DISCUSSION PAPER

WATER SUPPLY · WASTEWATER TREATMENT COORDINATION STUDY

For

U.S. ENVIRONMENTAL PROTECTION AGENCY

By

INTASA, INC. in association with HYDROCOMP, METCALF & EDDY and TETRA TECH, and in consultation with JOE E. MOORE, Jr.

Contract No. 68-01-5033

INTASA

1030 CURTIS STREET • MENLO PARK, CALIFORNIA 94025 • (415) 323-9011

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PREFACE

This paper was prepared during the first phase of the water supply-wastewater treatment coordination study. It is intended to provide the public with background information, including recent data and data sources, on study-related topics: i.e., availability and use of the water resource; adequacy of measures to protect and enhance in-stream and drinking water quality; water and wastewater treatment requirements and current technologies; and water supply and wastewater treatment costs.

The public will have the opportunity to influence the course of this study in several workshops to be held throughout the Nation. Thus in addition to the background material this paper includes a discussion of various issues and raises several questions related to the study. The purpose is to stimulate dialogue and debate with the interested public rather than to present an exhaustive list of issues/questions and assign priorities to them at this stage of the study. Workshop dates and locations are indicated on the following page.

DATES AND LOCATIONS OF PUBLIC WORKSHOPS

January 17 and 18	EPA Regional Office, Region IX 215 Fremont Street San Francisco, CA 94105 (415) 556-0774
January 24 and 25	EPA Regional Office, Region VI First International Building 1201 Elm Street Dallas, TX 75270 (214) 749-2106
January 31 and February 1	EPA Regional Office, Region IV 345 Courtland Street, NE Atlanta, GA 30308 (404) 881-3781
February 7 and 8	EPA Regional Office, Region II Federal Building 26 Federal Plaza New York, NY 10007 (212) 264-1800
February 14 and 15	EPA Regional Office, Region V 230 South Dearborn Street 26th Floor Chicago, IL 60604 (312) 353-2151

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I. INTRODUCTION

A. Background

The U.S. Environmental Protection Agency has sponsored this study in response to reporting requirements embodied in the Safe Drinking Water and Clean Water Acts of 1977. Relevant sections of those Acts as they pertain to this study are:

> "Not later than eighteen months after the date of enactment of this subsection, the Administrator shall submit a report to Congress on the present and projected future availability of an adequate and dependable supply of safe drinking water to meet present and projected future need. Such report shall include an analysis of the future demand for drinking water and other competing uses of water, the availability and use of methods to conserve water or reduce demand, the adequacy of present measures to assure adequate and dependable supplies of safe drinking water, and the problems (financial, legal, or other) which need to be resolved in order to assure the availability of such supplies for the future. Existing information and data compiled by the National Water Commission and others shall be utilized to the extent possible." (PL 93-523 Section 1442(c) as amended by PL 95-190 Section 3(3).
>
> "The Administrator, in cooperation with the states, including water pollution control agencies, and other water pollution control planning agencies, and water supply and water resources agencies of the States and the United States shall submit to Congress, within two years of the date of enactment of this section, a report with recommendations for legislation on a program to require coordination between water supply and wastewater control plans as a condition to grants for construction of treatment works under this Act. No such report shall be submitted except after opportunity for public hearings on such proposed report." (PL 92-500 Section 516(e) as amended by PL 95-217 Section 72).

Given the obvious relationship between quality and quantity concerns in both pieces of legislation, EPA decided that an integrated report to Congress would be the most expedient course of action to follow. The study was initiated on October 1, 1978 and will terminate on November 1, 1979.

This initial phase builds upon recent studies, surveys, and assessments in order to provide insight into the specific concerns as expressed by the Congress--i.e., water supply (with emphasis on drinking water availability) and opportunities to more effectively achieve national goals by coordinating water supply and wastewater treatment plans. Recommendations will be summarized in a final report which EPA will submit to Congress in December of 1979. Prior to submittal there will be public hearings, as required by the Clean Water Act.

B. Overview of This Paper

The U.S. Water Resources Council, in association with the principal water resource agencies and 21 state and local teams, recently completed an assessment of water availability and use. Results indicate that the natural water supply from all sources in the conterminous U.S. on a mean annual basis is about 1,400 bgd. Of this it is estimated that 106 bgd in 1975 and 134 bgd in 2000--less than 10 percent of mean annual supply in both cases--will be consumed. Thus on a mean annual basis there would appear to be sufficient water to meet National needs now and for into the future. Such a cursory examination masks the situation in regions such as the semi-arid west and southwest and certain locations in the east where water shortages have been experienced. The Assessment reports that severe municipal and rural water shortages have been identified at the local level within half of the 106 subregions used to disaggregate the national picture. Factors such as diminishing groundwater resources, increasing competition between uses, and inadequate water supply systems are expected to aggrevate these local and regional situations.

Congress also expressed an interest in examining "the availability and uses of methods to conserve water or reduce demand." Several conservation methods have been recently advanced including improved water management, revised pricing, public education, and implementation of various water-saving technologies. Present findings indicate that successful utilization of such methods varies according to community-specific circumstances including existing institutional attitudes and prevailing legal situations.

Depletion of groundwater sources in certain regions and subregions is a major concern of national scope. The EPA's Sole Source Aquifer program is designed to protect only large regional aquifers providing more than 50 percent of the public water supply. Is this program adequate to protect the groundwater resource in view of the fact that more than 25 percent of all groundwater withdrawals constitute mining?

These and related topics are covered in Section II of this report. The section provides considerable data and information to motivate the discussion that follows, and it formulates several issues/questions to initiate discussion.

With passage of the Safe Drinking Water Act (SDWA), Congress explicitly recognized that despite several water pollution control laws the safety of drinking water supplies is by no means assured. Figure I shows the magnitude of the problem by providing a schematic illustration of the various sources of pollutants that have been created by man's activities. While most point sources are being brought under control by the Clean Water Act amendments of 1977, pollution by nonpoint sources including urban stormwater runoff and runoff from rural and forested areas can still pose a threat to the quality of downstream supplies.

Are the present and pending measures to protect and enhance water quality in general and drinking water supplies in particular adequate? Section III addresses this question with specific emphasis on: adequacy of drinking water quality standards; proposed regulations to control organic chemicals; ability of small water supply systems to comply with primary standards and proposed regulation requiring granular activated carbon (GAC) treatment; protection of groundwater; and several other topics related to in-stream water quality as well as quality of water supplies. As in Section II, a discussion follows the presentation of data and information, and issues/questions are formulated to stimulate discussion.

Section IV examines treatment requirements and available technologies for both water supply and wastewater as required by the Safe Drinking Water and Clean Water Acts. Particular emphasis is placed on surfacing opportunities for coordination between water supply and wastewater treatment planning recognizing the basic difference that exists between the present prevailing mechanisms for planning and implementation in the two traditionally separate areas.

Topics covered in Section IV include: organics removal in water treatment; land treatment versus AWT; reuse versus treatment and discharge; reuse and water rights; in-stream water quality and treatment requirements; the SWDA and the 1985 goal of elimination of pollutants; and several areas in which treatment coordination opportunities and problems exist. Similar to the previous sections, several issues/questions are formulated that address the Congressional concerns as expressed in Section 516(e) of the 1977 amendments.

There is considerable debate going on about the level of capital investment required to meet the goals of the Safe Drinking Water and Clean Water Acts. Similarly, the debate goes on to cover costs associated with operation, maintenance, monitoring and administration of upgraded and new facilities. Major cost concerns associated with SDWA relate to upgrading municipal water supply systems to meet the primary standards and to comply with the proposed regulations on THM's and GAC treatment. Requirements of the Clean Water Act continue to cause public controversy and stimulate debate over the Nation's ability to

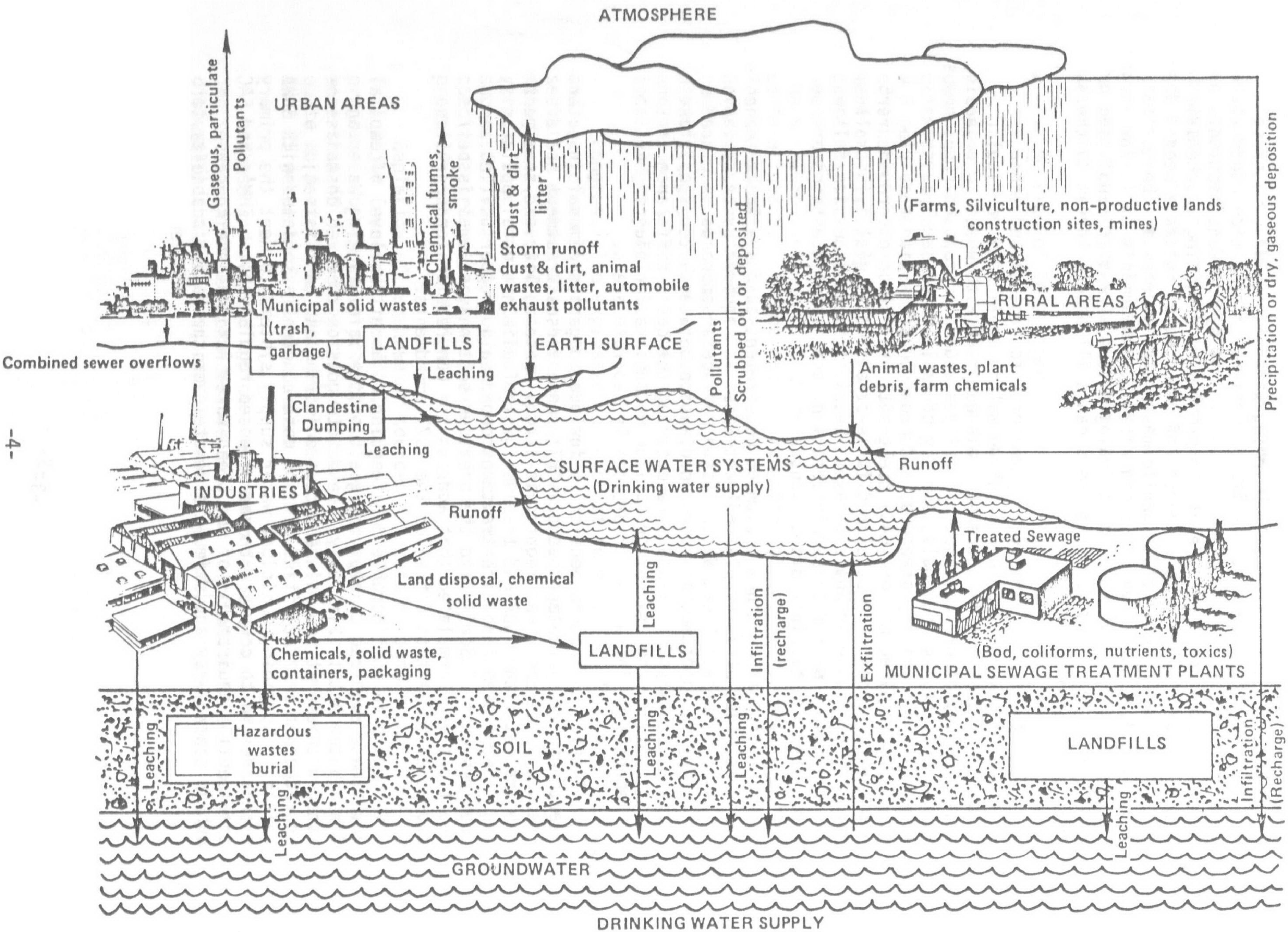


Figure 1 A SCHEMATIC REPRESENTATION OF SOME IMPACTS OF MAN'S ACTIVITIES ON SUPPLIES OF DRINKING WATER

fulfill the financial obligations of the Act as well as the wisdom of treating nonpoint source pollutants at exhorbitant costs.

Section V deals with water supply costs and costs associated with implementing the SDWA in terms of the primary drinking water standards and proposed requirements for GAC treatment. Wastewater treatment costs share in importance. Several issues are raised which may merit further examination including present methods of financing both water supply and wastewater treatment costs, alleviation of O&M cost burdens by providing additional incentives to construct revenue producing wastewater treatment facilities, and possible cost benefits associated with coordinating water and wastewater treatment planning.

II. THE AVAILABLE WATER RESOURCE AND ITS USE

A. National Availability

Precipitation in its various forms establishes the overall water supply. For the conterminous U.S. average annual precipitation amounts to 30 inches or 4,200 billion gallons per day (bgd). As Figure 2 illustrates, subtracting evaporation and transpiration from indigenous vegetation leaves about 1,400 bgd as the mean annual supply. This supply is then counterbalanced by losses such as streamflow to the ocean or across the nation's boundaries, seepage from groundwaters to the oceans, reservoir evaporation and domestic, agricultural or industrial consumptive uses. Table 1 compares the distribution of the 1,400 bgd under natural and 1975 conditions. In the interim, the water may have infiltrated and replenished groundwater supplies, emerged from groundwater as spring or base streamflows, accumulated in surface reservoirs, been withdrawn from surface or groundwater sources and used for one or more purposes, or proceeded directly to the ocean as a flood (Table 1).

Table 1

DISTRIBUTION AND DEVELOPED SUPPLIES OF
FRESHWATER FOR THE CONTERMINOUS UNITED STATES
(in billion gallons per day, for average annual conditions)

Distribution	Natural Conditions	1975 Conditions
. Streamflow to Oceans	1,300	1,200
. Streamflow to Canada	6	6
. Streamflow to Mexico	2	2
. Subsurface Flow to Oceans	92±	82±
. Reservoir Evaporation	0	10
. Consumptive Use	0	100
Total	1,400	1,400
Developed Supply (Withdrawals) 1)		
. Surface Waters		250
. Groundwater (Replenished)		60
. Groundwater (Mined)		20
Total		330

1) An additional 60 bgd of saline water from the oceans, estuaries and inland saline sources is also used, mostly for cooling.
Source: References 1 and 2.

