5 percent.

The use of 0.5 percent or above thus accords with the objective of restricting Class I designations to ground waters for which the socioeconomic value of protection is particularly high, but the designation is not so overly restrictive that it would result in a negligible Class I.

<u>Implementation of the Economic Test</u>

Implementation of the economic test has two principal steps:

(1) Estimating the cost of developing an alternative source to provide drinking water to the population currently served by the ground water under review; and

(2) Comparing the costs of the alternative for a typical user household to the test percentage of average household income for the population.

<u>Estimation of Costs for Alternative Water Source</u>

The classifier must calculate the cost of the most economical alternate systems. He or she may base the system cost estimates on a system the same size as the one being classified, or he/she may estimate the size of the system that would be needed.

Water supply system costs can be broken down into four major components:

(1) Acquisition;
(2) Treatment;
(3) Distribution and Transmission; and
(4) Support Services.

Each of these costs elements may be incurred in developing an alternative source to supply a community with drinking water. Acquisition costs are the costs of producing or acquiring water, and can be thought of as the costs of getting the water to the treatment plant. These costs include the capital, operating, and maintenance costs of wells, reservoirs and aqueducts, and payments to suppliers for purchased water. Treatment costs include the costs of treatment plant and equipment, and the costs of chemicals that are added to the water. Distribution and transmission costs are the costs of pumping the water from the treatment plant to the service population, and the capital and maintenance costs of the piping network. Support services costs are the costs of administrative and customer services that are not directly related to the physical process of delivering water.

Exhibit B shows the average cost structure of the small and large systems surveyed by ACT Inc. (ACT Systems Inc., 1977, 1979). Costs are separated into the four major components, with the exception of interest expenses which were not allocated to particular cost components, and have been shown separately.

Water system costs vary depending on the scale of the system. Exhibit C shows average costs for ground-water and surface-water systems serving populations in various size categories, based on survey data collected by Temple, Barker and Sloane Inc. (Temple, Barker and Sloane Inc., 1982). The data were collected in 1981 and have been inflated to 1984 dollars.

These data show that there are significant economies of scale in systems operation. Systems serving populations of approximately 300,000 have average costs of about $600 per million gallons whereas systems serving populations between 2,000 and 20,000 have average costs in the range of $1,000-$1,500. Also, for systems serving over 5,000 people, there appears to be little difference between the average costs of systems that use predominantly ground water and systems that use predominantly surface water. Cost estimates for an alternative source should, therefore, reflect the consideration of the size of the system (determined by the population currently served by the ground water under review).

Cost estimates should also reflect the scope of measures that would be needed to supply the population from an alternative source. Three basic possibilities arise when developing an alternative water source: the first possibility is that only the acquisition component of the system would be needed; the second is that both acquisition and treatment components would be needed; the third is that, in addition to acquisition and treatment components, a transmission and distribution network would need to be constructed. These situations would lead to different costs.

Acquisition costs only would be incurred when existing treatment and distribution capacity could be used with the alternative source. Source development may include such

EXHIBIT B

TYPICAL COST STRUCTURES FOR WATER SUPPLY SYSTEMS

	Small Systems[a]		Large Systems[b]	
	Percentage of Operating Expenses	Percentage of Operating Expenses Excluding Interest Charges	Percentage of Operating Expenses	Percentage of Operating Expenses Excluding Interest Charges
Acquisition	19	22	15	19
Treatment	15	18	10	13
Distribution and Transmission	36	43	31	38
Support Services	14	17	25	30
Interest Charges	16	-	19	-
Total	100	0	100	-

[a]Serving between 300 and 75,000 people.

[b]Serving over 75,000 people.

SOURCE: ACT Systems Inc., 1977, 1979

EXHIBIT C

TYPICAL WATER SYSTEM COSTS[a]
(1984 $/million of gallons produced)

	Source	
Population Served by System	Surface Water	Ground Water
1,000 - 3,300	1,085	1,493
3,300 - 10,000	1,063	924
10,000 - 25,000	795	718
25,000 - 75,000	727	710
75,000 - 500,000	596	606
over 500,000	457	574

[a]Operating expenses (including depreciation and capital charges), inflated to 1984 dollars.

SOURCE: Survey of Operating and Financial Characteristics of Community Water Systems, Temple, Barker and Sloane, Inc., 1982 measures as locating and drilling a new well field in an alternative aquifer, or switching from a ground-water source to a surface-water source.

Both acquisition and treatment costs may be incurred when a difference in water quality between existing and the alternative water source requires that additional treatment processes be added in order to meet water quality standards. For example, the ground-water supply for a community may require no treatment other than chlorination; however, switching to a nearby surface-water supply may require addition of unit processes such a coagulation, flocculation, sedimentation, and filtration to the existing treatment plant to remove contaminants entering the reservoir with surface-water run-off.