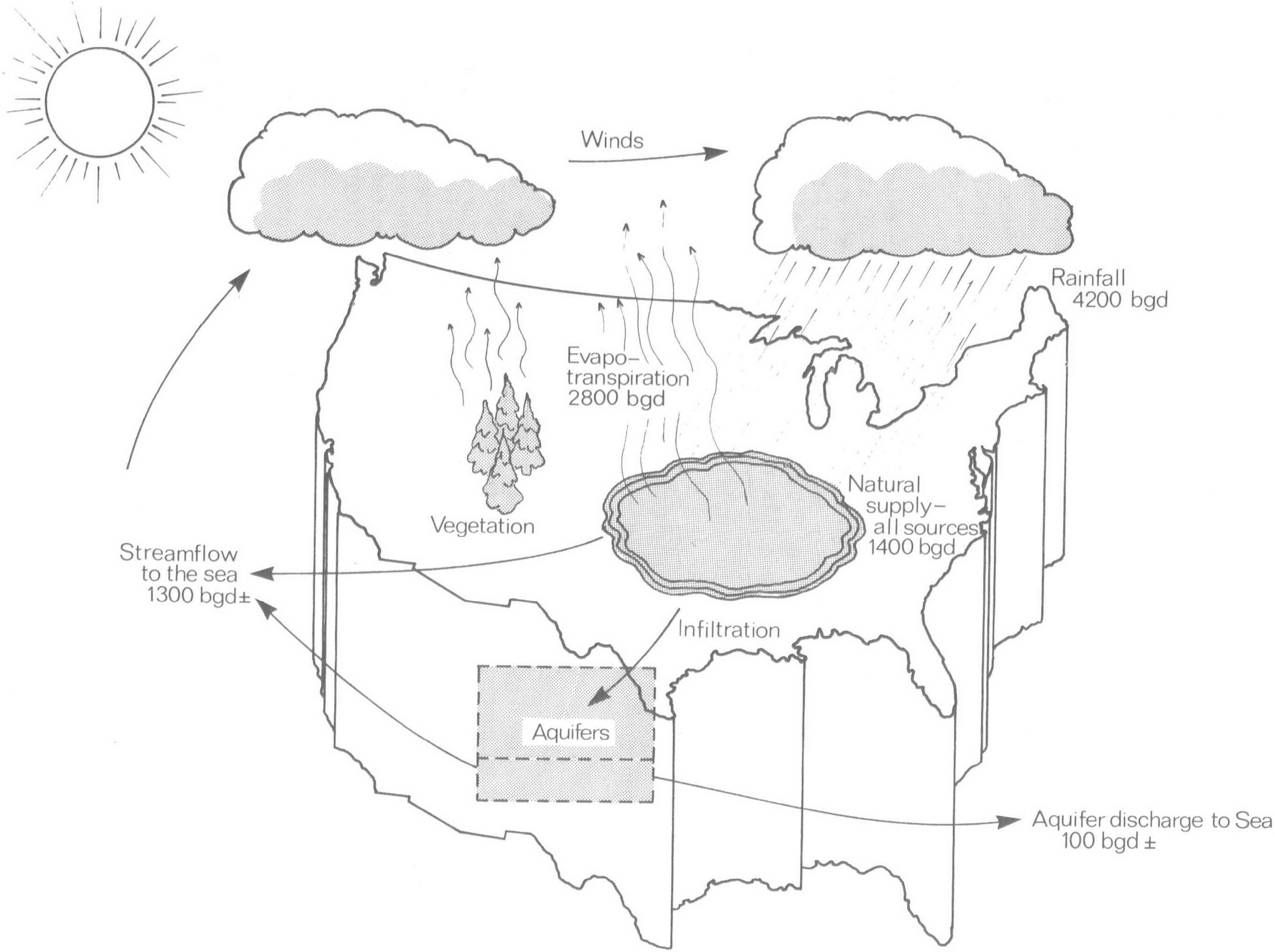


Figure 2 AVERAGE ANNUAL WATER CYCLE FOR THE CONTERMINOUS UNITED STATES (NATURAL CONDITIONS IN BILLIONS OF GALLONS PER DAY).

Surface and groundwaters are part of the same system, although they are frequently managed as if they were separate and unrelated. Where aquifers are intersected by surface streams, groundwater discharges to the streams. This groundwater contribution reaches the stream as a low continuing baseflow which is the main source of streamflow during protracted dry periods. It constitutes approximately 30 percent of the nation's mean annual streamflow.

Of the 80 bgd of groundwater pumped, about 60 bgd are estimated to come from aquifers which are replenished in comparable quantities and about 20 bgd are "mined". The term "mined" refers to groundwater which is withdrawn and not replaced; where mining is occurring the groundwater in storage from past centuries is being depleted. In semi-arid regions, groundwater replenishment may be on the order of one inch per year or less while withdrawals may amount to two or three feet per year.

Because of the high seasonal and annual variability in precipitation and the resulting variation in supply, the entire 1,200 bgd of streamflow is not available for use on a continuing basis. In 19 years out of 20, a level of reliability often used for municipal water supply, the streamflow which can be counted on is 680 bgd. By storing some of the water in wet years it is possible to draw upon this reserve during dry periods to make more water available than the actual streamflow. Thus the available streamflow depends on man's ability to regulate the streamflow through storage. Obviously, the figure of 680 bgd is not an absolute limit but the massive water projects that would be needed to significantly alter this figure are unlikely. It is also unlikely that a level of reliability significantly different than the 95 percent exceedence will be adopted for widespread use.

B. Present and Projected National Use

The recently released draft of the Second National Water Assessment by the Water Resources Council (WRC) contains two projections of future water use (Refs. 1-11). The one adopted here as a baseline for comparison is WRC's "National Future" projection. It was chosen because it is consistent with the Series E population projection and it was developed using a nationally consistent set of assumptions. The WRC divided the Nation as a whole into 21 regions, 18 of which are in the conterminous United States; these regions were further subdivided into 106 Aggregated Subregions (ASRs), 99 of which are in the conterminous U.S.

The most important assumptions behind WRC's National Future projection are as follows:

- National population growth is assumed to be the U.S. Bureau of the Census Series E.
- Domestic withdrawals for central systems are assumed to be constant on a per capita basis.

- Water use per irrigated acre is estimated based on crop requirements and assumed changes in on-farm efficiencies, off-farm efficiencies, incidental consumptive losses, etc.

- Electricity loads are based on OBERS-E, a shift to electricity from gas and oil, and projected trends in energy per capita and per unit product.

- Manufacturing production is based on OBERS-E.

- Manufacturing is assumed to achieve best available treatment economically achievable and zero discharge of toxic pollutants and, in conjunction with this requirement, to increase recirculation so consumption equals 75 percent of withdrawal.

Assumptions of secondary importance are:

- Population is allocated to the regions based on OBERS-E.

- Domestic, central-system consumption is a constant percentage of withdrawal.

- Steam-electric utilities implement wet cooling towers or cooling ponds.

- Manufacturing water consumption per unit production is assumed to increase due to changes in cooling technology.

1. <u>Off-Stream Freshwater Uses</u>

Figure 3 presents the National Future projection for major off-stream uses in terms of both freshwater withdrawals and consumption. The following is observed:

- The 28 percent increases in domestic and commercial withdrawal and consumption correspond to the population increase (24 percent) leaving per capita use approximately the same.

- Even though irrigation withdrawal is projected to decrease slightly, irrigation consumption is expected to increase 7 percent. This increase is three times the actual increase in domestic and commercial consumption.

- Significant decreases in withdrawals are projected for steam electric power and manufacturing. In contrast, major increases in consumption are projected for these uses--i.e., 644 percent for steam electric and 143 percent for manufacturing.

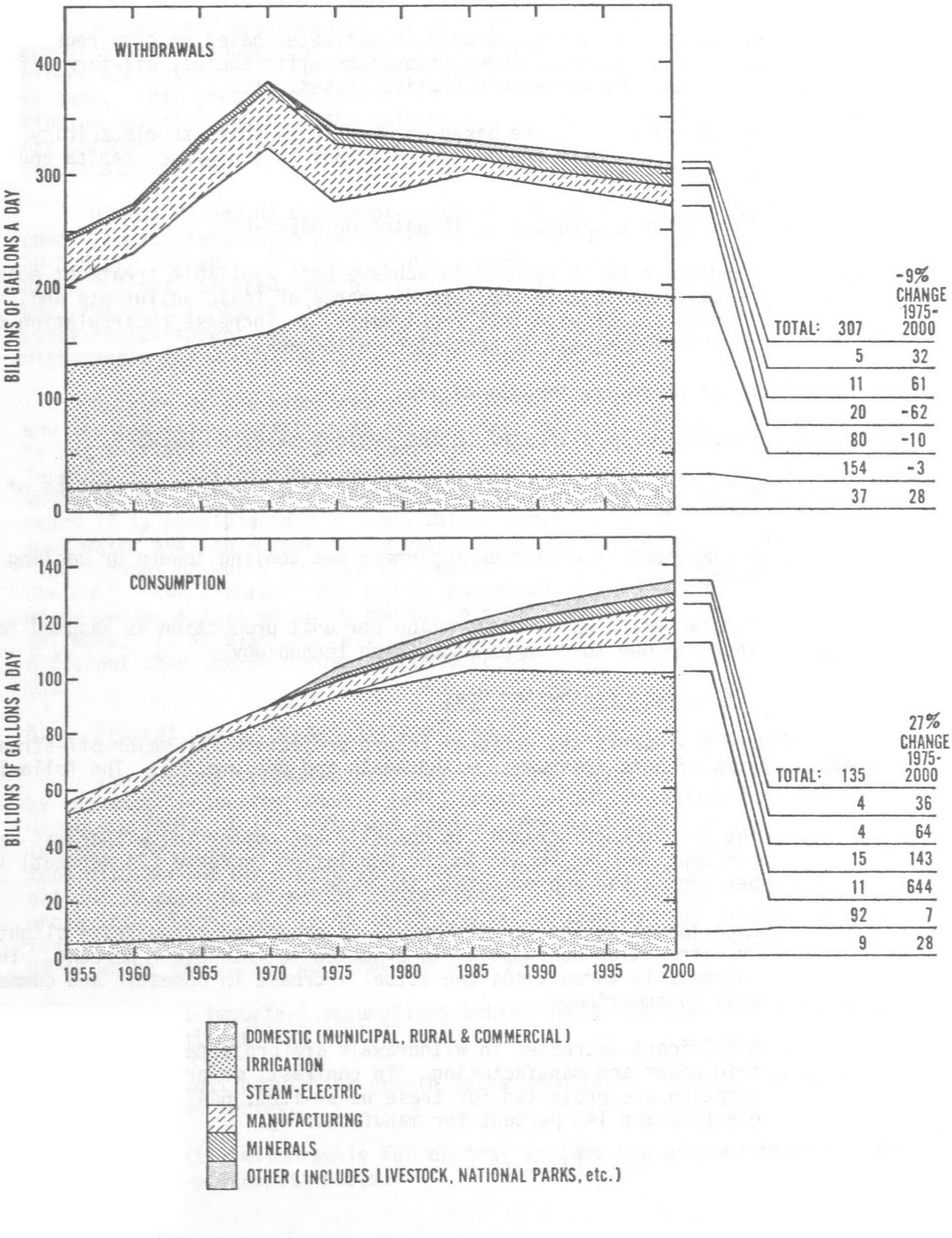


Figure 3 NATIONAL, OFF-STREAM, FRESHWATER USE.

Source: References 2 and 3.

2. In-Stream Freshwater Uses

The Second National Assessment also addresses in-stream uses of fresh water, although these uses are generally both more difficult to characterize and have less extensive data bases. Four main in-stream uses are considered:

. Recreation: The projected increases in activity occasions, water surface use and stream use are slightly greater than the anticipated population increase.

. Hydropower: Only a six percent increase in hydroelectric generation is projected for year 2000, indicating that most of the available, dependable flow and developable head for hydroelectic purposes is already being utilized. Water flow through turbines is estimated to be 805 bgd in 1975 and anticipated to be 907 bgd in 2000. With turbine flows equal to three quarters of mean annual streamflow, it is obvious that this water is reused both for flow through several turbines and for other purposes as it flows downstream.

. Navigation: The in-stream needs for navigation are estimated to be on the order of 141 bgd of outflow from the conterminous United States, or about 12 percent of average annual streamflow.

. Fish and Wildlife: Estimates for in-stream fish and wildlife needs are obtained based on monthly and average annual outflows from each ASR. On a preliminary basis the Assessment estimates that the needed aggregate outflow for the conterminous U.S. is on the order of 1,000 bgd.

3. Comparison with Other Projections

WRC's National Future (NF) projection was made at the national level. A State/Regional Future (SRF) projection was also made by teams in the 21 regions comprised of state and regional personnel. These two projections together with projections taken from WRC's First Assessment (Ref. 12) were compared. Based on this comparison the following is observed:

. The most significant difference among the projections is the much larger withdrawals which the First Assessment projected for steam electric and manufacturing based on an assumption of continued once-through cooling and limited recirculation. The SRF projection teams anticipated difficulty in achieving the intensive recirculation assumed by the NF projection for the manufacturing sector.

. The SRF anticipates significantly greater increases in agricultural withdrawals and consumption than either of the other projections.

- The SRF anticipates a significant increase in per capita domestic and commercial withdrawals, and both the SRF and the First Assessment project higher per capita domestic and commercial consumption than the NF.

C. Comparison of National Availability and Use

As a first step in assessing the adequacy and dependability of drinking water supplies, the national resource is compared to present and National Future projected use (Table 2). This comparison indicates that, on a nationwide basis, streamflow and interactive groundwaters represent more than twice the total withdrawals estimated for either 1975 or 2000 and over five times the estimated consumption.