Distribution and transmission costs may be incurred in situations where the installation of a new distribution system is necessary in order to supply the community with drinking water from an alternative source. Such extensive measures would generally be required in situations where a population is currently served by a number of private wells and the alternative would require a centrally located water supply system. This situation is particularly applicable to rural settings.

Estimation of costs for an alternative water source should be conducted using site-specific information to the fullest extent possible, because the costs of developing the source can vary widely depending on site-specific factors, and because the purpose of the test is to measure the effect of these factors on costs. However, the data on average system costs and cost structures presented in Exhibits B and C may be used to estimate costs for the system components that are likely to have similar costs to the national average. In these cases, national average system component costs for certain components would be combined with site-specific or source-specific estimates for other system components.

For example, development of an alternative source for a community of 4,000 people currently served by private wells may require development of all of the components of water supply system in order to utilize a nearby lake, which is the only suitable alternative source. In this case, the distribution and transmission and support services components of the system that would be required to develop this source might be typical of systems of similar size nationwide. The national average cost estimates could be used to estimate the costs of these components. From Exhibit B we note that these components typically comprise 60 percent of the costs of a small system (43 percent for distribution and transmission plus 17 percent for support services). From Exhibit C, we note that average costs per million gallons for surface water systems that serve between 3,300 and 10,000 people are $1,063. Thus $638 (60 percent of $1,063) could be used as the estimate of distribution and transmission and support service costs. (These costs would need to be inflated to the base year for which cost estimates are required. Further discussion of inflation adjustments can be found in Section III of this Appendix and Appendix E, which discuss the economic test for Class III ground-waters.) This estimate would then be added to source-specific estimates of acquisition and treatment costs. Acquisition costs might differ from national averages, for example, because use of the alternative source may involve purchase of expensive water rights and rights-of-way. Treatment costs might be high, for example, because the alternative source contains fertilizer and pesticide run-off from nearby agricultural land.

A number of information sources are available to estimate site-specific component costs. These sources include Federal and State agencies, architectural and engineering consulting firms, trade associations, and local water utilities. Various EPA reports on water supply and water treatment are also good sources of cost information (e.g., Culp, et. al., 1978). (Specific discussion of the use of data from Culp, et. al., is provided in section III of this Appendix in the context of cost estimation for the economic test for Class III). Other sources include the National Water Well Drilling Cost Survey (NWWA, 1979) for cost estimates of ground-water source development (acquisition costs). When utilizing cost estimates from disparate sources that refer to different time periods, care should be taken to allow for inflation (as well as local variations in labor and energy costs). EPA is expected to release updated cost information over the coming years in preparation for the implementation of the public water supply requirements of the Safe Drinking Water Act Amendments of 1986. Until these data are available, cost indices published quarterly by Engineering News Record can be used for this purpose.

Engineering costs are usually estimated in three components: capital costs (e.g., construction, capital equipment), operation and maintenance costs (e.g., labor, equipment replacement & maintenance, utilities, administration), and other costs (e.g., legal fees). Costs estimated in this way should be converted to equivalent annual costs. Annualization of capital costs is based on the expected lifetime of the capital and the cost of finance. As a first approximation, capital costs may be annualized by multiplying by a factor of 0.1. Thus:

Annualized Capital Costs = Capital Costs x Annualization (Factor (0.1)

and

Annualized Costs = Annualized Capital Costs + O&M costs.

Appendix E provides further discussion of annualization methodology.

For cost estimation, the required system size is determined by the substantial population currently served by the ground water under review. The following standard assumptions may be used to estimate the water capacity required to serve the population:

Average Household Size	= 2.75 persons
Average Annual Household Water Usage[1]	= 150,000 gallons

For example, a population of 4,000 people would require a system with an annual capacity of 218 million gallons (4,000/2.75 x 150,000 gallons per annum). This is equivalent to a capacity of approximately 0.6 million gallons per day (MGD).

Estimated costs of system components should be expressed on a common basis before they are combined. Typically costs are expressed on a per thousand gallon or per million gallon basis. (Exhibit C presents costs on a per million gallon basis). Annualized costs can be easily expressed on this basis by dividing annual costs by the capacity of the system.

Comparison of Costs with Average Household Income

Once the costs to utilize an alternative source have been estimated, the economic test can be performed by comparing the annual cost to a typical user household with the average household income of the population currently served by the ground water under review.

[1]150,000 gallons is used here to provide capacity for uses other than residential uses. This figure is based on an assumption of 150 gallons per person per day.

The estimated costs to a typical user should be based on the assumption that annual household water usage is 60,000 gallons. (Note that a higher assumption of water use (150,000 gallons) is used when determining system size.) Thus, if total estimated system costs are $1,000 per million gallons, the annual costs for a typical household would be $60 per household ($1,000/1,000,000 x 60,000). This figure is then compared with the average annual household income of the population served by the ground water under review. If data on the average household income of this population is not readily available, data for the county average household income may be used instead. These data are readily available from the Bureau of the Census publication entitled "County and City Data Book", which can usually be found in local libraries. Exhibit D presents state average household incomes, for reference. These aggregated data should be used instead only if more specific county data are unavailable. Again, income data should be inflated to the base year of the test.

When cost and income data have been compiled, the following division can be performed:

$$\frac{\text{Per Household Costs of Utilizing Alternative Source}}{\text{Average Household Income}}$$

The division will generally yield a ratio between 0.05 and 1 percent. If less than 0.7 percent, the ground water should be designated as Class II. If the result falls within or above the range of 0.7 to 1.0 percent, the ground water should be designated as Class I.

Example

A population of 6,000 (2,182 households) is currently served by individual wells in the Classification Review Area. The only viable alternative water source is a reservoir which is currently used largely for agricultural purposes, and is slightly contaminated by fertilizers and pesticides. Utilization of this alternative would require development of an acquisition system to pipe water to the population, a treatment plant capable of treating the water to drinking water standards, and distribution system to deliver the water to the service population. Thus, all of the system components would be required. The distribution and transmission component of the system and support services are likely to be similar to systems of similar size nationwide so national cost estimates may be used for these components. However,

EXHIBIT D

MEAN HOUSEHOLD INCOME BY STATE
(1980)

State		State	
Alabama	$21,200	Montana	$22,600
Alaska	$37,700	North Carolina	$21,800
Arizona	$25,100	North Dakota	$22,800
Arkansas	$19,700	Nebraska	$24,100
California	$28,100	Nevada	$27,600
Colorado	$27,200	New Hampshire	$24,800
Connecticut	$29,500	New Jersey	$29,400
District of Columbia	$26,300	New Mexico	$22,200
Delaware	$26,400	New York	$26,000
Florida	$23,500	Ohio	$25,600
Georgia	$23,200	Oklahoma	$23,000
Hawaii	$30,900	Oregon	$24,900
Idaho	$22,600	Pennsylvania	$24,800
Iowa	$24,600	Rhode Island	$23,900
Illinois	$28,400	South Carolina	$22,200
Indiana	$25,400	South Dakota	$20,000
Kansas	$25,000	Tennessee	$21,700
Kentucky	$21,500	Texas	$25,800
Louisiana	$23,900	Utah	$28,700
Maryland	$30,100	Vermont	$22,100
Massachusettes	$26,100	Virginia	$26,400
Michigan	$27,900	Washington	$26,700
Minnesota	$26,100	West Virginia	$21,800
Mississippi	$19,800	Wyoming	$27,700
Missouri	$23,500		

SOURCE: Bureau of the Census (1980), inflated to 1984 dollars.

acquisition and treatment must be estimated based on the specific circumstances.

Evaluation of this situation should proceed as follows:

i) Determine the system size.

The system would be required to supply a community with approximately 2,182 households. The system capacity required would be 327 million gallons annually, or 0.9 million gallons per day (2,200 x 150,000 / 365 days). 150,000 gallons per household represents a system size with capacity to supply residential, commercial, and other uses.

ii) Determine system components required.

In the case, all of the basic system components would be needed.

iii) Estimate costs of the system.

Distribution and transmission and support services components are typical of national costs, so they may be estimated using average values from Exhibits B and C. These costs are estimated as 60 percent (43 percent plus 17 percent) of $1,063 per million gallons, i.e., $638 per million gallons. Based on consultation with a local water utility, this 1981 dollar figure is inflated by 45 percent to reflect cost changes between 1981 and the year of the analysis. A cost estimate of $925 per million gallons is, therefore, used for these components.

A local engineering firm provides estimates of capital costs of $850,000 to construct a pipeline from the source and a treatment plant capable of treating the water to drinking water standards, and operation and maintenance expenses of $100,000 for the plant and pipeline in current dollars. Thus, approximate annual acquisition and treatment costs are:

	Annualized Capital Costs (Calculated by multiplying capital costs; $850,000, by annualization factor; 0.1)	$ 85,000
+	Annual O&M Costs	$100,000
=	Total Annual Costs	$185,000

In addition, fees of $200 per million gallons would be charged for use of water from the reservoir. Thus, total acquisition and treatment costs would be $795 per million gallons ($185,000 divided by 327 million gallons, plus $200).