If attention is focused upon domestic and commercial uses, in line with this study's primary concern for the adequacy and dependability of drinking water supplies, it is seen that anticipated withdrawals in 2000 are only about 5 percent of the once-in-20-year drought streamflow. Such a comparison does not show an imminent nationwide shortage of drinking water; instead, it tends to highlight an apparent national richness in water.

Table 2

COMPARISON OF WATER AVAILABILITY AND USE IN THE CONTERMINOUS U.S.
(in bgd)

Availability	1975	2000
Streamflow (Average Year)	1,200	
Streamflow (Once-in-20-year drought)	680	
Total Off-Stream Freshwater Use		
Withdrawal	335	304
Consumption	106	134
Domestic and Commercial Use		
Withdrawal	28	36
Consumption	7	9

D. Regional, Subregional, and Local Availability and Use

The national perspective masks the regional variability in both available supply and expected use; these must be examined to determine whether regional deficiencies exist. Table 3 compares the mean natural supply and the once-in-20-year drought streamflow with projected year 2000 water withdrawals and consumption for the 21 WRC regions. Also listed are projected domestic and commercial withdrawals and consumption.

Table 3

COMPARISON OF REGIONAL WATER AVAILABILITY
AND PROJECTED USE
(in bgd)

	Region	Water Supply		Year 2000 Total Off-Stream Water Use		Year 2000 Domestic and Commercial Water Use	
		Mean Streamflow	Once-In-20-Year Drought Streamflow	Withdrawal	Consumption	Withdrawal	Consumption
1.	New England	78.1	48.3	3.2	1.1	1.8	0.3
2.	Mid-Atlantic	79.2	48.4	13.9	3.5	6.0	1.0
3.	South Atlantic-Gulf	228.0	121.8	28.3	10.1	4.3	1.5
4.	Great Lakes	72.7	44.9	25.6	4.7	5.3	0.7
5.	Ohio	178.0	105.0	16.9	4.3	2.9	0.5
6.	Tennessee	40.8	31.4	6.0	1.1	0.5	0.1
7.	Upper Mississippi	121.0	65.3	7.9	2.7	2.4	0.4
8.	Lower Mississippi	433.0	202.0	24.8	5.5	1.0	0.4
9.	Souris-Red-Rainy	6.0	1.8	0.6	0.4	0.1	0.0
10.	Missouri	44.1	17.6	44.4◄	19.9◄	1.5	0.4
11.	Arkansas-White-Red	62.6	21.6	13.3	8.9	1.1	0.4
12.	Texas-Gulf	28.3	6.3	15.5◄	10.5◄	1.9	0.7
13.	Rio Grande	1.2	.2	5.6◄	4.0◄	0.4◄	0.2
14.	Upper Colorado	10.0	3.9	7.5◄	3.2	0.1	0.0
15.	Lower Colorado	1.6	1.2	7.9◄	4.7◄	0.8	0.4
16.	Great Basin	10.5	4.6	7.3◄	4.0	0.5	0.2
17.	Pacific Northwest	255.3	179.7	33.8	15.2	1.3	0.3
18.	California	48.2	20.2	41.3◄	29.7◄	4.4	1.8
19.	Alaska	905.0	705.0	0.8	0.5	0.1	0.0
20.	Hawaii	6.7	3.8	1.4	0.7	0.3	0.1
21.	Caribbean	4.8	1.6	0.9	0.3	0.5	0.1

Source: References 1 (pg. 17) and 3

Water supplies are most dependable in the Northwest, Northeast and Southeast because the drought flows are a high percentage, on the order of 50-70 percent, of the mean annual supply. The greatest variations, and least dependable supplies, occur in the semi-arid Southwest and South-Central regions where low flows are a small percentage, less than 40 percent of the mean supply. However, even in the humid regions of the country serious drought conditions can result from a series of dry years as evidenced by the 1961-65 drought in the Northeast. Thus, specific consideration of drought conditions and their frequency of occurrence is an important aspect of water availability throughout the country.

In comparing projected withdrawal and consumption with the once-in-20-years streamflow, the arrows in Table 3 indicate potential limitations of supply in the Missouri, Texas-Gulf, Rio Grande, Upper and Lower Colorado, Great Basin and California regions. It is noted that the Arkansas-White-Red region also experiences shortages, but these are masked by the dryness of the upper basins as compared with the relative wetness of the lower basins. Thus it is apparent that the geographic and temporal variations in water availability combine to make water supply a major concern in the Southwest and South-Central portions of the country.

In comparing projected regional domestic and commercial water use with the once-in-20-year streamflow as an indication of the adequacy and dependability of drinking water supplies, the Rio Grande Region is the only one which indicates a significant imbalance.

A detailed subregional comparison of available supplies and projected use is presented in Figure 4. Distinction is made between subregions which may be water-short during an average year and others which may have problems during dry years based on the once-in-five-year streamflow level. In general these 20 subregions are the ones that have intensive water developments withdrawing a large percentage of available supplies and also making extensive use of water for irrigation. More severe droughts, such as the once-in-20-year occurrence, result in shortages in other subregions scattered throughout the U.S.

The water-short subregions shown in Figure 4 are also those which depend most strongly on groundwater for supplies and, indeed, some regions are seriously depleting this resource by mining. Groundwater depletion is widespread in the Texas-Gulf, Rio Grande, Arkansas-White-Red, Lower Colorado and California regions, plus portions of the Upper and Lower Mississippi and the South Atlantic Gulf regions. Continuation of mining could ultimately exhaust local supplies and create severe shortages.

The Gila River Basin in the southern two-thirds of Arizona and western New Mexico is an instructive example of a water-short subregion, particularly groundwater problems. This basin encompasses an extensive agricultural area with irrigation representing 90 percent of total water withdrawals. Since surface water outflow from the basin is negligible, except in infrequent flood years, the expanding economy of the region is supported

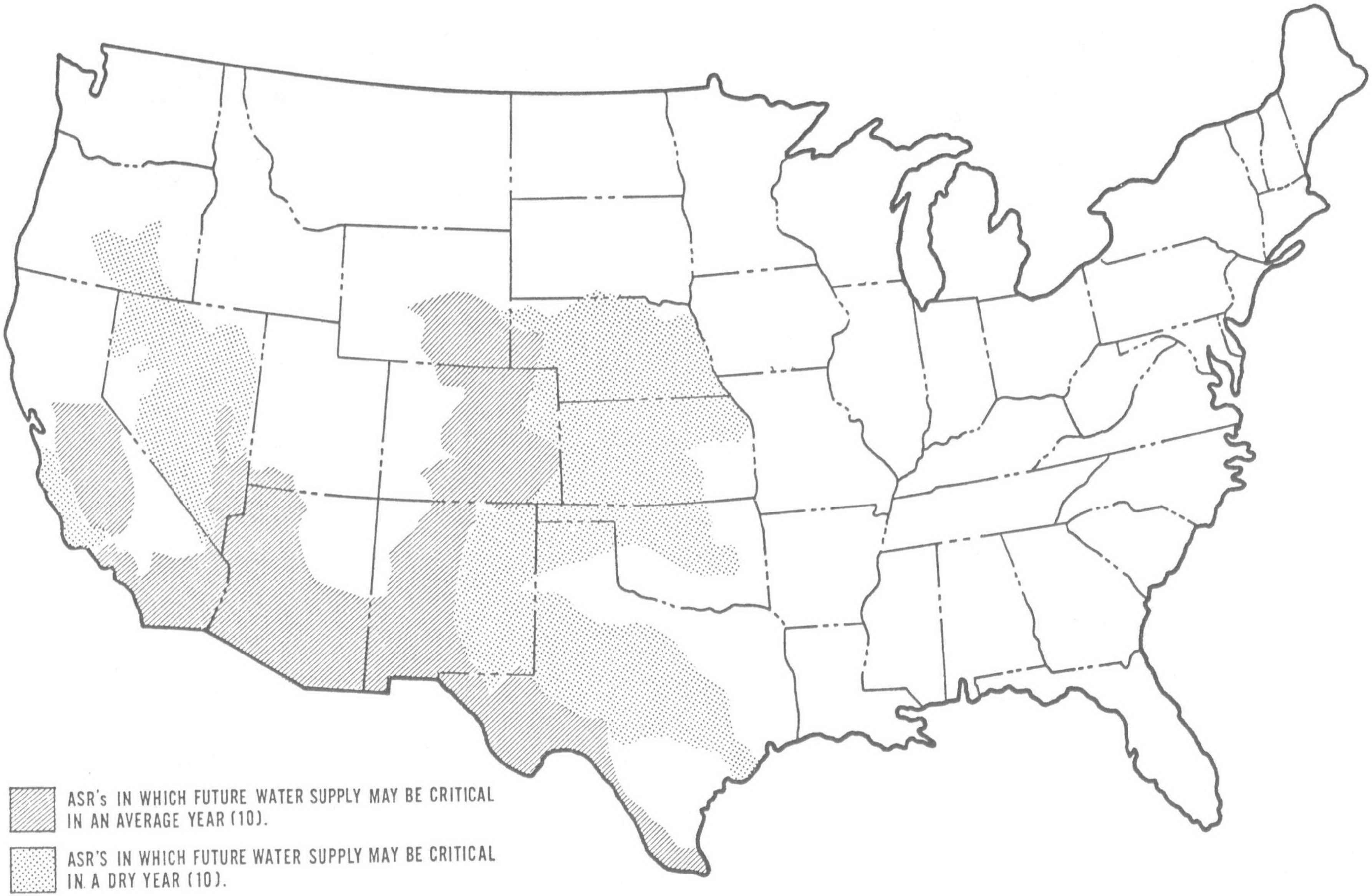


Figure 4 SUBREGIONAL COMPARISON OF AVAILABLE SUPPLIES AND PROJECTED USE

by mining groundwater. Table 4 compares overall water use with the available supply for the Gila Basin. Total supply in 1975 and 2000 is only 61 percent and 70 percent, respectively, of the total withdrawal indicating extensive reuse of the withdrawn but unconsumed water. Groundwater mining represents more than 55 percent of the total supply in 1975. If mining were to cease by 1985, as assumed by the Second Assessment, water supply and use would need to be balanced by either a reduction in use or an increase in supply. Since agriculture is the primary user, reducing irrigation use would require a 63 percent reduction in land area irrigated in 1975, or about 600,000 acres (Ref. 7). If groundwater levels continue to decline, economic pressures could bring about the same result since irrigated agriculture would be less profitable due to increasing pumping costs. In terms of drinking water, which would be less than the domestic and commercial use shown in Table 4, the existing groundwater resources without mining are more than adequate to satisfy the projected use. However, the competition among uses, in conjunction with the extensive mining occurring in the basin, poses a threat to all water uses.

Table 4

COMPARISON OF WATER AVAILABILITY AND PROJECTED USE:
GILA RIVER BASIN (ASR #1503)
(in bgd)

Availability	1975	2000
. Total Supply (with mining)	3.8	NA
. Total Supply (without mining)	1.7	1.8
- Surface Water	Negligible	Negligible
- Net Imports	Negligible	0.1
- Net Reservoir Evaporation	(0.2)	(0.2)
- Groundwater	1.9	1.9
. Groundwater mining	2.1	NA

Use	1975 W'drwl.	1975 Consump.	2000 W'drwl.	2000 Consump.
. Total Use	6.3	3.5	5.7	3.4
. Domestic & Commercial Use	0.4	0.2	0.6	0.3

Source: Reference 7.

Even the WRC subregions do not show the spectrum of problems involving adequacy and dependability of water supplies. Severe municipal and rural domestic shortages have been identified from a local point of view in half of the ASRs (Ref. 2, p. 35). Any community in the country is subject to the risk of drought. Generally speaking it is difficult and costly to provide a system which can cope with all possible droughts. Those communities using groundwater as a source are usually in the most favorable position since the supply does not usually decrease rapidly and can be augmented fairly quickly through construction of a new well. The exception to this generalization is source aquifer depletion by mining but, even in this case, droughts should not interrupt the community's supply until the aquifer is depleted to the point where it is no longer a feasible source.

Communities depending on surface streamflow can always expect a drought period in which available supplies present serious problems. Such an occurrence is more likely to happen in the regions where current use is a substantial fraction of available supply but it can happen in any part of the country. Local problems are sometimes accentuated by failure of the community to keep its system expansion on a par with increasing demand or by its failure to discourage growth if supplies cannot be increased. Such was the case in the water shortage for New York City during the early 60's.

While shortages created by drought are annoying, they do not usually create insurmountable problems for most communities. Emergency supplies and public education leading to reduced use have seen many communities through relatively severe drought without serious consequences.

E. Discussion-Issues/Options

Problems of national significance regarding availability of the water resource and its various uses have been previously identified by others and are apparent from the foregoing section. These problems occur on a regional, subregional, or local basis as opposed to being of national scope. The national significance is that major regions of the country are using water in excess of their presently sustainable supplies. Some areas are entirely dependent on groundwater mining. Other areas, where surface waters are used, have been able to satisfy growing demands by means of the relatively high yields from normal and wet-year streamflows. When droughts occur, however, it is often found that increases in demand have eliminated the drought protection which the system was designed to provide. As a result of these droughts, or when groundwater mining evolves into dwindling of the available supplies, severe economic, social, and political repercussions are often cited as the basis for national intervention to rescue affected areas. In effect, national taxpayers are called upon to subsidize state and local governments who failed to plan satisfactorily for an adequate and dependable water supply. To avoid such occurrences is a national concern.

On the use side the problem is increasing competition among uses for the limited supplies within various regions and subregions. Although this competition is most intense in water-short subregions of the Southwest and South-Central U.S., it also occurs in the water-rich Northeast where growing metropolitan areas compete for the upstream supplies which are preferred as drinking water sources. Thus competition for water is a nationwide phenomenon.

1. Groundwater Depletion

Mining of groundwater is no more inherently wrong than mining of mineral resources such as coal, petroleum, or iron. Where mining occurs on a continuing basis, however, it will eventually lead to shortages and curtailment of uses unless another water source can be found. The shortages do not usually occur suddenly; instead groundwater levels decline progressively while large withdrawals are still economical. All users, including local communities and rural households, have to periodically deepen their wells until well-lowering and higher-lift pumping are economically infeasible. A more devasting effect can occur when a large user pumps so rapidly that he draws low-quality water into the aquifer and degrades the source for everyone. Other adverse impacts which are often associated with groundwater mining are greater energy requirements, damage from subsidence and fissures, lower aquifer water capacity, and salt water intrusion. If mining is to be acceptable, specific evaluation of these effects is necessary considering the aquifer and all its users as a whole.

Comprehensive groundwater management and conjunctive groundwater/surface water management have been recommended frequently in response to groundwater depletion; however, they are not yet widely practiced. The goal of such management would be to prevent unwise use or premature depletion by mining, to promote integrated use of ground and surface waters and to allocate the groundwater resource in an environmentally and economically sound manner. Water rights, well and pumping permits, groundwater management districts, quota systems, and pump taxes are some of the specific techniques which deserve further attention. Clearly, one approach cannot be expected to solve the depletion problem everywhere it occurs since aquifer characteristics, state laws, surface sources, uses and so forth vary. Still, there is an urgent need to take actions which move toward long-term protection of groundwater sources for important ongoing and future uses.

2. Inadequate Water Supplies

This situation is probably best characterized as "intense competition among uses for limited supplies on a subregional and local basis". Thus, both the available supply and the projected uses must be examined in an effort to bring them into balance. Opportunities for augmenting supplies are discussed here while opportunities for more efficient use are discussed in subsequent subsections. Extensive background studies have been performed on a variety of alternatives for augmenting availability of supplies. The most promising approaches are reuse and improved management of the supplies already developed.

a. Reuse

A second use of water discarded by a first user is defined as reuse. It may occur either indirectly, after water has been discharged to a natural water course, or directly when the first user's effluent is piped directly to the second user. Reuse is distinguished from recirculation, which involves reuse of effluent by the first user, and from conservation which involves a decrease in either gross water use or consumption. A recent assessment of reuse potential indicated that about 173 bgd of wastewater is presently available for reuse and that the total of present uses which could accept wastewater as a supply is 331 bgd (Ref. 13). However less than one bgd is presently being directly reused. These figures do not account for indirect reuse--i.e., where water withdrawn from the stream has been used before--which can account for as much as one gallon out of five withdrawn for municipal water supply (Ref. 14).

Although indirect reuse has evolved without major effort, there are significant impediments to direct reuse. The impediments vary depending on the use anticipated; for example, direct reuse of municipal wastewater as the source for a potable supply involves many uncertainties from a public health viewpoint and is currently unacceptable. Water reuse for landscape and agricultural irrigation and for industrial purposes has more immediate promise. Even in these cases, however, there are significant impediments:

- Public health. Potential for disease transmission from wastewater use on human food crops, on landscaping, or in industrial processes with direct bodily contact still exists.
- Economics. The cost of adequately treating and delivering water to the point of use may be more costly than alternative sources.
- Water law. A new consumption occurs in the second use and as a result it encroaches on downstream water rights.
- Aesthetics. Many people object to "sewage", even if it is treated, on their golf course or on the park lawn where children play.
- Governmental Incentives/Disincentives. Federal assistance is available for wastewater treatment and discharge to the ocean, and for major water supply reservoirs in conjunction with flood control and irrigation. Federal assistance is not available to further treat the effluent for a specific use even if it turns out to be the least expensive alternative.

b. Water Management

Improved water resource system management involving joint operation of existing reservoirs or conjunctive use of surface and groundwater supplies is analogous to the groundwater management answer to depletion. It may provide opportunities to increase dependable supplies in specific circumstances. Of course the important supply numbers are those which pertain to droughts. It is difficult to generalize on this potential, because seriously water-short regions may not have extensive systems of reservoirs and thus the potential for joint operation or conjunctive use may be limited. Marginal regions where periodic drought is an increasing threat, and where extensive systems for water management have been developed, may offer opportunities for more efficient management.

In addition to the above opportunities, further development of the existing resource is a possibility. However, this will frequently require expensive and lengthy transmission facilities for interbasin transfers. Such projects will be increasingly resisted to protect in-stream uses, to reserve undeveloped water for in-basin use and for environmental reasons.

There are other potential means for augmenting supplies including desalination, watershed vegetation management, weather modification and so forth. These techniques are still in the research/pilot project stage and must overcome significant technical, cost, and environmental and legal questions before they are of major significance even in specific sites favorable to their application.

3. In-Stream and Off-Stream Uses

The recent recognition of, and increased public commitment to, in-stream fish and wildlife water needs could involve more of the Nation's water supply than all other uses combined, thus creating intensive competition between in-stream and off-stream uses. Since this in-stream use did not receive significant attention during the past 75 years, disagreement on how much water each use deserves is large and finding an appropriate balance will be difficult. Even when reliable estimates of in-stream fish and wildlife needs are available, there will be a major problem of finding an equitable means for allocating water to this use. For example, in its present deliberation of needed changes in water law, California is considering the purchase of water rights in order to provide in-stream flows. Although other in-stream uses such as recreation, navigation and hydropower are also important, fish and wildlife requirements will be substantial in most cases and will be most difficult to reconcile. Even though these are not consumptive uses, conflicts will occur because off-stream consumption usually lessens downstream flows and because return flows usually re-enter the stream a significant distance below the point of withdrawal, often resulting in great reductions of streamflows between the two points.

4. Conservation

Conservation offers an opportunity to all users to alleviate competition for limited supplies. The timing is ideal for wider adoption of reasonable conservation measures not only because of the recent attitudinal changes stemming from environmental awareness, but also because additional developable supplies are increasingly expensive. More and more frequently conservation is likely to be recognized as one of the most economical near-term means for satisfying water needs associated with increased population or production. The main issue with conservation is not whether it should occur but instead how much is desirable and what mechanisms should be used to encourage it. Following are observations on opportunities for conservation by various groups of users:

- Domestic in-house use might be reduced to between 50 and 70 percent of present average values with the use of pressure-reducing valves, flow-limiting shower heads and dual-cycle toilets. Such changes could be achieved in new and remodelled homes (Ref. 15).

- Metering of domestic central supplies may reduce outdoor uses at presently unmetered houses by 60 to 80 percent (Ref. 15).

- Additional conservation measures oriented toward sprinkling should be able to realize a 10 percent reduction in yard use with no significant sacrifice in landscaping (Ref. 15).

- Conservation on the part of commercial and industrial users of municipal supplies could achieve a 5 percent reduction simply based on good housekeeping. Adoption of additional measures such as water conserving toilets, changes in production processes and recycling should provide substantial water savings.

- Irrigation use is a prime candidate for conservation because of the relatively large quantities of water involved and the possibility for releasing conserved water to other uses such as domestic. However, agricultural practices are very sensitive to cost changes and the increased efficiencies projected by the Second Assessment will require intensive efforts. In general, it may be more important for agriculture to lessen consumptive losses rather than to decrease overall withdrawals but new consumption reducing technology is expensive.

The benefits of conservation vary. In coastal locations where water supply diverted from mountain streams is used only once and then discarded to the ocean, any savings in withdrawal is important since it makes water available for a different use, or perhaps a whole sequence of uses. On the other hand, with inland users, savings in water consumption are more important than water withdrawn since it is only consumed water which is unavailable for downstream uses. An important aspect of any conservation strategy may be to not go too far. For example, normal-year sprinkling use may provide a crucial buffer which allows domestic users to reduce their demands during drought periods enabling reduced municipal supplies to satisfy the vital uses.

Industrial recirculation provides an opportunity to reduce competition for water supplies in some localized settings. To the extent that headwaters or groundwater withdrawals are not developed by industry, they can be made available to other users. Recirculation is now being extensively implemented as a result of water quality regulations. The additional possibility of industrial conservation through process changes which decrease consumption may be helpful in special local situations and should not be overlooked. Such measures were not considered in the Second Assessment.

5. Water Consumptive Treatment Technology

A consideration which may present problems in specific locations is the extent to which regulations based on water quality control require increased consumptive use with possible adverse effects on downstream users. Three specific examples of this situation are:

- The need for steam electric facilities to use either cooling ponds or cooling towers to satisfy heat discharge regulations; the estimated 50 percent increase in nationwide steam electric consumption may have significant impacts in water-short subregions.

- The need for manufacturing concerns to similarly treat cooling waters may have similar consequences.

- Emphasis on land treatment as a means of eliminating discharge of pollutants and as an environmentally desirable management technique may result in significant increases in consumption, or at least significant decreases in return flows and hence in-stream flows.

6. Institutions

It is clearly Federal policy that the primary authority over water management, and particularly over water rights, resides with the states. What is not clear is how the Federal interest to address significant problems and opportunities such as groundwater depletion, conservation, and reuse can be most productively and smoothly interfaced with state and local authority. Institutional complications arise because: water quality programs are mandated and financed on the Federal level but are developed and implemented by state and local authorities; major water resources projects are developed primarily by the Federal government with state and local input; and, municipal water supply is primarily the responsibility of local agencies within public health guidelines issued by Federal authorities.

7. Coordinated Planning

Water supply planning generally occurs in one of three forms: a local water agency or other user makes a specific plan to develop the supplies it needs; a federal or state agency develops a major project that also contains the provision of water supply; or a broad, regional multiagency, multiobjective, multipurpose plan is developed that also includes a water supply element. Water quality planning is generally performed on a totally separate basis, except when there is a water quality element to the broad, regional plan described above. There is usually no attempt to coordinate plans for water supply and wastewater facilities on the local level. The absence of such coordination is becoming more significant as the water resource becomes intensively developed and the gross insults to water quality are eliminated. More subtle concerns are now emerging and are dependent on quantity/quality interactions: the effects of wastewater treatment technologies on streamflows; the effects of low streamflows on fish and wildlife; and, the reuse of wastewaters as water supplies.

Presently available data bases are also inadequate for addressing the more subtle coordination problems. Even the water availability and use data base for the Second Assessment required major upgrading during the assessment process and further refinements combined with an ongoing program of updating are needed. Water quality data and data on other environmental aspects of the resource such as fish and wildlife flow needs and the presence and effects of toxic substances are even less adequate.

Based on the foregoing discussion and with a view toward Congressional interest in present and projected availability of adequate and dependable volumes of drinking water, and in capturing benefits from coordination of water supply and wastewater treatment, there follow some initial questions which merit further discussion:

- What Federal initiatives would be helpful in addressing the groundwater depletion problem?
- How much reuse is advisable and how can it be encouraged on the local level?
- What specific contributions to water availability can be made by comprehensive water system management which includes joint operation of reservoirs and conjunctive management of surface and groundwaters and how can such management best be implemented?
- How much conservation is desirable and how can it be encouraged?
- How can the transferability of water rights be improved while still protecting the interests of all parties involved?
- Should wastewater treatment construction grants offer incentives to encourage reuse and conservation? If so, what should they be?
- How can the water consumptive impacts of land treatment and required changes in manufacturing and steam electric cooling technology be coordinated effectively with water supply considerations?
- To what extent should comprehensive water system management for water supply include management for water quality?
- How should the need to improve the reliability of in-stream flows for fish and wildlife be reflected in wastewater treatment programs?
- Should water supply and wastewater treatment planning be performed in tandem on the local level to achieve the needed coordination?

III. MEASURES TO PROTECT AND ENHANCE WATER QUALITY

A. Introduction

This section reviews major legislation affecting drinking water supplies and water pollution control. Present water quality standards for drinking water supplies and streams are discussed. Specifically, this section addresses:

- Adequacy of drinking water quality standards;
- Lack of compliance by small water supply systems;
- Method of control of organic chemicals;
- Protection of groundwater; and
- Implementation of nonpoint source pollution controls.

B. Legislation

Many acts designed to protect the Nation's streams and drinking water supplies have been passed since the first one, the Rivers and Harbors Act of 1899. The two most recent ones are the Safe Drinking Water Act (PL 93-523) and the Federal Water Pollution Control/Clean Water Act (PL 92-500).

1. Safe Drinking Water Act

The Safe Drinking Water Act delegates the regulation of the quality of drinking water supplies to the EPA and the states. The major provisions which relate to the safety of drinking water and coordinated water supply-wastewater treatment planning include adoption of national interim primary standards, proposed state underground injection control program, regulations for designation of sole source aquifers, proposed regulations for organic chemicals and research on water quality problems. The Primary Drinking Water Standards are designed to protect drinking water quality of public water supply systems and self-supplied public facilities. Suppliers must monitor water quality at regular intervals and notify the customers and state enforcement agencies when quality or monitoring violations occur.

The Underground Injection Control Program of the states is intended to protect groundwater from contamination from all types of injection wells. Such facilities include industrial wells, reinjection of brines from oil and gas operations, drainage wells, and solution mining. The proposed regulations state that all aquifers which might be used as drinking water supplies are to be protected unless prior use, contamination, or impractical development precludes its use as a drinking water supply. In most states, aquifers with TDS concentrations below 5,000 mg/l are protected. In water-short areas, aquifers with TDS concentrations between 5,000 and 10,000 mg/l may also be protected to insure an adequate supply for the future. The primary mechanisms for control are proposed regulations covering well construction and operation, a permit system for new wells, and rules covering new requirements for old wells.

The Sole Source Aquifer designation is a measure designed to protect large regional aquifers. Guidelines for designation are:

- Source for large population, generally covering several counties, and providing more than 50 percent of the public water supply.

- Contamination could result in significant hazard to public health.

- Alternative, acceptable water supply sources are not available.