Totalling the costs for the system gives:

$765 + $925 = $1,690 per million gallons.

iv) Comparing costs for a typical user household to the average household income.

Costs to the typical household are based on annual usage of 60,000 gallons per household. The cost estimate implies an annual cost of $101 for the typical user ($1,690 divided by 1,000,000 x 60,000).

Recent census data shows that average household income for the county is about $12,000. Thus, the test ration is:

$$\frac{\$101}{\$12,000} = 0.8 \text{ percent}$$

In this case, the costs of utilizing the alternative source are so high that the ground water is irreplaceable according to the economic test criteria, and so it warrants a Class I designation.

III. <u>Economic Test to Indicate that Contaminated Ground Water is Untreatable</u> (Class III)

The economic test can be applied to determine whether a contaminated ground water should be provided the level of protection of a Class II or Class III ground water. This test is provided for comment as a more rigorous test than the "reference technology approach" discussed in the main sections of these guidelines. Economic feasibility is determined in this test with reference to typical costs of drinking water supplies relative to the income of service communities. Data show that annual water supply costs typically represent between 0.1 percent and 0.3 percent of the annual average income of the service community. The economic test designates the ground water as Class III-untreatable if the cost of treating the water to drinking water standards and developing it as a source of drinking water is excessive. Specifically, the use of a contaminated ground water as a source of drinking water is defined to be economically infeasible if the annual total cost (including treatment) to a hypothetical user household would exceed a percentage of the mean annual household income in the hypothetical user population. A hypothetical user population must be used because, by definition, the potential Class III ground water is not currently used and, therefore, the test must be based on a hypothetical user population.

The economic test, thus, identifies ground-water sources which have particularly low economic value (under present or foreseeable future conditions), because treatment and use of such ground waters for drinking purposes would be very costly, and highly unlikely, even though there <u>may</u> be technical procedures available to render these of drinking water quality. Such ground waters, therefore, warrant a lower level of protection than other ground waters. Since this a two-step process, the actual cost of treating the ground water will be of utmost importance; again to avoid the bias of designating "clean" ground waters as Class III due to non-quality factors.

The first threshold test examines total costs over a range of 0.3 to 0.4 percent of household income. This level has been chosen with reference to typical water supply costs relative to the mean household incomes of the service populations. Typical water supply costs relative to national average household income show that costs are typically between 0.1 percent and 0.3 percent of the mean household income. These data suggest that the threshold percentage of household income for the economic test should be chosen to exceed 0.3 percent to accord with the objective of identifying contaminated ground waters that are particularly costly to treat and use as sources of drinking water.

The second step focuses on treatment costs when they increase total system costs to a level which exceeds a total household cost of $300 per year or when they increase current rates more than 100 percent. These criteria are being proposed for assessing "treatability." EPA is seeking comment on these criteria.

Implementation of the Class III Economic Test

STEP 1: Determine Size of Hypothetical User Population

The first step in the economic burden test is to determine the size of the "hypothetical user population", that is, the population that could use (on a conceptual basis) the ground water as a source of drinking water. The size of the hypothetical user population is determined through two approaches, with the second being the controlling:

1) the mean population served by ground-water systems in the state, and

2) a population that could be served by the maximum sustained yield of the aquifer in question.

Exhibit E presents the mean size population served by ground-water supply systems in each state. For example, the mean population served by ground-water systems in the State of Maryland is 3,916. These data may be used for the first estimate.

The second estimate is determined based on the estimated sustained yield of the aquifer. The U.S. Geological Survey office (e.g., District Office) in the state or the state geological or water surveys will often have hydrogeological information (e.g., maps, reports, and surveys) on most aquifers within a state. Consultation with these and other individuals with local expertise and experience can likely provide a reasonable estimate of an aquifer's sustained yield. For more detailed assessments, a review of boring logs, geotechnical evaluations or other data sources will be needed. Field assessments and ground-water monitoring may also be needed to assess not only aquifer yield, but quality parameters as well. Once the sustained yield is estimated, a population equivalent can be determined based on an annual water use of 150,000 gallons per household per year. For example, geotechnical and hydrogeological data may indicate that an area in Maryland, which is being classified, has an