If an aquifer is declared a sole-source aquifer, then an Environmental Impact Statement on groundwater effects following NEPA guidelines must be prepared for all federally funded projects. Four areas have been declared sole-source aquifers: the Edwards aquifer in Texas; the Rathdrum Valley aquifer in Spokane, Washington; the northern island of Guam;and Nassau, Suffolk County on Long Island, New York.

Areas currently under study include: Biscayne, Florida; Cape Cod, Massachusetts; Tenmile Creek, Maryland; Twin Cities and the Karst region of Minnesota; and Fresno and Scott's Valley near Santa Cruz in California.

2. Federal Water Pollution Control Act/Clean Water Act

This is the primary legislation covering point and nonpoint source discharges to surface water. The Act provides two strategies for the abatement of current water pollution and the prevention of new pollution. The desired water quality is defined in terms of "water quality standards." The second strategy is based on limiting the amount of pollution discharged into water by individual sources. These pollution control strategies are enforced under the National Pollutant Discharge Elimination System(NPDES). NPDES permits issued by EPA or the state contain conditions designed to assure compliance with water quality standards and effluent limitations. The NPDES system requires a permit for all point source discharges to surface water. The treatment requirement depends on the type of pollutant. An industrial discharger must use best practicable control technology

(BPT) for all pollutants by July, 1977 which may be extended under certain conditions. For conventional pollutants defined as biochemical and chemical oxygen demand, total suspended solids, total phosphorus, oil and grease, the industrial discharger must use best conventional control technology (BCT). For other pollutants best available technology economically achievable must be used by July 1, 1984. Publicly-owned treatment works (POTW's) must use secondary treatment by July, 1977 or July 1, 1983 for best practicable wastewater treatment technology (BPWTT).

Water quality management planning on state and areawide levels is intended to control point and nonpoint sources of pollution. Areawide wastewater management planning (Section 208) is designed to determine the significant pollution problems in an area, to identify effective control measures and to decide how to implement them. States are to set up a planning process (Section 303) to coordinate areawide plans (208) and river basin plans (209), and encourage inter-governmental cooperation. The states are to develop implementation schedules for effluent limitations and water quality standards for streams, and prepare an inventory at existing POTW's and ranking by need for any new waste treatment works.

The act also establishes a number of programs to provide funds to control pollution. Two programs are: the Municipal Construction Grants Program which provides grants for the planning, design, and construction of publicly-owned wastewater treatment plants; and the Rural Clean Water Program which provides funds to implement contracts between rural land operators and the U.S. Department of Agriculture to control nonpoint source pollution.

3. Other Acts

The Toxic Substances Control Act regulates the testing manufacture and distribution of toxic chemicals prior to marketing.

The Resource Conservation and Recovery Act seeks to promote reuse and recycling and regulate hazardous and solid waste disposal. A major concern is to minimize the impact of land fill or dump leachate on groundwater aquifers. The goal is to close or upgrade open dumps by 1983. Guidelines for establishing sanitary landfill sites and types of waste that should be disposed of in them were developed in February, 1978.

Under the Clean Air Act, the EPA set national ambient air quality standards, new source performance standards for new plants, and emission limits for existing stationary sources. Sludges, a by-product of most air quality control technology, must be disposed of carefully to avoid pollution of drinking water supplies.

The National Environmental Policy Act requires that all federal agencies prepare an Environmental Impact Statement for all major projects before commencing construction or operation. The impact of the project on the environment including water supplies would be assessed and, if necessary, mitigating measures identified.

The Surface Mining Control and Reclamation Act authorizes the Office of Surface Mining to regulate surface mines based on final regulations to be published in December, 1978. This Act is intended to reduce pollution from new and existing mines and also sets up an abandoned mine reclamation fund for use in abating pollution from abandoned mines.

C. Existing Standards

1. Drinking Water Quality Standards

As stipulated in the Safe Drinking Water Act, interim drinking water regulations have been set and became effective on June 24, 1977. The primary drinking water regulations are based on human health considerations and apply to all systems serving more than 24 people or having 15 service connections. These standards, covering ten inorganic chemicals, chlorinated hydrocarbons, bacteria, and radionuclides are presented in Table 5. Secondary standards including factors affecting taste, odor and the corrosion properties of water were also established as guidelines for states to enforce (Ref. 17). The primary standards have been reviewed by the National Academy of Services (Ref. 18)

Specific monitoring requirements including frequency and analytical techniques were mandated in the primary regulations with some discretion allowed the states. Actual monitoring is a local responsibility. The analyses must be performed by an EPA or state approved laboratory. The monitoring is more frequent for systems using surface water than groundwater sources. There are also differences in monitoring depending on the population served by the system and whether it is a community or non-community water supply system. If monitoring shows a violation of a primary drinking water standard then both the state and the public must be notified. If a significant health hazard exists, emergency provisions for supply would be made. Permanent correction of the problem could include a variance or exemption.

2. In-Stream Water Quality Standards

In-stream standards are established to improve the habitat for fish and aquatic life and protect in-stream recreation and downstream water withdrawals. For example, better raw water quality results in improved finished drinking water quality at a lower cost at downstream communities. Lower suspended solids results in a lower turbidity which increases the effectiveness of disinfection.

Minimum standards were set for in-stream quality and states may set more stringent standards if desired. The standards vary depending on use. The federal standards have only two classes: Class A for water contact recreation and Class B for protection of fish, wildlife and other aquatic life. Most states have more use classifications.

Table 5

PRIMARY DRINKING WATER QUALITY STANDARDS

Parameters	Annual Average Maximum Daily Air Temperature °F	°C	Maximum Level+
Inorganic Chemicals			
Arsenic			0.05
Barium			1.
Cadmium			0.010
Chromium			0.05
Lead			0.05
Mercury			0.002
Nitrate (as N)			10.
Selenium			0.01
Silver			0.05
Fluoride			
	53.7 and below	12.0 and below	2.4
	53.8 to 58.3	12.1 to 14.6	2.2
	58.4 to 63.8	14.7 to 17.6	2.0
	63.9 to 70.6	17.7 to 21.4	1.8
	70.7 to 79.2	21.5 to 26.2	1.6
	79.3 to 90.5	26.3 to 32.5	1.4
Chlorinated Hydrocarbons			
Endrin (1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4-endo-5, 8-dimethano naphthalene)			0.0002
Lindane (1, 2, 3, 4, 5, 6-hexachlorocyclohexane, gamma isomer)			0.004
Methoxychlor (1, 1, 1-Trichloroethane) 2, 2-bis (p-methoxyphenyl)			0.1
Toxaphene ($C_{10}H_{10}Cl_8$-Technical chlorinated camphene, 67-69 percent chlorine)			0.005
Chlorophenoxys: 2,4-D, (2, 4-Dichlorophenoxyacetic acid)			0.1
Chlorophenoxys: 2, 4, 5-TP Silvex (2, 4, 5-Trichlorophenoxy-propionic acid)			0.01

Parameters	Maximum Level
Turbidity (for surface water sources)	1 TU up to 5 TU*
Coliform Bacteria	
Membrane filter technique:	1/ml mean/month 4/ml in one sample if <20 samples/month 4/ml in more than 5% if >20 samples/month
Fermentation tube with 10 ml portions:	no coliforms in >10% of portions/month no coliforms in >3 portions/sample if <20 samples/month no coliforms in >3 portions of 5% of samples if >20 samples/month
Fermentation tube with 100 ml portions:	no coliform bacteria in >60% of portions/month no coliform in 5 portions in one sample if <5 samples/month no coliform in 5 portions in 20% of samples if >5 samples/month

Radioactive Material	Level
Combined radium 226 and radium 228	5 pCi/l
Gross alpha particle activity**	15 pCi/l
Beta particle and photon radioactivity from man-made radionuclides	4 millirem/year
Tritium for total body	20,000 pCi/l
Strontium-90 in bone marrow	8 pCi/l

+mg/l unless otherwise stated.

*Includes Ra^{226} excludes Radon, Uranium.

**If meet special requirements.

Source: Reference 16

Maximum criteria and toxicities of selected elements to aquatic life have been determined (Ref. 19 & 20). In-stream water quality standards are used in evaluating NPDES permits.

D. Discussion - Issues/Options

1. Safe Drinking Water Standards

The primary control measure for protecting drinking water quality are the standards set under the Safe Drinking Water Act. The degree of protection provided depends on the adequacy of the standards themselves and effectiveness of enforcement.

The National Academy of Sciences reviewed the primary standards and the literature to identify needs for any new standards (Ref. 18). Research is being conducted to determine the need for revised or new maximum contaminant levels (MCL's). Enforcement of the standards is necessary to insure protection of drinking water quality. The states are to develop an implementation program which is then reviewed by the EPA. Forty states had been designated as primary enforcement agencies by December, 1978.

The standards are enforced at different levels depending on the size of the system. Small systems are likely to have water quality problems due to lower levels of treatment, inadequate monitoring of treatment equipment or badly-maintained distribution systems (Refs. 21 and 22). Table 6 displays results of a survey of water supply systems which serve varying population levels. Due to high costs, upgrading treatment may be difficult and there is a shortage of innovative ways to provide safe drinking water to segments of the population served by smaller systems. Physical or administrative integration through regional planning is one approach that could be considered.

Table 6

STATUS OF SURVEYED WATER SUPPLY SYSTEMS

Number of Systems:	446	501	22	969 (total)
Population Group Served: (in thousands)	<.5	.5-100	>100	18,203
Evaluation of Systems:				
. Met standards	50%	67%	73%	59%
. Exceeded recommended limits	26%	23%	27%	25%
. Exceeded mandatory limits	24%	11%	0	16%
Study Population (in thousands)	88	4,652	13.463	18,203

2. Organic Chemicals

New standards for organic chemicals were proposed on February 9, 1978 covering trihalomethanes and synthetic organic chemicals. Trihalomethanes (THM), principally chloroform, were isolated from community water supplies in the U.S. in 1974. It has been established that the precursors which react with chlorine during water treatment (disinfection) are the naturally occurring humates in surface waters (i.e., nonpoint source input of decayed vegetation and aquatic material) which react with chlorine to produce haloforms in μg/l concentrations. Other organic compounds in raw water sources are from municipal and industrial point source discharges and from urban and rural nonpoint sources.

The concern over THM's in drinking water supplies relates to their carcinogenicity as identified by the National Institute of Health. Other organics which have been identified in drinking water in very small quantities are toxicants, carcinogens, mutagens and teratogens as indicated by animal bioassay tests conducted at high doses. The full effect on humans of long-term ingestion of very low levels of organic chemicals in drinking water is not known. Research, workshops, and symposia have been studying the health effects of chlorination and other alternatives for disinfection. Candidates are ozone or chloromine. No final conclusions can be made yet as to the use of alternatives to chlorine for disinfection.

Only within the last few years has technology produced the instrumentation and sophisticated techniques necessary to measure small quantities of the many types of organic chemicals detected in drinking water. Even with the aid of analytical techniques such as gas chromatography and mass spectrometry, most of the specific organic compounds in drinking water have not been identified and methods of analysis for many of them have not yet been standardized.

The proposed organic standard is a maximum contaminant level of 0.1 mg/l for THM. The standard was set for THM, not just chloroform, since other halogens can combine with organics. Communities over 75,000 people or 52 percent of the national population would be required to monitor for THM's within three months and comply with the proposed standard within 18 months. Communities with 10,000 to 75,000 people would begin monitoring within six months. Of the 312 systems affected by the proposed regulations, 43 systems are estimated to exceed the standard. The regulations propose the use of granular activated carbon (GAC) for all systems serving over 75,000 people in areas of significant contamination by synthetic organic chemicals. The EPA estimates that 50 systems will need to install GAC treatment (Ref. 24).

The position of the American Water Works Association (AWWA) on the proposed regulations for organics in drinking water is that the EPA should set an MCL of 0.3 mg/l for chloroform, the primary THM formed after disinfection, not all THM's. Also, the AWWA proposes that the EPA establish MCL's for 23 organic contaminants in drinking water rather than require treatment with GAC. The AWWA feels that the expense of GAC is not warranted given the uncertainties in determining the hazards of low level exposure, high cost of treatment, and possible side-effects of the treatment itself such as desorption and GAC introduction of substances due to the regeneration process.

3. Groundwater Contamination

Protection of groundwater is important since approximately 48 percent of the population uses it for drinking water (Ref. 25). Groundwater pollutants include sanitary waste, toxic chemicals, fertilizers, and heavy metals (Ref. 26). Pollutants can reach the groundwater through direct and indirect pathways, making control difficult. Recent legislation and regulations (e.g., Safe Drinking Water Act and Resource Conservation and Recovery Act) have made significant progress, particularly for protection of large regional aquifers and control of injection wells. However, control of all types of waste disposal at the local level is often spread among several agencies resulting in a lack of comprehensive safeguards.

Approaches used by the states for waste disposal regulation vary from permits for waste disposal operations (i.e., lagoons and landfills) in Montana and Pennsylvania to permits for a waste-generating facility in Florida and Delaware. California has a waste disposal classification system which assigns wastes to disposal sites with specified vertical and lateral liquid permeabilities. The discharge must be compatible with the region's water management plan. On-site waste disposal is regulated by some states, some counties, or divided among several agencies. Technical control measures which can protect groundwater aquifers include minimizing leakage from surface impoundments and wastepiles, proper well construction, proper siting and operation of septic tanks and cesspools, irrigation practices to minimize leaching of fertilizers and pesticides, control of feedlot runoff, careful siting and control of waste input to landfills and dumps to minimize leaching. Groundwater management can lessen problems resulting from excessive pumping of groundwater such as saltwater intrusion. Contamination problems still occur because the source of pollutants may not be recognized, the appropriate control measures are not used, and existing laws are not enforced. Another problem may be conflicts between the goals of the many acts. For example, the goal of elimination of discharge of pollutants from point sources of the Clean Water Act and the air quality standards of the Clean Air Act may result in land disposal of sludges which can pollute groundwater.