EXHIBIT E

MEAN POPULATION SIZE SERVED BY GROUND-WATER SYSTEMS
BY STATE OR TERRITORY

State		State	
American Samoa	1,360	North Carolina	422
Alabama	2,136	North Dakota	665
Alaska	492	Nebraska	839
Arizona	2,202	Nevada	466
Arkansas	1,848	New Hampshire	610
California	1,799	New Jersey	5,639
Colorado	732	New Mexico	1,702
Connecticut	582	New York	1,779
Delaware	1,083	Ohio	2,085
Florida	2,435	Oklahoma	1,109
Georgia	1,050	Oregon	540
Guam	3,370	Pennsylvania	742
Hawaii	8,438	Puerto Rica	3,037
Idaho	769	Rhode Island	1,690
Iowa	1,492	South Carolina	841
Illinois	2,707	South Dakota	930
Indiana	2,141	Tennessee	5,269
Kansas	1,614	Texas	1,384
Kentucky	903	Trust Territory	306
Louisiana	1,473	Utah	1,287
Maryland	3,916	Vermont	433
Massachusetts	3,072	Virgin Islands	65
Michigan	1,297	Virginia	388
Minnesota	2,513	Washington	848
Mississippi	1.557	West Virginia	842
Missouri	1,270	Wisconsin	1,331
Montana	278	Wyoming	508

SOURCE: ICF, Inc. Analysis, based on the Federal Reporting Data System Interactive (FRDS/Interactive), which identified public water supply systems (ground water and surface water).

estimated sustainable yield of 50 gallons per minute or 72,000 gallons per day (gpd). The population equivalent that could be served by this yield is 480 (72,000 gpd divided by 150 gpd/person). Because the latter, hydrogeological factor is controlling, the hypothetical user population for the aquifer under review is assumed to be 480 persons. Using the national average of 2.75 people/household, the user population of 480 is equivalent to 175 households (i.e., 480 people divided by 2.75 people/household).

STEP 2: Determine the Mean Annual Income Per Household

The second step in the economic burden test is to determine the mean annual household income of the hypothetical user population. This determination may be made by assuming it to be equal to the mean household income in the county where the ground water is located. These data are readily available from the Bureau of the Census publication entitled "County and City Data Book", which can usually be found in local libraries. When county-level data are not available, state-level data may be used as default values. Exhibit F indicates the mean annual income per household in each state as provided by the 1980 Census inflated to 1984 dollars. In the State of Maryland, for example, the mean annual income per household is $30,000 (1984 dollars).

STEP 3: Estimate The Cost of the Water Supply System

The next step is to estimate the cost of the ground-water supply system which could serve the hypothetical user population size determined in Step 1. In order to do this, it is important to consider the four major cost components of a newly developed water supply system: acquisition, treatment, delivery, and support service.

Acquisition costs are primarily the costs of acquiring and physically developing a water supply at the site. They include the cost of the land, rights of way, and well field development costs. The latter can vary depending on hydrogeologic conditions, particularly the depth of the aquifer and the geologic formation overlaying the aquifer.

Treatment costs include the costs of the treatment plant and equipment, and the costs of the chemicals that are added to the water. For a water of given quality, the costs of treatment depend on the quantity of water treated and the treatment technologies used. The capacity of a treatment plant is determined by the size of the population. (Much of the cost analysis for Step 3 will pertain to treatment costs.)

EXHIBIT F

MEAN HOUSEHOLD INCOME BY STATE
(1980)

State		State	
Alabama	$21,200	Montana	$22,600
Alaska	$37,700	North Carolina	$21,800
Arizona	$25,100	North Dakota	$22,800
Arkansas	$19,700	Nebraska	$24,100
California	$28,100	Nevada	$27,600
Colorado	$27,200	New Hampshire	$24,800
Connecticut	$29,500	New Jersey	$29,400
District of Columbia	$26,300	New Mexico	$22,200
Delaware	$26,400	New York	$26,000
Florida	$23,500	Ohio	$25,600
Georgia	$23,200	Oklahoma	$23,000
Hawaii	$30,900	Oregon	$24,900
Idaho	$22,600	Pennsylvania	$24,800
Iowa	$24,600	Rhode Island	$23,900
Illinois	$28,400	South Carolina	$22,200
Indiana	$25,400	South Dakota	$20,000
Kansas	$25,000	Tennessee	$21,700
Kentucky	$21,500	Texas	$25,800
Louisiana	$23,900	Utah	$28,700
Maryland	$30,100	Vermont	$22,100
Massachusetts	$26,100	Virginia	$26,400
Michigan	$27,900	Washington	$26,700
Minnesota	$26,100	West Virginia	$21,800
Mississippi	$19,800	Wyoming	$27,700
Missouri	$23,500		

SOURCE: Bureau of the Census (1980), inflated to 1984 dollars.

Delivery costs include transmission and distribution costs. Transmission costs are the costs of pumping the water from the treatment plant to the main distribution network. Distribution costs include the cost for the piping network which provides the water to the water users.

Support services are primarily administrative and customer service costs that are associated with the management of a water supply system.