4. Nonpoint Source Control

Vast regions of the U.S. are dedicated to agriculture, silviculture and mining. Within these agricultural and silvicultural regions, pesticides and other chemicals are applied to the land in copious quantities, and combined with urban runoff and mine drainage, constitute a large proportion of the pollutant loads to drinking water supplies.

The major problems mentioned by the 38 states reporting in the 1975 National Water Quality Inventory (Ref. 27) are as follows:

Agriculture	100%
Urban	97%
Mining	71%
Silviculture	55%
Construction	55%
Hydrologic Modification	24%
Residual Waste Disposal	21%
Salt Water Intrusion	11%

In terms of volume, sediment is generally the major nonpoint source contaminant. However, the pollutants which are more important with respect to the deterioration of drinking water supplies are those which constitute a potential health hazard. Taken in this context, the major pollutants from nonpoint sources include pesticides, nitrates, pathogens, organic chemicals, and heavy metals, especially lead. The impact of a particular pollutant depends on the nature of the contaminant, the levels at which it is present, and the effectiveness of water treatment methods. Some idea of the magnitude of nonpoint source pollutants can be gained by comparing the export of phosphorus and nitrogen from selected basins in the Northeast. Mean phosphorus loading for agricultural areas was highest at 31 $kg/km^2/yr$ with urban areas only 2 percent lower at 30 $kg/km^2/yr$ and forested areas the lowest at 8 $kg/km^2/yr$ or 28 percent lower (Ref. 27). Nitrogen loading showed the same general relationship with the highest loading from agricultural areas (982 $kg/km^2/yr$) and the lowest from forest (440 $kg/km^2/yr$) (Ref. 27). The relative pollutant contribution of nonpoint versus point sources will vary from one state to another depending on land use, geology, climate and other factors. One study in Iowa showed that over 90 percent of the annual phosphorus and nitrogen loads in most of the state's river basins were from nonpoint sources (Ref. 27).

There are structural controls and management practices to minimize nonpoint pollution. Management practices to minimize pollutant discharges in urban runoff range from preventive measures such as litter control and street sweeping to retention and treatment of the stormwater. The benefits of the preventive measures are cleaner neighborhoods as well as reduced surface water pollution. The potential benefits of stormwater retention and treatment in water-scarce areas include reuse of the water for recreational lakes, groundwater recharge, or water supply augmentation.

Management practices for agriculture such as minimum tillage, terracing, diversions, stripcropping, contouring, and grassed waterways are useful in minimizing erosion. Erosion can remove nutrients and pesticides with the sediment. These constituents and the topsoil with which they are usually associated should be retained on-site in the interest of agricultural production and stream water quality.

Successful implementation of management practices will require legislation, ordinances, or education to increase public awareness of the problem and potential benefits. Some states have passed appropriate legislation such as the Soil Erosion and Sediment Act in Michigan in 1973. Maryland, Illinois and Virginia have laws to regulate mining and reclamation activities and to control abandoned mines. Other improvements in nonpoint source problems can be implemented through Federal legislation, such as the Surface Mining Control and Reclamation Act and the Areawide Wastewater Management Planning (Section 208), and specific EPA enforcement actions. The Surface Mining Act and 208 Plans have not been adequately implemented yet so their effectiveness cannot be judged at this time.

Another consideration in nonpoint pollution control is the effect of controlling the activity which is causing the pollution. Examples of such tradeoffs are loss in food production if less chemical fertilizers and pesticides are used and lower coal output if strict environmental regulations of coal mines are enforced.

The discussion above leads to some obvious conclusions and questions:

- Small water supply systems are less likely to comply with water quality standards. In 1971 only 50% of surveyed systems met drinking water quality standards. High costs make upgrading systems difficult. What policies may be adopted to improve compliance with standards for small water supply systems? Can regionalization help solve this problem?

- Protection of groundwater is divided among federal, state and local agencies. The Sole Source Aquifer program may help to protect large, regional aquifers. The Underground Injection Control Program is being developed by the EPA and states to control direct entry of waste into aquifers. However, the pathways to groundwater include other indirect paths from ponds, dumps, and stockpiles. How can groundwater best be protected and what should the role of federal, state and local agencies be? What approach should be taken--legislation, permits, etc.?

- Steps to implement nonpoint source controls have been taken such as the Rural Clean Water Program, the 208 program, and some state legislation. However, more needs to be done to get the best management practices accepted and used by the public. How can management practices to control nonpoint sources be implemented to prevent significant degradation of raw drinking water sources? Should regulation be done by state, local, or 208 agencies? Are more financial incentives needed?

Water supply and wastewater treatment functions have been separated in most communities. Lack of coordinated regional or river basin planning has resulted in location of waste treatment discharges upstream of water supply intakes increasing water treatment costs to the downstream community. Need for increased water supply in an area may not have been considered when the types of waste treatment plants were investigated. What is the relationship between quality of intake water and quality of wastewater discharge and ambient water quality in the stream? How can use of land treatment or injection of waste be used to maintain or increase water supplies while still protecting water quality? What regulatory framework would allow flexibility to consider local cases and insure adequate protection? What grant conditions or institutional arrangements would insure that the water quality impacts of waste treatment operations or management practices for nonpoint sources are considered before implementation?

IV. WATER SUPPLY AND WASTEWATER TREATMENT

A. Introduction

To date, efforts to satisfy treatment needs for water supply and for wastewater have followed separate paths. In the case of water supply, quality requirements and therefore treatment needs are dictated by the end use (e.g., agricultural, industrial, power generation and potable supplies) and the quality of the source. Potable supply quality, furthermore, is based on the primary standards adopted as a result of the SDWA. Planning for, and implementation of treatment technologies to meet these standards are carried out principally at the municipal level.

Wastewater treatment needs also depend on the end use or disposition (e.g., surface or groundwater discharge, land application or other reuse) and to some extent, wastewater strength and volume. However, treatment of wastewater depends to a much greater extent on legislation and regulations establishing water quality criteria and/or effluent standards. To achieve this, specific treatment goals are established on a national basis as a result of the FWPCA/CWA. In addition, financial assistance, as well as extensive guidelines for the planning and implementation of wastewater treatment facilities have been promulgated at both the Federal and state levels.

In this discussion of opportunities for coordination between water supply and wastewater treatment planning, recognition of this basic difference between the present planning and implementation framework of the two areas is important. The discussion highlights areas in which coordination opportunities or problems may exist. Additionally, issues are raised for discussion of how such coordination is facilitated or hindered by the present framework. In effect, this section addresses the concerns of Section 516(e) of the 1977 amendments.

B. Treatment Requirements and Methods

1. Water Supply Treatment

Conventional water treatment methods such as coagulation, sedimentation, filtration, and disinfection are effective in removing suspended solids (as measured by turbidity) and bacteria, two constituents prescribed in the primary drinking water standards. These conventional processes can also be effective in reducing the levels of some heavy metals and radionuclides (Refs. 28, 29, 30, 31).

Other non-conventional treatment processes that have been used or studied to remove various inorganic constituents regulated by the primary standards include ion exchange for nitrate and fluoride removal (Ref. 32) and reverse osmosis, which is effective in significantly reducing the levels of most dissolved solids (Ref. 31, 32). Such non-conventional treatment processes are relatively expensive and have not been used extensively. This is primarily because it is frequently more cost effective to develop an alternative source of water supply than to remove inorganic constituents which exceed the standards.

While the primary drinking water standards are not substantially different from those established by the United States Public Health Service and various states, the mandatory application of these standards to virtually all public water supply systems requires upgrading of many treatment facilities with improved or additional treatment processes.

Treatment for the removal of organic chemicals is directly related to proposed regulations under the SDWA as already discussed. Under these proposed regulations, granular activated carbon (GAC) absorption could become required treatment for systems serving more than 75,000 people and using a surface water supply. Estimates of the number of systems that would require GAC vary widely between EPA's original estimates of 61 systems and AWWA's estimates of 391 systems (Refs. 33, 34). Other potential treatment methods for organics removal presently practiced or currently under investigation include the following: ozonation or ozonation in combination with activated carbon as practiced in Europe (Ref. 35), powdered activated carbon, and ion exchange resins. An alternative to additional treatment which may be acceptable in some systems is to change the sequence of treatment operations, particularly disinfection, to reduce the potential for trihalomethane formation.

2. Wastewater Treatment

The underlying goal of the Federal Water Pollution Control Act is to eliminate the discharge of pollutants into navigable waters by 1985. Specific objectives relating to wastewater treatment include: a minimum of secondary treatment for all publicly owned treatment works, or a higher degree of treatment where discharge is to water quality limited (WQL) stream segments, by July 1, 1977. Extensions to July 1, 1983 may be granted on a case-by-case basis under the 1977 amendments. Requirements for point source discharges other than POTW's (e.g., industrial) and nonpoint sources are discussed in the previous section.

To meet these requirements, EPA has provided grant funding for municipal wastewater treatment and industrial wastewater discharged to municipal sewers. Of the 25,400 million gallons per day of wastewater treated by publically owned treatment works, 95 percent is discharged to surface waters (i.e., 14 percent to oceans, 17 percent to estuaries, 64 percent to rivers and lakes). The remaining 5 percent is evaporated from lagoons or applied to the land. Thus, over 30 percent of the treated wastewater going to oceans or estuaries is currently unavailable for direct or indirect reuse without major changes in collection and discharge systems. As of 1978, it is estimated that 84 percent of the 25,400 MGD receives at least secondary treatment or will receive such treatment based on treatment works in the design/construction stage. Constituents remaining in secondary effluent include suspended solids, degradable organics, nondegradable organics, nutrients, and some heavy metals. Approximately 13 percent of the total flow receives treatment beyond secondary for discharge into water quality limited surface waters. For most of this flow, the advanced wastewater treatment (AWT) processes used are filtration and coagulation-flocculation to remove suspended solids and phosphorus. Synthetic organic materials are not significantly removed by the conventional treatment methods used in municipal plants. Only by applying non-conventional treatment processes such as activated carbon absorption to wastewater treatment processes can such constituents be removed (Refs. 36, 37, 38).

Control measures for nonpoint source discharges include structural controls such as treatment of combined sewer overflows and urban stormwater. Treatment methods to meet these needs are generally conventional methods for removal of suspended solids, BOD, and bacteria. Nonpoint sources were considered in the 208 wastewater management plans for the designated areas but specific federal funding programs have not been developed except for agricultural nonpoint source control as provided in the 1977 amendments.

Wastewater treatment has been aimed mainly at protecting recreational uses, aesthetics, and fish and wildlife. From the viewpoint of downstream users of the water as a potable supply some improvement occurs indirectly from dilution and the regenerative capacity of the watercourse. Present regulations for point sources rarely require removal of specific organic and inorganic substances to protect drinking water supplies. A major problem in assessing treatment needs to maintain or enhance water quality is identification of the significant sources of pollution in a particular area. For example, organics can be discharged into waters in urban runoff, rural and agricultural runoff, industrial wastewater discharges, and municipal wastewater discharges. Organics can also be released in streams or lakes by decaying plant life which form complexes of pannic, fulvic and humic acids that can be converted to chloroform during chlorination.

Because wastewater treatment has been tied to in-stream beneficial uses, the requirement of treatment beyond secondary or BPT has been established for WQL segments of surface waters. In other non-WQL surface waters, secondary treatment is all that is required by the NPDES permit. Additional treatment or reuse in this case is not required and EPA is not proposing to fund any related costs.

For WQL segments, the principal options are AWT, land treatment, or reuse. In the case of irrigation with wastewater, the options of land treatment and reuse can be combined. In other types of reuse, such as groundwater recharge or industrial reuse, recreational reuse, or ultimately direct municipal reuse, appropriate AWT and reuse could be combined. For example, to reuse municipal effluent in a recreational lake, the nitrogen and phosphorus content would generally have to be reduced using AWT.

3. AWT Processes and Systems

AWT processes include filtration, nitrification, denitrification, chemical precipitation, ion exchange, and carbon absorption. These unit processes can be added to a secondary treatment plant in any combination to form an AWT system. While the individual processes are quite selective in their removals, the combined AWT system can remove a wide variety of constituents. For example, biological denitrification removes nitrate-nitrogen but has little effect on other constituents. An AWT system, however, of chemical precipitation, nitrification, denitrification, and filtration can remove BOD, suspended solids, nitrogen, and phosphorus down to very low levels.

AWT systems have been used in this country to provide water for reuse in several dual water systems including Irvine Ranch Water District, California, St. Petersburg, Florida, and Grand Canyon Village, Arizona. These reuse systems also accomplish conservation of potable water supplies. One instance where direct reuse for potable purposes has been planned and accomplished is at Windhoek, Namibia. The AWT system employed at Windhoek includes the processes that follow secondary treatment; specifically, polishing ponds, pH adjustment, algae flotation with alum, foam fractionation, lime flocculation, breakpoint chlorination, sedimentation, rapid sand filtration, activated carbon absorption, and chlorination. The reclaimed water is then blended with the normal potable supply.

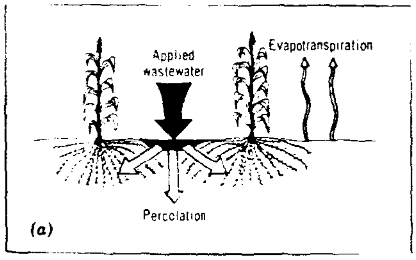
The principal problems associated with AWT are high cost of construction and operation, increased complexity of operation and resulting skilled personnel requirements, large requirements for resources such as energy and chemicals, and increased amounts of wastewater sludge for disposal.