Because a Class III candidate ground water is not currently used, it would typically be necessary to include all four of the system components in estimating the costs of developing this resource as a water supply source. Each cost component needs to be evaluated on a site-specific basis. However, default values can be used to estimate acquisition, and support services costs if it can be shown that the site has no extraordinary characteristics that would result in costs which are substantially different from the national average costs for a system of that size. Because the Class III candidate ground water is contaminated, default values should <u>not</u> be used to evaluate treatment costs. Treatment costs are strictly site-specific and are determined by the nature and level of contamination of the ground water.

Default values for acquisition, delivery, and support service costs can be derived from Exhibits G and H. Exhibit G presents annualized costs (i.e., annualized capital and O&M) for ground-water systems of various sizes, based on nationwide data. The costs are expressed as 1984 dollars per million gallons ($/MG). Thus, if the total annual water demand is known, Exhibit H can be used to estimate the annual system cost (excluding treatment costs). Exhibit H presents the relative contribution of cost components to the total water supply system cost. These percentages are based on water supply systems across the nation and grouped into two size categories: 300 to 75,000 population and greater than 75,000 population. For example, acquisition costs for a system serving a population of 5,000 typically represent 22 percent of total costs.

As an example of how to use Exhibits G and H, assume a user population of 5,000 (1,800 households). Exhibit G indicates that for a user population of this size, the annual cost of ground-water supply systems equals $924 (1984 dollars) for each million gallons produced. Because acquisition, delivery, and support services costs make up 82 percent of this total cost (Exhibit H), total costs, excluding treatment costs, to the hypothetical user population of using the ground water as a source of drinking water amount to $758

EXHIBIT G

COSTS OF GROUND-WATER SUPPLY SYSTEMS[a]
BY POPULATION SIZE CATEGORY
(1984 $/million gallons produced)

Population Served by System	Annual Cost
25 - 1,000	4,616
1,000 - 3,300	1,493
3,300 - 10,000	924
10,000 - 25,000	718
25,000 - 75,000	710
75,000 - 500,000	606
over 500,000	574

[a]Operating expenses (including depreciation and capital charges, inflated to 1984 dollars.

SOURCE: Survey of Operating and Financial Characteristics of Community Water Systems, Temple, Barker and Sloane, Inc., 1982

EXHIBIT H

COST COMPONENTS AS PERCENTAGES
OF WATER SUPPLY SYSTEM COSTS

Cost Component	System Serving 300-75,000 Population (% of total costs)[a]	System Serving Greater than 75,000 Population (% of total costs)[a]
Acquisition	22	19
Delivery	43	38
Service	17	30
Total	82	87

[a]Total costs are the sum of annualized capital costs and O&M costs.

SOURCE: ACT Systems, Inc., 1979.

(1984 dollars) per million gallons produced (i.e., \$924 x 82 percent). The total annual water usage is 270 million gallons (i.e., 1,800 households x 150,000 gallons per household per year), so the annual costs to the hypothetical user population for acquisition, delivery, and support services are \$204,660 (i.e., \$758/mg x 270 mg).

Determining the most economic treatment system involves a series of assessments. First, the specific ground-water contamination problem in the Classification Review Area must for a Class-III determination be fully characterized. Again, the contamination problem should be areal in extent, and cannot be attributed to a specific disposal site or other activity. Much of the data may be provided in program-specific permit applications, although supplemental information may be available from USGS, local authorities, and local research organizations.

Once the contamination has been characterized, the desired water quality levels should be determined for each chemical constituent of concern. If all chemical constituents of concern are present at less than drinking water standards (MCLs) or Health Advisories, the water requires no treatment.

The next step is to identify all of the treatment trains which are capable of reducing contaminant concentrations to the desired range. Exhibit I tabulates contaminant removal efficiencies for common treatment technologies. Any treatment technology which does provide removal of any of the contaminants of concern may be eliminated from further consideration. The process of identifying the treatment trains which are capable of achieving the desired concentration levels can be done systematically by evaluating all possible combinations of treatment technologies from among the non-eliminated choices, or may be done heuristically using expert judgement.

The treatment trains identified in this process can then be costed out, and the least costly selected. Any of these treatment trains that includes another of the treatment trains as a subset, can be disregarded because it will clearly be inefficient. (In some cases, public water systems add apparently redundant technologies to remove chemical constituents for 'aesthetic' reasons, or to provide backup treatment to accommodate fluctuations in influent quality.) If no treatment trains can be identified, the ground water will automatically be Class III.

EXHIBIT 1

REPORTED TYPICALLY ACHIEVEABLE CONTAMINANT REMOVAL EFFICIENCIES[a,d]

	Air Stripping and Aeration	Carbon Adsorption	Chemical Precipitation	Desalination	Flotation	Granular Media Filtration	Ion Exchange	Ozonation
Arsenic	0[b]	50	85	95	45	60	99	25
Barium	0[b]	30	80	95		70	95	0
Benzene	98	75	70	75		40		97
Cadmium	0[b]	85	90	60	60	70	99	
Carbon Tetrachloride	98	Moderate[c]	95		75	90		
Chlordane	Good[c]	Good[c]				40		
Chromium VI	0[b]	95	98	90	50	50	96	
1,1-Dichloroethylene	98	97	98			55		
1,2c-Dichloroethylene	97	70				90		
1,2t-Dichloroethylene	75	95	30					
Dichloromethane	80	70	60	15	40	40		
2,4-D	Poor[a]	Good[c]	Good[c]					
p-Dioxane	0[b]							
Endrin	0[b]	99						Moderate[c]
Ethylene glycol	Good[c]	Good[c]						
Fluoride		0	75			30		
Formaldehyde	Good[c]							
n-Hexane	99							
Lead	0[b]	95	85	60	98	50	97	30.
Lindane	0[b]	95	Good[c]	65	85	50		
Mercury	0[b]	90	80	90	75	55		
Methyl Ethyl Ketone	99							
Nitrate		15	96	70		10	90	50
PCB	0[b]	15			97	20		
Selenium	0[b]	10	70	97		60	98	99
Silver	0[b]	25	70	40	45	20	99	
Tetrachlorethylene	98	99	95	80	30	0		40
Toluene	95	75	75	50	40	65		
Toxaphene	Good[c]	99						
1,1,1-Trachloroethane	80	99	50	98		97		
Trichloroethylene	98	Poor[c]	60					
2,4,5-TP	Poor[c]	Good[c]		Good[c]	Good[c]			
Trihalomethanes	75	99	95	80	80	60	50	
Xylenes	99		90	80	97	75		

[a] Data represent the percent of contaminant which can be expected to be removed from solution using treatment systems similar to those currently installed in full scale or pilot scale water treatment operations. Percent removal are generated from available literature a listed at the end of this section, and are rounded to the nearest 5 percent (below 95 percent). These numbers are representative of achievable efficiencies, and are not absolute indicators of specific system treatment efficiencies.

[b] Although reported data were unavailable, the physical nature of those contaminants precludes effective removal via air stripping.

[c] Only qualitative data were available in the literature.

[d] Blanks indicate that no data were reported in the available literature.

To cost out the treatment trains, the individual system components should be listed. Exhibit J lists the system components typically required with each treatment technology. When using published cost curves, it is important to read the accompanying test which describes the system components included in the cost curve, and identifies which components must be costed separately. The following reference (along with Culp et al.) provide cost curves for a range of treatment technologies and system sizes:

- Estimating Water Treatment Costs, Gummerman, Culp and Hansen, EPA 600/2-79-162a.
- Treatability Manual, Technologies For the Control Removal of Pollutants, EPA 600/2-82-001C; and
- Estimation of Small System Water Treatment Costs, EPA 600/2-84-184a.

Again, updated cost assessments will likely be available from EPA or the water utility industry, under the public water supply provisions of the Safe Drinking Water Act Amendments of 1986. The costs references generally provide separate estimates of capital costs and annual O&M costs. These can be annualized based on the expected lifetime of the capital and the cost of finance. As a first approximation, capital costs may be annualized by multiplying by a factor of 0.1. Thus:

Annualized Capital Costs = Capital Costs x Annualization Factor (0.1)

and

Annualized Costs = Annualized Capital Costs + O&M Costs

Appendix E provides further discussion of annualization methodology.

Costs calculated in this way for eight standard treatment technologies are presented in Exhibit K.

As an example, the annualized costs to treat a groundwater contaminated with air stripping, precipitation, and rapid sand filtration for a system supplying a population of 5,000 (or 1,800 households) would be approximately $159,800 (the sum of $28,000 for air stripping, $62,700 for precipitation, and $69,100 for rapid sand filtration) in 1982 dollars. This figure should be inflated to a dollar figure for the base-year of the analysis. It should then be divided by the

EXHIBIT J

DEFAULT COMPONENTS OF EACH TREATMENT TECHNOLOGY

<u>Aeration/Air Stripping</u>

Aeration tower
In-plant pumping

<u>Activated Carbon</u>

Carbon columns
Backwash pumping
Washwater surge basin

<u>Chemical Precipitation</u>

Lime feed system
Contact clarifier
Sludge pumping
Sludge drying beds
Slugde hauling

<u>Desalination</u>

Reverse Osmosis
In-plant pumping

<u>Flotation</u>

Dissolved air flotation
Sludge pumping
Sludge drying beds
Sludge hauling

<u>Filtration</u>

Granular media filtration beds
Granular media
Backwash pumping
Washwater sewage basin