4. Land Treatment Processes

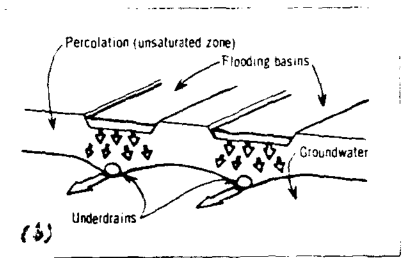
Land treatment processes can result in either a percolation of treated effluent to groundwaters or a discharge to surface waters. The three principal processes -- slow rate, rapid infiltration, and overland flow -- are illustrated in Figure 5 and defined as follows:

- Slow rate is the application of wastewater to croplands, forest lands, or landscaped areas for treatment or reuse by irrigation. Treated water percolates to groundwater or it may be collected in underdrains for surface discharge such as at Muskegon County, Michigan.

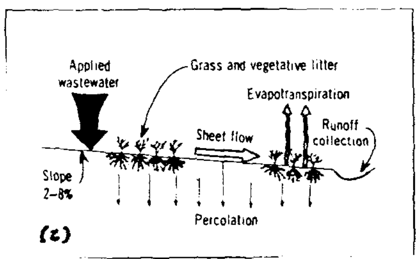
- Rapid infiltration is the application of wastewater to permeable soils for treatment as it passes through the soil. Treated water usually percolates to groundwater or is indirectly discharged to surface water by lateral flow and seepages. Wells or underdrains may be used to recover the water for surface water discharge or reuse.



(a) Slow rate or irrigation. Examples: Pleasanton and Bakersfield, Ca., and Lubbock, Tex.



(b) Rapid infiltration. Examples: Phoenix, Ariz., Ft. Devens, Mass., and Lake George, N.Y.



(c) Overland flow. Examples: Pauls Valley, Okla., Paris, Tex., and Utica, Miss.

Figure 5 LAND TREATMENT PROCESSES

- Overland flow is the application of wastewater to relatively impermeable soils for treatment as it flows in a thin sheet down vegetated slopes. Treated water is collected at the bottom of the slopes and discharged to surface waters.

The main problems with land treatment are its lack of wide acceptance in the technical community and by the public, land acquisition and control, and institutional and legal contraints such as water rights and treatment requirements prior to application.

a. Acceptance of Land Treatment

Land treatment was used in the past but gradually its use declined. Part of the problem is accepting a technology with natural or non-structural components that can generally match AWT technology in level of treatment efficiency. Questions have been raised with respect to land treatment including potential health risks from viruses, nitrate contamination of groundwater, the ability of the land treatment system to operate efficiently over many years, and the loss of water as return flows for in-stream uses. The EPA has conducted extensive research in many of these areas but results have not yet been widely disseminated for public debate and resolution. Indications are, however, that the relative health risks from land treatment versus conventional treatment are essentially the same (Ref. 39). The long-term effects studies that are completed indicate no significant adverse environmental effects. These studies were conducted at sites where land treatment has been practiced from 15 to 45 years (Refs. 40, 41).

b. Land Acquisition

Land acquisition is a problem that starts with land use planning and site selection and involves lease options, purchase, or contracts with landowners to take the wastewater. If local governments must purchase the land for land treatment, the cost of that land can be raised by the landowner to the point where the land treatment alternative is no longer cost effective.

c. Water Rights

Water rights laws consist of two main types: the Riparian Doctrine which may pose problems for implementing land treatment processes in states east of the Mississippi, and the Appropriative Doctrine in states west of the Mississippi.

According to the Riparian Doctrine, anyone owning land adjacent to, or underlying, a natural watercourse has the right to use, but not to consume, the water. Within this theory have arisen two subtheories--"natural flow allocation" and "reasonable use" that affect the manner in which a riparian right can be exercised. In natural flow, the landowner can diminish neither the quantity nor the quality of the water before returning it to the watercourse. Beyond minimum consumptive uses, such as drinking, bathing, or cooking, this right is very restrictive and gave rise to the reasonable use theory. Water under natural flow can be withdrawn for a "natural," riparian, or nonriparian use. Reasonable use requires that the water be used for a legal and beneficial purpose. Because the water under riparian theory is closely aligned with the concept of land ownership, the rights to water ownership pass with sale of the land (Ref. 42).

Appropriative rights have been established in state constitutions and implemented by statute and defined in the courts, often on a case-by-case basis. As a result, wide variations exist among the western states that recognize such rights. In general, the basic principles of appropriative rights theory are first in time, first in right for the water, and subsequent appropriations cannot diminish the quantity or quality of a senior right. Usually, permits are required to establish the right to appropriative water; water thus appropriated must also be put to beneficial use. To protect the right to a specified quantity, the user must show a continuous use of the permitted amount. Rights to appropriated water are not connected with land ownership. They may be bought, sold, exchanged, or transferred as regulated by specific state limitations (Ref. 42).

Problems posed by water rights relate to quantity and location of discharge rather than quality. For land treatment, the main problem arises in western states where the existing effluent discharge upstream is claimed by an appropriative water right downstream. To remove the previously discharged effluent from the stream, subject it to land treatment, and use a large portion of it consumptively, as in irrigation of cropland can result in litigation. The problem can be overcome by (1) exchanging water rights; (2) purchasing a new water supply to replace that formerly withdrawn from the stream such as from groundwater; or (3) in some cases, using a land treatment system that returns the treated water to the river or stream such as overland flow or underdrains in slow rate or rapid infiltration systems.

C. Discussion - Issues/Options

1. Planning and Implementation Mechanisms

The proposed requirement for GAC treatment is essentially the only specific treatment requirement mandated for water supply by proposed regulations. In all other cases, the decisions taken by a water supply utility or agency to insure compliance with drinking water standards as well as the financial responsibility to carry them through are basically local. For example, a utility could choose to develop an alternative supply source rather than upgrade treatment processes. On the other hand, the supply agency has no effective control of the raw water quality as affected by other users/dischargers.

Planning and implementation of POTW's, however, is to a large extent financed by the Federal Government. As a consequence, the process is greatly controlled by guidelines established under the Construction Grants Program.

2. Where to Remove Pollutants

One interaction between wastewater treatment plans and water supply plans is in deciding on the degree of treatment required for each. For the case of an upstream wastewater discharge and a downstream water supply intake, the question arises as to how much additional wastewater treatment is cost effective to protect the downstream use.

With current EPA grants for the wastewater management program the argument could be made that industrial pretreatment followed by AWT at the municipal wastewater treatment facility should produce a high quality effluent that, after dilution, should not require downstream users to employ new and expensive water treatment methods. On the other hand the contribution of pollutants from nonpoint sources may still necessitate intensive treatment at the water supply intake prior to municipal use. In this case, the nation's citizens would be paying for organics removal twice, once at the wastewater treatment plant upstream and again at the water treatment plant downstream. Other unresolved questions are the effectiveness and implementation of Best Management Practices (BMPs) for nonpoint source control, the degree of industrial pretreatment and the in-stream regenerative and dilution capabilities.

In addition to the implied example of an "upstream" wastewater discharger and a "downstream" water user with treatment at each point, other conditions may prevail. In general, either the water intake or the wastewater discharge point could be relocated, trading off additional treatment facilities for additional conveyance facilities.

3. Clean Water Act 1985 Goal

The 1985 goal to "eliminate the discharge of pollutants" has yet not been clearly defined. In reality, treatment levels and water quality criteria have been established which reduce the discharge of pollutants to acceptable levels for various beneficial uses, but do not, in fact, "eliminate" the discharge of pollutants. With the advent of national drinking water standards in the SDWA, and the establishment of water quality limited segments and associated criteria, the basic intent of the goal may need to be reexamined.

4. Wastewater Treatment and Discharge Versus Reuse

In arid or water scarce areas of the country, substitution of reclaimed water for potable water, currently used for certain nonpotable uses such as irrigation, could be beneficial. Benefits could include improved water quality for municipal supply, reduced costs, and energy savings. Large suppliers of irrigation water of a quantity sufficient for potable supply (with conventional treatment if necessary), such as the U.S. Bureau of Reclamation, could provide water supply for municipalities. In return, the treated effluent from the municipal wastewater treatment plant could be distributed as the irrigation supply. For example, the system at Northglenn, Colorado, involves this source substitution. There are several potential benefits from this type of reuse scheme: the development of a new water supply by a municipality could be avoided; nutrients in wastewater could be recycled to the land; and in many cases, energy savings could be realized. Institutional and legal complexities, however, may become insurmountable.

5. Land Treatment Versus AWT

Alternatives to meet treatment needs for discharge to WQL segments of receiving waters usually include land treatment or AWT systems. Moreover, when the 1985 goal of elimination of the discharge of pollutants is addressed by EPA, these alternatives will face most municipal dischargers. Table 7 shows a comparison of conventional, land treatment, and AWT systems in terms of effluent quality. The benefits and risks involved in both technologies must be evaluated at the specific site, considering the total environment and taking into account the natural treatment capacities of soils and streams.

For land treatment, as discussed previously, the risks are equally low for properly designed and managed systems. The benefits, however, can include nutrient recycling, and savings in costs and energy. The savings depend on low operation costs and the potential for revenue from crop sales. Additional savings in capital costs can be realized if the degree of pretreatment prior to land application is reduced. The EPA has formulated guidance on this subject based on the degree of public access and contact with the site as shown in Table 8.

6. Organics Removal in Water Treatment

Because organics removal for other than taste and odor control is rarely practiced in current United States water treatment facilities, the applicability of various alternatives and their design criteria need definition. As previously discussed, GAC treatment is the leading candidate for widespread use, but design variables such as contact time and frequency of carbon regeneration need further study to optimize the process and minimize costs. Other alternative processes also require further study. A fundamental question as yet not fully resolved is the extent to which GAC treatment should be required.

Table 7

COMPARISON OF EFFLUENT QUALITY FOR CONVENTIONAL, LAND TREATMENT, AND ADVANCED WASTEWATER TREATMENT SYSTEMS

System Type	BOD	SS	NH_3-N	NO_3-N	Total N	P
	Effluent constituent, mg/L					
Conventional treatment						
- Aerated lagoon	35	40	10	20	30	8
- Activated sludge	20	25	20	10	30	8
Land treatment						
- Slow rate	1	1	0.5	2.5	3	0.1
- Overland flow	5	5	0.5	2.5	3	5
- Rapid infiltration	5	1	....	10	10	2
Advanced wastewater treatment						
- Biological nitrification	12	15	1	29	30	8
- Biological nitrification-denitrification	15	16	....	....	3	8
- Tertiary, 2-stage lime coagulation & filtration	5	5	20	10	30	0.5
- Tertiary, 2-stage lime coagulation, filtration & selective ion exchange	5	5	....	....	3	0.5

Table 8

GUIDELINES FOR ACCESS TO LAND TREATMENT SYSTEM SITES

Process	Site isolation and public access	Acceptable preapplication treatment
Slow Rate	. Isolated site, restricted public access, nonfood crops	Primary treatment
	. Agricultural site, restricted to crops that are not eaten raw	Biological treatment & disinfection 1,000
	. Landscape irrigation with public access	Biological treatment & disinfection
Rapid infiltration	. Isolated site, restricted public access	Primary treatment
	. Urban locations, controlled public access	Biological treatment
Overland flow	. Isolated site, no public access	Screening or comminution
	. Urban locations, no public access	Screening or comminution & aeration to control odors during storage or application

The preceding paragraphs lead to the following initial questions that may warrant further consideration and discussion:

- Should the SDWA be expanded to include federal financial aid and coordination with POTW's?
- Should the construction grants program for POTW's be broadened so that it can be used as a vehicle to achieve greater coordination?
- Are there any incentives within the present planning framework to encourage joint planning of facilities or tighter coordination? If not, what type of incentives are needed?
- How might the goals of the Clean Water Act be restated to reflect the national concern over trade-offs between levels of wastewater treatment and water quality criteria based on various water uses including, but not limited to drinking water supplies?
- If reclamation and reuse, including land treatment, are to be encouraged how can their impact on in-stream flows and appropriate water rights be mitigated? Should all streams have minimum flow requirements?
- What is the role of the SDWA and proposed regulations for organic chemicals, if any, in the debate of AWT versus land treatment.
- What mechanisms can be used to encourage wastewater reuse or substitution given the complexity of the existing institutional framework?
- Should water users be encouraged to seek unclaimed wastewater as an alternative source? What incentives can be provided?
- Should GAC treatment be specifically linked with other wastewater planning activities and treatment requirements such as industrial treatment/pretreatment and nonpoint source control?

V. WATER SUPPLY AND WASTEWATER TREATMENT COSTS

A. Introduction

Preceeding sections have highlighted numerous issues that arise from efforts to implement the goals of water and wastewater treatment policy and legislation. Every implementation action or lack of action necessarily carries a price tag. Full compliance with specific objectives will require expenditures of capital now, and additional operation, maintenance, monitoring and administrative costs indefinitely into the future. Impacts such as increased energy and resource utilization are also associated with such actions. On the other hand, failure to protect water quality may force development of a new water supply to replace a polluted source at considerable expense. There may also be impacts that are less amenable to quantification such as decreasing in-stream water quality detrimental to fish and wildlife, or increasing health risks from an inadequately treated potable water supply.

The purpose of this section is to provide a framework for discussing the monetary costs associated with implementing policies embodied in the Safe Drinking Water Act (SDWA) and Clean Water Act (CWA). In particular, emphasis is given to areas of cost overlap between water and wastewater programs. Some of the issues that arise, however, necessarily merge nonmonetary impacts with the monetary price tags associated with various actions.

The discussion that follows is an initial attempt to assemble cost estimates and projections from a variety of sources in an orderly fashion. The nature of available cost information is such that an extremely diverse data base exists. In most cases it is only possible to discuss relative cost impacts because of the danger of comparing "apples and oranges" from available data.

B. Cost of Water

1. Historic Costs of Water Supply

The water supply industry is a major utility in the U.S., comprising 35,000 community water systems that served approximately 192 million customers in 1976. The industry is characterized by many small and few large systems: 80 percent of the systems serve eight percent of the population and eight percent serve 80 percent of the population (Ref. 43). In 1975, the annual revenues were $4.9 billion.

Although all water systems produce a similar product and incorporate similar types of production and distribution processes, economies of scale favor the larger systems. A recent investigation of 12 large and 30 small water suppliers reported that the average total cost for small systems is more than twice that for the large systems (Ref. 44). Similar economies of scale were also shown in the results of a survey of 984 community water systems (Ref. 43). Obviously, costs will vary in specific localities with the type and accessibility of the source, the extent of treatment required, and the topography and extent of the service area.

Table 9 indicates the relative distribution of O & M and capital cost among the principal functions in water supply systems (Ref. 45). Two thirds of capital investment is for the transmission and distribution system while treatment facilities account for only 10 percent. Treatment costs account for about 12 percent of the O & M costs. These figures are for relatively large plants and will vary widely for smaller systems. Another study shows the percentage of treatment costs to be as high as 22 percent of total costs (Ref. 46).

Historic expenditures for municipal and industrial water supply treatment and distribution through 1971 totalled about $94 billion; 83 percent of these expenditures were made by state and local agencies, 10 percent by private sources and only seven percent by the Federal government (Ref. 14).

Table 9

UTILITY PERCENT COSTS BY CATEGORY

Type of Cost	Support Services	Acquisition	Treatment	Power & Pumping	Transmission & Distribution
Operating	31	22	12	16	19
Capital	10	13	10	--	67

Source: Reference 45.

2. Local Costs of the SDWA

Primary standards established by the SDWA require upgrading of the level of water treatment, and therefore an increase in the cost of treatment for a large number of public systems. As discussed in the preceeding section, upgrading essentially falls into two major categories: treatment to meet current primary drinking water standards, and to meet the proposed organic contaminant regulations. Not included are costs to rehabilitate or extend distribution systems or to repair or replace antiquated treatment plants.

The major source of data for examining the cost implications of the primary drinking water standards is an economic evaluation of the primary drinking water regulations prepared for EPA (Ref.47). The study suggests that total national capital costs will range from $1.1 to $1.8 billion to implement the regulations. Total annual costs, including amortization of investment, range between $426 and $545 million. This is the most comprehensive economic study which has been made.

The cost of complying with proposed regulations for organic contaminants is currently under debate. An economic impact analysis of the regulations, prepared for EPA in July 1978 (Ref. 48), indicates that the total national capital cost to install granular activated carbon (GAC) treatment would be in the range of $616 million to $831 million dollars. This is in sharp contrast to water supply industry estimates of $4 billion to $5 billion (Ref. 49). The major difference between the two estimates is apparently the number of systems assumed to require carbon absorption; the industry estimate assumes that essentially all 390 systems serving greater than 75,000 persons would be required to install carbon treatment while the EPA estimate assumes that 61 systems will be affected.

Estimates of the individual system costs for GAC treatment also differ widely. The average per capita or per household costs for the various system sizes used in the EPA economic impact analysis are shown in Table 10. These costs are comparable to estimates by the Environmental Defense Fund of $10.00 - $15.00 per family per year for GAC (Ref. 50) but much lower than the costs reported by several major utilities. (See Table 11). The treatment plant capacities for each population range shown in Table 10 are 20.0 mgd, 60.0 mgd, and 300.0 mgd, respectively.

The costs for adding GAC vary widely depending on assumptions as to contact time, carbon make-up, regeneration frequency, and site specific difficulties. For treatment plants of less than 1 mgd capacity, a major factor in GAC treatment cost is the cost of on-site carbon regeneration. The cost of GAC could be reduced considerably if a central carbon regeneration facility was available within reasonable travel distances (Ref. 43). Pilot plant operations to define operating parameters for individual cases could help refine the estimates.

The foregoing discussion dealt solely with the use of GAC to cope with organic chemicals in drinking water. Systems affected only by the MCL for THM can employ alternatives to GAC such as alternative disinfectants, or moving the point of chlorine application which will often prove less costly than GAC treatment (Refs. 14 and 52).

C. Costs of Wastewater Treatment

In contrast to the cost picture presented for water supply, historical data on national costs for aggregate spending on wastewater treatment facilities is not readily available. The current basis for estimating national costs to implement the Federal Water Pollution Control Act for publicly owned wastewater treatment facilities is the 1976 EPA Needs Survey (Ref. 53). The costs are those required to meet the 1983 interim goal of the act using population projections through 1990.

Table 10

INCREASE IN ANNUAL PER CAPITA AND HOUSEHOLD COSTS DUE TO GAC, IN 1978 DOLLARS

	Population Served		
	75,000 100,000	100,000 1 Million	Over 1 Million
Annual Cost Per Capita 1)			
Standard cost, without site specific additional costs:			
. 9 minute contact time	$10.80	$ 7.00	$5.40
.18 minute contact time	$15.30	$10.00	$8.50
Annual Cost Per Household 2)			
Standard cost, without site specific additional costs:			
. 9 minute contact time	$16.20	$10.50	$7.10
.18 minute contact time	$23.00	$15.00	$11.40

1) Assuming costs allocated only to residential customers
2) For a family of three, assuming that non-residential customers pick up the same proportion of GAC costs that they do of other system costs.
Source: Reference 48.

Table 11

COST OF GRANULAR ACTIVATED CARBON TREATMENT
($ Per Household Per Year)

City 1)	Treat. Plt. Capacity (mgd)	Cost of GAC Treatm't	Present Cost w/o GAC	Cost with GAC	% Incr.
. Philadelphia PA	---	26	45	71	58
. Washington Suburban Sanitary Commission MD	240	6.50-12.20 2)	--	--	--
. Cincinnati OH	---	25	40	65	63
. Indianapolis ID 3)	190	80-85	120	200-205	65-70
. Kansas City MO 4)	100	24	72	96	33

1) Values shown for Philadelphia and Cincinnati are from Reference 50 and for other cities from Reference 51.
2) Based on 4 persons per household for 1,020,000 population served by a 240 mgd water treatment plant.
3) Post-contractor GAC columns, on-site carbon regeneration furnace, regeneration every 6 weeks and 18 minute contact time.
4) City estimate for post-contractor GAC columns, off-site regeneration 6 times per year.

Costs in the 1976 Needs Survey are presented in eight categories as shown in Table 12. The "secondary treatment" category refers to those facilities for which only secondary treatment is required to meet the 1983 goals, i.e., those not discharging to water quality limited segments. Costs shown in the "more stringent treatment" category are based on estimates by individual states of the need for treatment beyond secondary level. This cost definition essentially meets the objectives of the Act promulgated to date, but does not achieve "zero discharge of pollutants", and actual cost may be much higher (Ref. 54).

The next four categories in the Needs Survey, as depicted in Table 12, relate to collection system costs and only indirectly affect treatment capabilities. For example, reduction of infiltration/inflow decreases the hydraulic loading on treatment facilities. From the table it can be seen that the costs for construction and upgrading of collection systems are larger than those for wastewater treatment.

Table 12

1976 EPA NEEDS SURVEY ESTIMATES

Need	Construction cost, $ billions	Subtotals
. Secondary treatment	13.0	34.3
. More stringent treatment	21.3	
. Reduction of infiltration/ inflow to sewers	3.0	
. Sewer replacement and/or rehabilitation	5.5	43.4
. New collector sewers	17.0	
. New interceptor sewers	17.9	
. Control of combined sewer overflows	18.3	
. Urban stormwater control 1)	54.1	62.4
Total	150.0	

1) The 1977 amendments removed this category from those elements eligible for Federal funding.
Source: Reference 53.

Over 40 percent of the total capital needs are associated with the remaining two categories, combined sewer overflow and stormwater control. The cost for stormwater control was based on treating all discharges from separate stormwater collection systems for solids, BOD, and bacteria for the 80th percentile storm.

In contrast to water supply systems wherein capital as well as O & M costs are borne by the utility and ultimately passed on to the user, wastewater system financing is affected greatly by grant funding. With the exception of control and treatment of stormwater, the capital costs presented in the Needs Survey are those eligible for Federal and, in some cases, state grant funds. Operation and maintenance costs of wastewater management systems are funded by the local entity, with state assistance is some states.

D. Discussion - Issues/Options

1. Water and Wastewater Treatment Costs

Based on the above it can be observed that estimates of national costs to bring all potable water supply systems in full compliance with the primary drinking water standards are considerably less than the cost needs for water pollution control facilities. Even using the maximum figure (capital cost of $1.8 billion) for meeting the current primary standards and the high industry estimate of about $5 billion to fully implement GAC treatment, the total is less than five percent of the $150 billion identified as needed for wastewater management and treatment. Nevertheless, it is still a significant number. Any one specific water supplier may find the cost to upgrade to be very large. Because the increased capital, operating and monitoring costs must be funded by the local agency, the impact on individual consumers will be directly related to the level of treatment and will be highly visible.

Further clarification of "zero discharge of pollutants" may be required in order to provide a better cost picture associated with that goal. For example, indications are that estimated costs to remove nitrogen and phosphorus from all wastewater discharges are more than twice the current "more stringent treatment than secondary" needs (Ref. 54). It has also been estimated that cost of removing the last one percent of impurities is twice the cost of removing the first 99 percent (Ref. 55).

Historically, capital costs have been of principal concern to communities because of the need to provide substantial amounts of local funding. With the construction grant assistance program, the problem of local funding has been alleviated to a large extent, and many communities have proceeded with elaborate wastewater treatment plants. Because the capital costs of new secondary treatment plants are similar to those of land application systems, there has been little incentive to select land application systems. However, land treatment systems provide a higher level of treatment than secondary treatment plants. The CWA encourages "innovative" technologies such as land treatment and reuse by authorizing 10 percent additional grant money.

Currently the important element of the local cost burden is operation and maintenance cost. Because there is no grant assistance for operating costs, these costs have a full local impact. Operation and maintenance costs may be substantially less for reuse systems than for conventional treatment and discharge-to-surface waters. This is particularly true in the case of land treatment systems for wastewater, and to a lesser degree, it is true for systems where sludge is applied to land. Thus municipalities may find reduced O & M costs to be an incentive for implementing land treatment systems. In addition, some land treatment systems can also produce crop revenues such as is the case in Muskegon County, Michigan.

The above discussion raises several questions. Some of the obvious ones are:

- The highest available cost estimate for meeting the primary standards of the SDWA and for implementing GAC treatment is less than 10 percent of that for wastewater management and treatment. Are the present methods of financing water and wastewater equitable or should Federal support be considered for upgrading water treatment?

- Nutrient removal or removal of the last one percent of impurities could easily double the cost reported in the 1976 Needs Survey. Should in-stream water quality be enhanced beyond that achievable under the 1983 interim goal at such a cost?

- Benefits from reuse of wastewater include (1) savings in capital and operating costs of treatment, (2) decreased production of sludge, (3) reduced consumption of energy and resources, (4) agricultural enhancement and reclamation of underutilized lands, and (5) production of added revenue to municipalities to offset high O & M costs. How should Federal participation through the grants program be modified to further encourage municipalities to capture a wider range of these benefits? Are the potential benefits sufficient to warrant the legal, institutional and political complications to be encountered? If so, how can the grants process be modified without increasing the inherent complexity?

2. Water and Wastewater Treatment Coordination

The question of the stage in the water use cycle at which to remove pollutants is addressed in the previous section. An evaluation of relative costs was recently prepared for the EPA (Ref. 56). It included a detailed analysis of the unit costs for various wastewater and water treatment processes in order to determine the relative cost effectiveness of providing AWT for wastewater or GAC for water treatment to produce a high quality finished drinking water supply.

For each of the plant capacity assumptions made, the use of GAC in water treatment yielded a water of higher quality at less cost than did use of AWT on upstream wastewater discharge. The cost advantage depends on the magnitude of the wastewater stream as compared with the water supply stream. The comparison was based only on the removal of organics, measured as BOD, COD, or TOC. Nevertheless, it seems apparent that it is more cost effective to remove organic chemicals at the water treatment plant than to attempt to do so at the wastewater treatment plant. This approach does not necessarily protect the quality of the streamflow; thus treatment of the wastewater beyond secondary levels may still be necessary to protect stream quality. Furthermore, this example ignores industrial discharges and nonpoint sources as possible contributors of organic contaminants. For such discharges, source control and treatment may be more cost effective than relying on downstream water treatment.

Section 516(e) of the Clean Water Act specifically calls for recommendations for legislation on a program to require coordination between water supply and wastewater control plans as a condition to grants for construction of treatment works under the Act.

Issues surrounding the congressional request are complex as the monetary and non-monetary benefits will vary from location to location. Some of the more obvious conclusions and questions follow:

- If the 1985 goal of "zero discharge of pollutants" remains in effect and, subsequently, the Nation will continue to strive for achieving it, the type of planning coordination suggested by 516(e) will have little benefit since most tangible treatment related tradeoffs will cease to exist. Consolidation of administrative services may remain as the only source of substantial benefits. Therefore, an important question is whether the Nation should continue to strive for this goal, particularly in light of the SDWA?

- In general, it appears less costly to remove pollutants at the point of use vis-a-vis the point of discharge, if one considers only the cost of securing pure water and ignores in-stream water quality. Does this cost saving alone warrant modification of the grants process or should the issue be broadened to include increased incentives for reuse?

- Most localities discharge their waste downstream of their intake for water supply. It thus follows that coordination of water supply and wastewater treatment plans must be on some kind of regional or watershed basis. Watershed-wide coordination can probably achieve bigger cost savings by concentrating funds on critical pollutant discharges. At the same time institutional, legal and political complexities also increase. If coordination is desirable, how can it be best achieved? Through creation of watershed agencies responsible for planning and management? Through broadening the planning and implementation scope of Section 208? Through the addition of other conditions in the grants program that will require a grantee to coordinate with other affected municipalities?

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