<u>Ion Exchange</u>

Pressure Ion Exchange System

<u>Ozonation</u>

Ozonation system

<u>Ancillary Operations</u>

Administrative
Raw water pumping
Polished water pumping
Clearwell storage

EXHIBIT K

ANNUALIZED COSTS OF TYPICAL TREATMENT COMPONENTS
FOR TOUR TYPICAL PLANT SIZES

	Population Served			
Component	500	2,500	5,000	25,000
Aeration/ Air Stripping	$16,500	$20,700	$28,000	$70,200
Activated Carbon	$18,800	$27,000	$33,900	$113,900
Chemical Precipitation	$35,200	$51,500	$62,700	$127,700
Desalination	$43,900	$109,500	$171,500	$595,600
Flotation	$30,100	$37,300	$48,900	$109,800
Filtration	$56,200	$61,400	$69,100	$107,700
Ion Exchange	$10,100	$26,400	$38,900	$74,800
Ozonation	$6,000	$7,000	$9,300	$19,200
Ancillary Operations	$25,900	$24,000	$46,200	$110,900

All figures are in 1982 dollars.

number of households in the hypothetical population to calculate an annual cost per household. This value in turn is divided by the annual average (mean) household income and a percentage is then derived. This value is then employed in STEP 5 to classify the ground water.

STEP 5: Classify the Ground Water

Two threshold values must be considered in completing the Class III test: first, the total system cost threshold and then secondly, the treatment cost threshold. If the value estimated in STEP 4 exceeds the proposed range of "total system cost threshold" percentages (0.3-0.4 percent) and the treatment cost component of total system costs increase water rates more than 100 percent or establish a rate greater than $300 per household per year, than the ground water is Class III. If the value is less than the proposed range of economic criteria percentages and the treatment cost threshold, then the ground water is Class II.

Because the Class III test must focus on whether or not a particular ground water source is untreatable, the classifier must focus on the treatment costs associated with similarly-sized or comparable systems. Current data show that treatment costs nationwide typically comprise 18 percent of the total cost of systems serving 300-75,000 population and 13 percent of the total costs of systems serving more than 75,000 population (ACT Systems, Inc., 1979). In making a Class III designation the classifier must compare the effect that treatment costs of the system being classified will have on household water bills. If treatment costs produce a household rate greater than $300 per year or a rate increase greater than 100 percent over current rates (or any other baseline percentage as established for similarly-sized or comparable systems within a state or region) then the ground water is Class III-untreatable.

In some cases the classifier may wish to undertake additional analyses of the treatment costs. If, for instance, a ground water resource is being classified in the arid southwestern United States where acquisition and delivery costs comprise a major part of total system costs and, yet, very costly treatment technologies would need to be employed, the classifier may wish to compare the treatment costs associated with the system being classified with typical treatment costs of similarly-sized or comparable systems elsewhere in the state or EPA region, instead of comparing them against a national standard. Again, the objective of this test is to determine which systems would require treatment processes which are so costly that they are "economically" untreatable.

Example

A Class IIIA determination is being considered for a hypothetical site in Maryland. Past industrial activity and urban recharge have resulted in generally poor water quality of the aquifer. As a result, an application for continued land disposal activity includes a Class IIIA determination. The five steps of the Class III economic test are examined in this hypothetical problem.

STEP 1: Determine Population Size/Number of Households

Due to widespread industrial contamination, local ground water in the area has been not used for drinking in more than 30 years. Public water is supplied from a surface water source. Since the ground waters are shallow, a Class IIIB assessment is unlikely.

The US Geological Survey District Office has been consulted to obtain old water supply reports for the area as to estimate the yield of the aquifer under review. Based on these reports, the Classification Review Area would support a sustained yield of approximately 625 gallons-per-minute (gpm) which is equivalent to 0.9 mgd. This yield could reasonably serve a population of 6,000, assuming water usage of 150 gpd/person.

Exhibit E indicates that the mean population size served by ground-water systems in Maryland is 3,900. Because the 3,900 average is less than the 6,000 population (based on yield), the classifier may choose which hypothetical population figure is most appropriate. If, for instance, the ground-water resource being classified is in the path of encroaching development (even though such development will not utilize local ground water) the higher figure may be selected for analysis. In this example, the 6,000 figure is used as the hypothetical user population. This population figure represents about 2,182 households (i.e., 6,000 people divided by 2.75 people/household).

STEP 2: Determine the Mean Annual Income Per Household

In Maryland, the mean annual income per household is $30,100 (see Exhibit F). This income estimate is used in the absence of more specific survey data.